Handbook of National Accounting

Integrated Environmental and Economic Accounting 2003

Final draft circulated for information prior to official editing

United Nations
European Commission
International Monetary Fund
Organisation for Economic Co-operation and Development
World Bank

Studies in Methods
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NOTE

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Foreword

The revision of the United Nations H*andbook of National Accounting - Integrated Environmental and Economic Accounting* (commonly referred to as SEEA), presented in this volume has been undertaken under the joint responsibility of the United Nations, the European Commission, the International Monetary Fund, the Organisation for Economic Co-operation and Development and the World Bank. Much of the work was done by the London Group on Environmental and Natural Resources Accounting, through a review process that started in 1998.

The handbook provides a common framework for economic and environmental information, permitting a consistent analysis of the contribution of the environment to the economy and of the impact of the economy on the environment. It is intended to meet the needs of policy makers by providing indicators and descriptive statistics to monitor the interaction between the economy and the environment as well as serving as a tool for strategic planning and policy analysis to identify more sustainable development paths.

The handbook covers complex and diverse topics some of which are still subject to debate. Whenever possible, it reports best practices, and where a variety of approaches exists, their advantages and disadvantages are presented. Even though a single recommendation could not always be given, the handbook represents a major step towards harmonized concepts and definitions, and will provide the basis for the further development of standards.

The revision process has required numerous meetings over several years in which experts in environmental accounting throughout the world have participated. The revised SEEA owes much to their collective advice and wisdom. At the same time, the revision has been a major exercise in cooperation between national and international statistical agencies. It may serve as a model for future collaborative work on the development of improved statistical systems and standards. The revised SEEA is intended for use by both national and international agencies for compiling environmental accounts reflecting their information needs and priorities.

The publication of handbook was endorsed by the Statistical Commission of the United Nations. It is jointly published by the five organizations.

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List of abbreviations and chemical formulae

ABS	Australian Bureau of Statistics
ADI	acceptable daily human intake
AN	non-financial asset (in the SNA asset classification)
AP	acidifying potential
AWRC	Australian Water Resources Council
BAT	best available technologies
BOD	biological oxygen demand
CAS	Chemical Abstracts System
CBS	Central Bureau of Statistics (Netherlands)
Cd	cadmium
CEC	Commission of the European Communities
CEPA	Classification of Environmental Protection Activity
CFC	chloroflurocarbons
	consumption of fixed capital
CGE	computable general equilibrium
CH_4	methane
Cif	carriage, insurance and freight (used for trade figures)
CO	carbon monoxide
CO_2	carbon dioxide
COD	chemical oxygen demand
COFOG	Classification of Functions of Government
COICOP	Classification of Individual Consumption by Purpose
COPNI	Classification of the Purposes of Non-profit Institutions Serving Households
COPP	Classification of the Outlays of Producers by Purpose
CORINAIR	core inventory of air emissions (in Europe)
CORINE	co-ordination of information on the environment (in Europe)
CPC	Central Product Classification
Cr	chromium
CS	capital service flows
Cu	copper
CV	contingent valuation
D	depletion
da-	"damage adjusted" (as a prefix to GDP, GNI, etc.)
DETR	Department of the Environment, Transport and the Regions (UK)
DKK	Danish kroner (currency unit)
DMC	domestic material consumption
DMI	direct material input

DMO	domestic material output
dp-	"Depletion adjusted" (as a prefix to GDP, GNI, etc.)
DPO	domestic processed output
EA	environmental asset (in the SEEA asset classification)
ea-	"environmentally adjusted" (as a prefix to GDP, GNI, etc.)
ECE	Economic Commission for Europe (of the United Nations)
ECU	European Currency Unit (fore-runner of the Euro)
EDP	environmentally adjusted domestic product (term used in SEEA 1993)
EEZ	exclusive economic zone
EFTA	European Free Trade Area
EIOT	environmental protection input-output table
EP	eutrophication potential
EPA	Environmental Planning Agency (Sweden)
EPE	environmental protection expenditure
EPEA	environmental protection expenditure accounts
EPER	environmental protection expenditure and revenues
ESN	energy supply in the Netherlands
EU	European Union
EVRI	Environmental Valuation Reference Inventory (US and Canada)
EWC	European Waste Catalogue
FAO	Food and Agriculture Organisation (of the United Nations)
FCCC	Framework Convention on Climate Change (of the United Nations)
FIM	Finnish mark (currency unit)
Fob	free on board (used for trade figures)
GARP	Green Accounting Research Project
GDP	gross domestic product
ge-	"greened economy" (as a prefix to GDP, GNI, etc.)
GNI	gross national income
GOS	gross operating surplus
GREENSTAMP	GREEned national STAtistical and Modelling Procedures
GWP	global warming potential
H^+	hydrogen ion
ha	hectare
HFC	hydrofluorocarbon
Hg	Mercury
IC	intermediate consumption
IEA	International Energy Agency
IFEN	Institut français de l'environnement
IMF	International Monetary Fund
IPCC	Intergovernmental Panel on Climate Change
ISIC	International Standard Industrial Classification

ITSQ	International Transferable Share Quotas
ITQ	International Transferable Quotas
IUCN	International Union for the Conservation of Nature
kmsr	kilometre of standard river
LCA	life cycle analysis
m	metre
M	maintenance costs
MFA	material flow analysis
MIPS	material intensity per service unit
N_2O	nitrous oxide
N	nitrogen
NABS	Nomenclature for the Analysis and Compilation of Scientific programmes and Budgets (Eurostat)
NACE	Nomenclature statistique des activités économiques dans la Communauté européenne
NAICS	North American Industrial Classification System
NAM	national accounts matrix
NAMEA	national accounting matrix including environmental accounts
NAS	net additions to stock
NC	not classified
NDP	net domestic product
n.e.c.	not elsewhere classified
NGO	non-governmental organisation
NH_3	ammonia
Ni	nickel
NIER	National Institute for Economic Research (of Sweden)
NM-VOC	non-methane volatile organic compounds
NNI	net national income
NOAA	National Oceanic and Atmospheric Administration (of the United States)
NOEC	no observable effect concentration
NOS	net operating surplus
NOx	nitrogen oxides
NPISH	non-profit institutions serving households
NPV	net present value
NR	not recorded
NSCB	National Statistical Coordination Board (of the Philippines)
O_2	oxygen (gaseous)
O_3	ozone
ODP	ozone depleting potential
OECD	Organisation for Economic Co-operation and Development
P	phosphorous

PACE	pollution abatement and control expenditure
PAH	polyaromatic hydrocarbon
PFC	perfluorocarbon
PIM	perpetual inventory method
PIOT	physical input output tables
PJ	petajoule
PM_{10}	particulate matter of size 10 microns or smaller
PPP	polluter pays principle
PTB	physical trade balance
R&D	research and development
RIVM	National Institute of Public Health and Environmental Protection (Netherlands)
ROW	rest of the world
RR	resource rent
R	rate of interest
rV	income element of resource rent
RV	resource value
SAM	social accounting matrix
SBI	Sustainable Budget Index (of Botswana)
SEEA	System of integrated Environmental and Economic Accounts
SEEAF	System of integrated Environmental and Economic Accounts for Fisheries
SEK	Swedish kroner (currency unit)
SERIEE	French acronym for the European System for the Collection of Information on the Environment
SF_6	sulphur hexafluoride
SFA	substance flow analysis
SNA	System of National Accounts
SNI	sustainable national income
SO_2	sulphur dioxide
SO_x	sulphur oxides
SUTEA	supply and use table with environmental extensions
TBFRA-2000	Temperate and Boreal Forest Resource Assessment
TDO	total domestic output
TMC	total material consumption
TMI	total material input
TMO	total material output
TMR	total material requirement
TNO	Netherlands Organisation for Applied Scientific Research
toe	tonnes of oil equivalent
TRA-2000	Global Forest Resource Assessment
TWh	terawatt hours

UK	United Kingdom
UN	United Nations
UNCSD	United Nations Commission for Sustainable Development
UNU	United Nations University
V	stock value (of a natural resource)
VAT	value added tax
VOC	volatile organic compounds
VPA	virtual population analysis
WRI	World Resources Institute
WTA	willingness to accept
WTP	willingness to pay
Zn	zinc

Chapter 1 Introduction to SEEA 2003

A Introduction

1 The objective of this handbook

1.1. The effect of mankind's activity upon the environment has been an important policy issue throughout the last part of the twentieth century. On the one hand there has been growing concern about the impact of each country's economic activity upon the global and local environment. On the other hand there has been increasing recognition that continuing economic growth and human welfare are dependent upon the services provided by the environment. These services include the provision of raw materials and energy used to produce goods and services, the absorption of waste from human activities, and the basic roles in life support and the provision of other amenities such as landscape.

1.2. These concerns translate into questions about whether environmental endowments are being used responsibly. Is their use posing a threat to economic development now, either by being used up too quickly with no prospect of replacement or by generating a level of pollution which threatens human health and the existence of species? Even if current behaviour does not pose such a threat at present, would it do so if continued without change into the future? These are the basic questions underlying the desire for sustainable development.

1.3. The purpose of this handbook is to explore how sets of statistical accounts can be compiled which will permit investigation and analysis of the interaction between the economy and the environment. Only by integrating the two areas can the implications for sustainability of different patterns of production and consumption be examined or, conversely, can the economic consequences of maintaining given environmental standards be studied. Policy makers setting environmental standards need to be aware of the likely consequences for the economy. Those determining the development of industries making extensive use of environmental resources either as inputs or sinks, need to be aware of the long-term environmental effects.

1.4. The topic is wide and the handbook extensive. While significant progress has been made in the last few years, this is an area where active research and investigation is still proceeding. Where best practices have emerged, these are reported. When there is still a division of opinion about how best to proceed, the alternatives are presented with arguments for and against each option. Nevertheless wherever possible this handbook presents harmonised approaches, concepts and definitions which should provide the basis for the development of standards, and it contains advice on how to compile environmental accounts and carry out analysis based on them.

2 The structure of the chapter

1.5. Section B looks at the question of sustainability. The three most common interpretations of sustainability, the so-called three-pillar approach, the ecological approach and the capital approach, are presented. The usefulness of the SEEA as a framework for operationalizing each of the three is discussed.

1.6. Section C shows how four categories of accounts run through the handbook. These are 1) physical and hybrid flow accounts; 2) accounts that portray the environmental transactions in the existing System of National Accounts (SNA) in more detail; 3) environmental asset accounts in physical and monetary terms; and 4) accounts that show how existing SNA aggregates can be modified to account for depletion and degradation of the environment and for environmental defensive expenditure.

1.7. Section D gives a very quick overview of each of the following chapters setting these in the context of the four accounting categories given in Section C.

1.8. Section E looks at a number of issues related to implementing the system including noting present limitation and areas for future work.

B Sustainable development and the SEEA

1.9. Many of the concerns related to resource depletion and environmental degradation are reflected in the concept of sustainable development. In its most widely accepted formulation, that of the Brundtland Commission, it is stated that:

> "Humanity has the ability to make development sustainable -- to ensure that it meets the needs of the present without compromising the ability of future generations to meet their own needs." (World Commission on Environment and Development, 1987, p. 8).

1.10. The Brundtland Commission left its definition intentionally vague so that the concept of sustainable development would not be confined to any particular category of needs. While this is helpful in terms of the simplicity and wide appeal of the message, the Brundtland definition offers little in the way of a measurable objective for sustainable development. Not surprisingly, in the time since the Brundtland report, researchers from many disciplines have attempted to operationalize the concept. Their goal has been to understand its implications for the current and future path of development. The result has been the emergence of a number of diverging views of sustainable development. Broadly speaking, three currents of thought are evident within the range of views, which can be referred to for convenience as the three-pillar approach, the ecological approach and the capital approach. The basic tenets of each of these approaches are presented below and the applicability of the SEEA to their measurement is discussed.

1 The three-pillar approach to sustainable development

1.11. A widely held view of sustainable development is that it refers at once to economic, social and environmental needs. According to this view there must be no single focus (or object) of sustainability, but instead all of the economic, social and environmental systems must be simultaneously sustainable in and of themselves. Satisfying any one of these three sustainability "pillars" without also satisfying the others is deemed insufficient for the following reasons. First, each of the three pillars is independently crucial. Second, each of the three pillars is urgent and little time is available for debating which one should be addressed first; they must therefore be addressed simultaneously. Finally, the three pillars are interconnected. There is, therefore, a risk of unwittingly causing (or worsening) problems in one system while attempting to correct problems in another. The only sure way to avoid this is to integrate decisions such that effects in all three systems are considered before action is taken (Robinson and Tinker, 1998).

1.12. The three-pillar approach to sustainable development is wide-ranging and complex. The SEEA has a great deal to offer with regard to certain elements of the approach and less to offer for others. Clearly, the SEEA provides for the compilation of much information relevant to environmental and economic systems, but it offers relatively little for understanding social systems. As for the interactions between the three pillars, the SEEA has clearly a great deal to say about the interaction of environmental and economic systems (indeed, it is about little else), but offers less with respect to economic/social interaction or social/environmental interaction.

2 The ecological approach to sustainable development[1]

1.13. Central to the ecological view of sustainable development is the notion that economic and social systems are sub-systems of the global environment. It follows that sustainability in the economic and social spheres is subordinate to sustainability of the environment. Development, from the ecological viewpoint, is seen to refer to the "capacity of [an ecosystem] to respond positively to change and opportunity" or the "maintenance of [ecosystems'] dynamic capacity to respond adaptively" (Golley, 1990). The key property to be sustained then is the capacity of ecosystems to respond with resilience to external perturbations and changes.

1.14. A strong current within the ecological viewpoint is the notion that the "health" of ecosystems must be protected and enhanced if they are to exhibit the resilience that is necessary for sustainability. Ecosystem health is a metaphor derived from the human health sciences that is difficult to define precisely. In simple terms, it can be thought of as a "resource" that enables ecosystems to adapt and evolve in the face of changing circumstances.

1.15. The ecosystem health approach to sustainable development implies measurement within two broadly defined categories. The first includes measures of the "pressures" placed on ecosystems by human activities (material and energy extraction, physical restructuring, pollutant emissions, human appropriation of space and ecosystem productivity, etc.). These pressures are often the cause of reduced ecosystem health as manifested in degraded service flows and/or reduced management options. The second category includes measures of the responses of ecosystems to these human pressures. The response measures can be of four types: measures that describe the state of the ecosystem; measures that describe the causes of changes in the state of the ecosystems; measures that describe the likely changes in ecosystems in the face of known pressures; and measures of the capability of ecosystems to deal with imposed pressures.

1.16. Despite the utility of the SEEA for addressing the data needs of the ecological approach to sustainable development, the system's full power (which lies in the integration of environmental and economic data) is not fully exploited by an approach focussed exclusively on ecosystems. This power is best exploited by the last of the three broad approaches to sustainable development noted above, the capital approach.

[1] This section draws heavily upon Rapport, 1995.

3 The capital approach to sustainable development

1.17. The capital approach to sustainable development is most closely associated with the thinking of economists on the subject, although the approach goes well beyond what is typically the domain of economics (see, for example, Daly and Cobb; 1989; Pearce et al., 1989; Pearce and Turner, 1990; Victor, 1991; El Serafy, 1996). It borrows the concept of capital from economics, but broadens it in a variety of ways to incorporate more of the elements that are relevant to the sustainability of human development. In doing so, it takes concepts from the physical sciences (especially ecology and geography) and from the non-economic social sciences and integrates them within a framework based on capital.

1.18. Although one finds a certain amount of disagreement among economists regarding sustainable development, substantial agreement exists on one point: sustainable development is closely related to the long-standing economic concept of income. Most economists refer back to Hicks' (1946) definition of income in this regard:

> income is the maximum amount an individual can consume during a period and remain as well off at the end of the period as at the beginning.

1.19. The Hicksian concept of income is easily explained with a simple example. Imagine an individual whose only source of income is a stock portfolio valued at $1 million at the beginning of a year. This is a very well managed portfolio, paying its owner a net return of 10% annually. The investor's annual income in this case is $100 thousand, as this is the maximum amount that she can consume in a year without depleting her capital investment (that is, her stock portfolio).

1.20. Although there are obvious and important differences between the economic affairs of an individual and those of an entire nation, the above definition of income applies equally well to both. The income of a nation can thus be defined as the amount that it can collectively spend during a period without depleting the capital base (or wealth) upon which it relies to generate this income.

1.21. The advent of sustainable development has altered the way in which many economists think about national income and its relationship to national wealth. In the past, economists tended to focus on produced capital as the underpinning of wealth and, therefore, of income. To the extent that natural resources were considered at all, they were seen to be free gifts of nature in effectively limitless supply. In recent years, with the emphasis of sustainable development on the preservation of the productive capacity of the environment, many economists have argued that the contribution of a nation's natural capital cannot be ignored in discussions of the sustainability of national income and wealth. Others have added that human capital and social capital must also be considered. This has led to the following interpretation of sustainable development from a capital standpoint:

> Sustainable development is development that ensures non-declining per capita national wealth by replacing or conserving the sources of that wealth; that is, stocks of produced, human, social and natural capital.

1.22. Although human and social capital are important topics and are currently the subject of considerable debate and research, they clearly do not fall within the rubric of integrated environmental and economic accounting. For this reason, they are considered no further here. Likewise, produced capital is not treated at great length in the SEEA and readers interested in learning more about it are referred to other sources, in particular the SNA.[2] Where the SEEA does offer a great deal is with respect to the measurement of natural capital. The remainder of this section is therefore devoted to a discussion of natural capital and its relationship to sustainable development, and to what the SEEA offers by way of a measurement framework for natural capital.

Natural capital and sustainable development

1.23. Natural capital is generally considered to comprise three principal categories: natural resource stocks, land and ecosystems. All are considered essential to the long-term sustainability of development for their provision of "functions" to the economy, as well as to mankind outside the economy and other living beings. It is helpful to consider these functions as falling into one of three groups:

> Resource functions cover natural resources drawn into the economy to be converted into goods and services for the benefit of mankind. Examples are mineral deposits, timber from natural forests, and deep sea fish;
>
> Sink functions absorb the unwanted by-products of production and consumption; exhaust gases from combustion or chemical processing, water used to clean products or people, discarded packaging and goods no longer wanted. These waste products are vented into the air, water (including sea water) or are buried in landfill sites. These three destinations are often referred to as "sinks";
>
> Service functions provide the habitat for all living beings including mankind. Some aspects of habitat are essential, such as air to breathe and water to drink. These are called survival functions. If the quantity and quality of survival functions are diminished, biodiversity of species is threatened, not excluding the human species. Some service functions are not essential in the same way but improve the quality of life, for example by providing a pleasing landscape for leisure pursuits. These are called amenity functions and affect mankind only (or at least are the only ones measurable to us in human terms).

1.24. According to the capital approach, the long-term sustainability of development is seen to depend upon the maintenance of natural capital (in addition to the other forms of capital). If stocks of natural capital decline to the point where they are no longer able to adequately provide the functions listed above, any pattern of development that relies on these functions is not sustainable. Of course, this is not to say that some other pattern of development is not possible, only that change will be required to either 1) eliminate the need for a particular natural capital service or 2) find a means of replacing the natural capital service with a service of produced capital.[3]

1.25. Even if many researchers accept the basic idea that sustainable development requires maintenance of natural capital, the relationship between natural capital and other types of capital remains a matter of debate. Although there is agreement that all forms of capital are important when considering sustainability, there is a

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[2] Produced capital is treated in two elements of the SEEA framework. The first is in the asset accounts, where cultivated natural resources are treated as produced capital and the second is the environmental protection and resource management accounts, where produced capital employed for environmental purposes is measured.

[3] Sewage treatment plants are a good example of the latter. Because sewage production far exceeds that which rivers could accept without suffering a dramatic decrease in functioning, society has been forced to divert financial and human resources away from other purposes into the production and operation of sewage treatment plants. These plants do nothing more than replace the waste assimilation service that the natural capital (the river) cannot provide at current levels of sewage production.

divergence of opinion as to whether the various forms are complements or substitutes (especially as to whether natural capital can be replaced by other forms). Many researchers argue that produced and human capital are very often, if not always, substitutes for natural capital. Society has, they note by way of example, employed produced and human capital to devise chemical fertilizers that substitute for the natural fertility of soil. Even soil itself can be replaced in a limited way through the use of hydroponics. History is full of similar examples where technological advancement has allowed substitution of scarce resources with those that are more abundant. Many would claim there is every reason to believe that such advancement will continue, even at increased rates, in the future.

1.26. Others argue that the possibilities for substitution are more limited, even completely absent in some cases. Many forms of capital, they argue, are of value only when combined with another form. For example, a fishing fleet (produced capital) is essentially worthless unless combined with healthy fish stocks (natural capital) to exploit. In this case, the fishing fleet and the fish stocks are said to be complementary. But this is just a limited example of complementarity, where a subset of one type of capital is complementary with a subset of another type of capital. Another possibility is that a certain form of capital provides a service that is essential to the functioning of the entire planetary system and for which there exists no known substitute. Although examples of this type of capital are few (and there may be no absolute example), global atmospheric systems that provide the services of protection from solar radiation and climate regulation come close.

1.27. The controversy over the degree of substitutability for natural capital has translated into a continuum of capital-based approaches to sustainable development. At the opposing ends of this spectrum are found the concepts of weak and strong sustainability.

> Weak sustainability seeks to maintain from year-to-year the per capita income generated from the total capital stock available to a nation (measured in monetary terms). No regard is given to the composition of this stock, as it is assumed that all forms of capital are substitutes for one another. Weak sustainability clearly allows for the depletion or degradation of natural resources, so long as such depletion is offset by increases in the stocks of other forms of capital (for example, by investing royalties from depleting mineral reserves in factories).
>
> Strong sustainability requires that all forms of capital be maintained intact independent of one another. The assumption implicit in this interpretation is that different forms of capital are mainly complementary; that is, all forms are generally necessary for any form to be of value. Produced capital used in harvesting and processing timber, for example, is of no value in the absence of stocks of timber to harvest. Only by maintaining both natural and produced capital stocks intact, the proponents of strong sustainability argue, can non-declining income be assured.

1.28. Regardless which position is accepted between these two extremes, the effect of an increasing population is the same. Not only must capital stocks be non-diminishing, but they must in fact grow at the same rate as the population if per capita income is to remain constant. Of course, the effects of technological change may mean that the population can grow faster than capital stocks with no reduction in income earning potential if technology allows more productive use to be made of existing stocks.

Weak and strong sustainability: Implications for natural capital

1.29. The same basic principle is apparent in both the weak and strong interpretations of sustainability: development must be compatible with long-term maintenance of capital stocks. The implications of this principle for natural capital differ depending upon which interpretation one accepts however.

1.30. Under a regime of weak sustainability, natural resource stocks may be depleted, and environmental systems degraded, but only if this depletion/degradation is offset by equivalent or greater increases in other forms of capital. That is, so long as there is no reduction in total capital, development is assumed to be sustainable.

1.31. Since it is the total capital stock that is to be maintained, all forms of capital must be measured using the same yardstick. Practically speaking, this implies measurement of natural capital in monetary terms.

1.32. Strong sustainability requires that natural capital stocks be maintained intact independent of other forms of capital. In practice, this requires invoking certain principles for the use of natural capital. Inherent in these principles is the notion that prudence should be applied when making decisions about natural capital. Our limited scientific understanding of the environment requires that this be so. While it may eventually turn out not to be necessary to maintain a particular form of natural capital, it is dangerous to assume this and foreclose future options. Sustainability, we are reminded, is a problem over the long run as much as or more so than one concerning the current period. The caution called for by strong sustainability is often expressed in terms of the "precautionary principles" expressed below:

> Renewable resources should not be used in excess of their natural regeneration;
>
> Non-renewable resources should be used prudently and efficiently with care that the same function is available to future generations, say by technological development or shift to use of renewable resources;
>
> Sink functions should not be used beyond their assimilative capacities;
>
> Activities which cause deterioration in service functions should be avoided or at least minimised.

1.33. Because strong sustainability requires the independent maintenance of capital stocks, there is no reason why all forms of capital must be measured using the same unit of measure. This allows for measurement of natural capital stocks in physical units as well as in monetary units. Physical measurement of natural capital is often straightforward. Stocks of many natural resources (for example, subsoil and timber assets) can be measured using simple physical units. Measuring the natural capital represented by environmental systems, the waste assimilation capacity of a river system for example, is much more difficult. The SEEA includes accounts designed to measure such ecosystem services, but it must be noted that current knowledge and experience in this field is limited. The ecosystem accounts presented in the SEEA should then be viewed as works in progress. They will evolve along with understanding of ecosystems and the services they provide.

4 The SEEA as a framework for measuring sustainable development

1.34. It is clear from the foregoing that the SEEA can serve as at least a partial framework for measuring sustainable development from all three of the broad approaches noted. The system has not been designed to serve any particular perspective and, indeed, should be of considerable value regardless of the user's particular point of view on the concept. This said, it is clear that the focus of the SEEA on macro-level accounts integrating environmental and economic data makes it particularly useful from the perspective of the capital approach. The SEEA has the capacity to respond to data needs across the full range of views within this approach. How this is so will be made clearer in the next section, in which the SEEA accounting system is described in its broad outlines.

C An overview of the SEEA accounting system

1.35. The SEEA is a satellite system of the SNA that comprises four categories of accounts. The first considers purely physical data relating to flows of materials and energy and marshals them as far as possible according to the accounting structure of the SNA. The accounts in this category also show how flow data in physical and monetary terms can be combined to produce so-called "hybrid" flow accounts. Emissions accounts for greenhouse gases are an example of the type included in this category. The accounts of this category are outlined in chapters 3 and 4 of the handbook.

1.36. The second category of accounts (chapters 5 and 6) takes those elements of the existing SNA which are relevant to the good management of the environment and shows how the environment-related transactions can be made more explicit. An account of expenditures made by businesses, governments and households to protect the environment is an example of the accounts included in this category.

1.37. The third category of accounts in the SEEA comprises accounts for environmental assets measured in physical and monetary terms. Timber stock accounts showing opening and closing timber balances and the related changes over the course of an accounting period are an example. These accounts are described conceptually in Chapter 7.

1.38. The final category of SEEA accounts considers how the existing SNA might be adjusted to account for the impact of the economy on the environment. Three sorts of adjustments are considered; those relating to depletion, those concerning so-called defensive expenditures and those relating to degradation. Chapters 9 and 10 cover this material.

1.39. The objectives and usefulness of the accounts in each of these categories are discussed in more detail below.

A note on terminology

1.40. The various accounts of the SEEA may be expressed in either physical or monetary units, or both. The accounts expressed in physical terms may employ any of the linear, volumetric, areal or mass units used in the International System of Units (for example, metres, litres, hectares or kilograms). For convenience, all such accounts are referred to generically as "physical accounts" in this handbook. The accounts expressed in monetary terms are, of course, presented using only currency as the unit of measure. These accounts are referred to generically in what follows as "monetary accounts". The use of "monetary" in this case is to be interpreted as synonymous with "economic value" as the latter is understood in economic theory. In particular, the measures included in the monetary accounts of the SEEA should be taken to reflect the objective weighting that is brought to bear through the use of socially determined relative prices.

1 Category 1: Physical and hybrid flow accounts

1.41. Many environmental data sets are now available which show the extent to which the precautionary principles listed earlier are respected. Often different data sets are collected and published for different sorts of environmental resources. The physical flow accounts of Chapter 3 bring a set of common measuring tools to bear on these presently disparate data sets. The framework chosen is that of the SNA. The objective is to see the extent to which the economy is dependent on particular environmental inputs and the sensitivity of the environment to particular economic activities.

1.42. Bringing the data together in a framework using common classifications helps to highlight any inconsistencies and gaps in the overall picture. It also allows links to be made to other economic series. Does an industry which is environmentally sensitive play a particularly large role in international trade of the country or provide many employment opportunities? If common units can be used, the possibility of aggregation and the presentation of simple indicators are facilitated.

1.43. Once the physical data are aligned with economic classifications, an obvious next step is to compare the physical quantities with the matching economic flows. This is developed in the SEEA by means of hybrid accounts (Chapter 4), which make up the remainder of the first category.

1.44. Hybrid environmental accounting is a means of confronting physical information about the use of environmental resources with information in both physical and monetary terms about the processes of economic production. It is the combination of different types of units of measure that leads to the name "hybrid" accounting.

1.45. The key sustainability policy goal to which hybrid accounts respond is the desire to maintain or improve economic performance while simultaneously reducing or eliminating the impact on the environment. This process is sometimes referred to as "decoupling". Decoupling can be brought about by changing consumption and production patterns away from materials with environmentally damaging consequences, by adopting new technologies which make more efficient use of environmental resources or which reduce the damage brought about by existing production patterns.

2 Category 2: Economic accounts and environmental transactions

1.46. The environment is not only used as an input by the economy. Increasingly, activities are undertaken and products are made with the deliberate intention of relieving pressure on the environment. Thus, as well as using the hybrid accounting structure to examine where pressures exist, it is also desirable to identify where expenditure is undertaken to alleviate or rectify these pressures. This is the objective of the accounts described in Chapter 5.

1.47. As well as direct intervention in the state of the environment via environmental protection expenditure, it is increasingly common for more environmentally friendly behaviour to be encouraged by means of economic instruments. These may be taxes to discourage consumption by increasing prices or they may be means of controlling property rights and access to environmental media by means of selling licences and permits. Measuring the use of these types of instruments is the objective of the accounts in Chapter 6.

1.48. The relationship of the accounts in this category to the measurement of sustainability is somewhat indirect. Clearly, expenditures made to reduce the pressure on the environment are an important measure of the human response to the sustainability challenge. However, the level of the expenditures themselves does not reveal directly whether development has become more sustainable or not. In order to assess this, one must turn to other categories of accounts within the system. What the accounts in this category do allow, however, is an assessment of the economic costs and benefits, including their sectoral impact, of reducing human impact on the environment. This is very important information for those interested in analysing sustainability from a fiscal perspective.

3 Category 3: Asset accounts in physical and monetary terms

1.49. The environment can be thought of in natural capital terms as a collection of assets of various types. As noted earlier, natural capital falls into three broad categories: natural resources, land and ecosystems.

Category 3 of the SEEA includes asset accounts in physical and monetary terms for each of these three broad categories. The methods for compiling these accounts are described in Chapter 7.

1.50. When natural resources are used in a production process, they are embodied in the final good or service produced. The price charged for the product contains an element which implicitly covers the value of the natural resource. Establishing this implicit element is at the heart of valuing the stock of the resource and seeing the full role of the resource in the production activity of extracting the resource and making it available to other units in the economy.

1.51. The asset accounts of the SEEA are highly relevant to the measurement of sustainable development from the capital perspective. Natural resources, land and ecosystems represent the stocks that provide the many environmental inputs required to support economic activity. If such activity is to be sustainable, the capacity of natural capital stocks to furnish these inputs must be maintained over time or the economy must find a substitute for the natural capital which is capable of delivering an equivalent input. If both of these conditions are not met the current pattern of development is not sustainable.

1.52. The debate between the concepts of weak and strong sustainability mentioned earlier is germane here. The weak sustainability viewpoint is essentially one of technological optimism in which it is assumed that the economy will always find a substitute for any scarce resource given the right price signal. The strong sustainability viewpoint takes the position that it is imprudent to assume that the economy will always find a substitute for natural capital because 1) the past technological successes do not assure success in the future; and 2) we do not know all there is to know about natural capital functioning and, therefore, we risk unexpectedly losing key inputs if we allow natural capital to be depleted or degraded.

1.53. Whatever perspective one takes on weak and strong sustainability, the asset accounts of the SEEA are fundamental to understanding the evolution of sustainability. Clearly, if one assumes a position of strong sustainability, the direct measures of natural capital provided in the asset accounts provide essential information. Even if one assumes a weak sustainability perspective, one would still wish to know how much natural capital is being consumed so that this can be compared with investments in other forms of capital to assess whether total capital is being maintained.

1.54. The asset accounts are also relevant to the intra- and intergenerational equity issues of sustainable development. In a number of countries, natural resources are owned and controlled by the government on behalf of the population at large. It is thus important to be able to see where income arises from the use of the resource and how it is apportioned between the extractor and the owner.

4 Category 4: Extending SNA aggregates to account for depletion, defensive expenditure and degradation

1.55. The final category of the SEEA (chapters 9 and 10) deals with the extension of the existing SNA aggregates to account for depletion and degradation of natural capital, as well as for so-called defensive expenditures related to the environment. Not every statistical office will be in a position to make such extensions (as they are data intensive and methodologically complex) and not every one will wish to (as they can be controversial). Nevertheless, it is the logical culmination of the SEEA to explore the possibilities as well as to note the theoretical, practical and institutional hurdles to doing so.

1.56. The use of resource functions raises the question of whether the resource is being depleted and if so whether the allowance in the economic accounts to maintain produced capital intact (the consumption of fixed capital) should be augmented by a term which might be called the consumption of natural capital.

1.57. Some of the expenditure in the economy relates to attempts to avoid using the sink function of the environment. This includes environmental protection expenditure and may include other expenditure of a type which might be described generally (albeit not very precisely) as defensive expenditure.

1.58. Putting a value on the actual use of the sink function remains a much more difficult problem than the two just mentioned. While it might be possible to make some order of magnitude estimates for marginal changes in the use of the sink function, comprehensive estimates go beyond standard accounting into the realm of modelling.

1.59. Like the asset accounts of Chapter 7, the extended aggregates presented in the SEEA are highly relevant to the measurement of sustainability from the capital perspective. However, unlike the asset accounts, which are relevant from both the weak and strong sustainability perspectives, the accounts in category 4 implicitly adopt the perspective of weak sustainability. The aggregate measures that are described in the SEEA can only be constructed by first valuing all forms of natural capital and then aggregating the value of natural capital with the value of produced and financial capital already included in the SNA.

D The structure of the handbook

1.60. The following gives a very brief overview of each of the chapters in the handbook. At the start of each chapter, there is also a more extensive "road-map" describing the objectives of the chapter and giving a brief description of its contents.

1 Chapter 2: The accounting structure of the SEEA

1.61. This handbook is a statistical document and running through all the chapters are accounts and tables which it is suggested could be compiled to illuminate the various issues under discussion. Chapter 2 provides an overview of the whole accounting system. This can be read either at the outset as a preliminary overview of what is to follow or finally as a synoptic review of the interconnections between the accounts and tables in different chapters.

1.62. As an aid to understanding, a synthetic data set for an artificial country, SEEAland, has been created. This country shares some of the characteristics of several industrialised countries but is better endowed with natural resources than any one of them and its economy has potentially more damaging impacts on the environment, solely in the cause of making the examples easier to follow.

1.63. The description of the accounting structure for the whole handbook is illustrated in Chapter 2 with summary versions of tables for SEEAland. More elaborate and more detailed versions appear in subsequent chapters. A summary table at the end of Chapter 2 is included as reference to the interrelations between the various tables.

2 Chapter 3: Physical flow accounts

1.64. Chapter 3 is the main chapter concerned with compiling flow accounts in physical terms. It is designed to show how the use of the environment can be monitored and documented in physical terms but using classifications and definitions consistent with the economic accounting structure of the SNA.

1.65. The chapter looks at physical flows of materials and energy in connection with the goods and services produced within the economy. This chapter contains examples dealing with the life cycle analysis for wood and timber products and an example of total material flow analysis. It elaborates a system which can provide indicators warning of threats to sustainability based only on physical data.

1.66. Chapter 3 introduces four concepts which are fundamental to the discussion throughout the handbook. These concepts are products, natural resources, ecosystem inputs and residuals. The concept of product is taken over from the SNA. The accounting system of the SNA measures the flows of products (economic goods and services) and shows how in a closed economy some are used to produce other goods and services in the current period (intermediate consumption) or in future (capital formation) and some are used to satisfy current human wants (final consumption). This closed economy must be opened to take account of transactions with the economies of other countries via imports and exports.

1.67. The SEEA opens the system further by looking at the flow of entities into the economy from the environment and those flowing from the economy to the environment. The environmental inputs flowing to the economy from the environment can be divided into natural resources (typically mineral and biological resources) and ecosystem inputs (the water and air necessary for all life forms). The flows from the economy to the environment consist of gaseous, liquid and solid wastes. In the SEEA, the term "residual" is used to encompass all these outflows from the economy which use environmental media as a disposal "sink".

1.68. The early part of Chapter 3 describes the overall framework within which accounts can be compiled for each of these four concepts and discusses the classifications of products, natural resources, ecosystem inputs and residuals that can be used in the accounts.

1.69. The later part of Chapter 3 considers the indicators and analyses that can be derived from the accounts. It shows how the law of the conservation of matter can be invoked to show how natural resources, ecosystem inputs and products can be combined to supply products to be used within the economy or residuals to be expelled to the environment. The table expressed in physical units which shows this transformation is referred to as a physical supply and use table and forms the basis of material flow analysis. Both these techniques have potential as powerful analytical devices based only on physical flow accounts.

3 Chapter 4: Hybrid flow accounts

1.70. Chapter 4 shows how a standard SNA supply and use table can be superimposed on the corresponding part of the physical table described in Chapter 3. The result is a hybrid supply and use table where the columns contain values of products plus the cost of labour and capital and in addition physical inputs of natural resources and ecosystem inputs while the rows contain values of products and physical measures of residuals.

1.71. Such a hybrid table is particularly useful for relating the generation of residuals to the production of particular industries. One of the most useful and most frequently compiled example concerns energy accounts and the associated emission generation.

1.72. Although the economics of production leads to specialisation, some industries make more than one product and some products are made by more than one type of industry. The supply and use tables described in Chapter 3 and the early part of Chapter 4 reflect this fact of life and show supply classified by industry and use classified by products. It is very useful analytically to convert the format of these tables to show either the supply of and use of products or the supply by and use by industries. A table converted to have the same classification along both axes is called an input-output table. The latter part of Chapter 4 explains how these can be constructed from the earlier tables. Further, it shows why such conversion is useful analytically.

1.73. If we know the proportionate environmental input into a product, say, and we know who uses the supply of this product, then we can calculate with a fairly good degree of approximation the total environmental input of all products. For example we can cumulate the environmental input into iron and steel, into various chemical products, into tyres and so on to find the total direct and indirect demands on the environment to produce a car. It may sometimes appear that the direct demands on the environment made by the economy fall when in fact all that happens is that the demands are made via another economy. One example concerns electricity. Country A may not consume fossil fuels to produce electricity but if it imports electricity from country B which simply generates it by burning fossil fuels there, the reduced dependence of country A on fossil fuels is more apparent than real. Analysis of input-output tables for both A and B can give insights into these sorts of issues.

4 Chapter 5: Accounting for economic activities and products related to the environment

1.74. Increasingly, steps are being taken to protect the environment. Chapter 5 looks at how the expenses connected with environmental protection can be identified within the present SNA and show whether it is purchased, produced for sale or undertaken on an own-account basis. By making these expenses explicit, the impact on operating costs of government legislation or voluntary agreements to improve environmental protection can be studied.

1.75. The chapter describes a variety of environmental protection and resource use activities, such as investment in clean technologies, restoring the environment after it has been polluted, recycling, the production of environmental goods and services, conservation, and the management of natural assets and resources. The chapter also outlines the uses and the limitations of the information, describes the basic concepts involved and sets out the internationally-agreed classifications needed to describe the various elements in the accounts.

1.76. The chapter discusses simple national aggregates which can be produced, such as the level of investment in the protection of the environment compared with the total investment in the economy, in order to show the relative national effort devoted to environmental protection. The chapter then describes simplified supply and use tables which show the connection between producers and consumers of environmental protection goods and services, the types of economic inputs (such as labour and capital) used and the type of outputs produced (whether for the market or for own use). This is followed by an analysis of the ways in which expenditure on environmental protection is financed.

5 Chapter 6: Accounting for other environmentally related transactions

1.77. Chapter 6 describes other monetary transactions connected with the environment, specifically those economic instruments increasingly being used to manage the use of environmental resources. These are the imposition of taxes with an environmental base and the issuing of licences and permits to bestow property rights over environmental resources to designated users.

1.78. These flows are captured within the SNA. The accounts can be portrayed in a matrix form to include such flows as taxes and payments for the use of assets as well as the flows of a supply and use table for products. Such a matrix presentation is often referred to as a social accounting matrix (SAM). This too can be represented as a hybrid table where physical measures of environmental inputs and residual outputs are added to the flow accounts of the SNA. This matrix is often referred to as a NAMEA (national accounting matrix including environmental accounts). Chapter 6 shows how such a table can be constructed and how the matrix form of presentation can be used to incorporate alternative classifications of the same concept, for example consumption classified by product and by (economic) function as a means of transforming the links between residuals and products into a link between residuals and economic functions.

6 Chapter 7: Asset accounts and the valuation of natural resource stocks

1.79. Chapter 7 looks at environmental assets and discusses how to account for changes in these assets in both physical and monetary terms. This permits the calculation of indicators showing to what extent the stock of a given asset is being sustained or not in both physical and monetary terms.

1.80. This chapter contains the main discussion on the classification of environmental assets. These are divided into natural resources, land and ecosystems. The first category distinguishes between renewable and non-renewable resources, between economic assets covered by the SNA and those outside the SNA boundary, and between assets which may be consumed by the economy (such as subsoil assets and biological resources) and those which are used but not consumed by the economy such as land and surface water.

1.81. The chapter then discusses the principles behind physical asset accounts; that is, getting from opening stock levels to closing stock levels by itemising the flows within the accounting period. A distinction is drawn between changes in quantity and changes in quality and/or the classification of the asset. It then relates the stocks and flows in physical terms to the transactions and accounting entries of the SNA. It also discusses to what extent a pure environmental classification can be used in monetary terms and how far some compromise with economic classifications is inevitable when valuation is involved.

1.82. The principles of economic valuation are discussed in Chapter 7 and related to the theory of the provision of capital services to the production process by fixed assets. The application of this theory to environmental assets which are currently regarded as “free” gifts of nature is discussed as the basis for reaching a valuation of the stock of these assets. There is detailed discussion of the manner of valuing each of the main classes of assets.

7 Chapter 8: Specific resource accounts

1.83. Chapter 8 takes the general considerations from the previous chapter and shows how these can be applied for specific resources. There are separate sections for mineral and energy resources, water, wooded land, timber and forest products, aquatic resources, land and ecosystems.

8 Chapter 9: Valuation techniques for measuring degradation

1.84. This chapter is concerned exclusively with the valuation techniques which could be applied to derive measures of degradation. In some cases, prices observed in the economy can be used in respect of environmental services which are currently unpriced. Some of the pricing techniques described are entirely consistent with national accounts but represent more analytical means of pricing various characteristics of a product. An example is the use of a hedonic price index.

1.85. Within the national accounts, the prices used reflect the prices actually paid in the market place. The assumption is the economic value is reflected precisely by market prices. This economic value should not be equated with welfare or well-being. Indeed, there is no attempt made within the SNA to measure welfare, although the macro-economic aggregates of the SNA are sometimes misquoted as welfare measures. The explicit omission of the additional values that would be required to produce an estimate of welfare is an important element in the objective measurement of economic activity in the SNA.

1.86. Often the satisfaction to be gained by acquiring a product is greater than the purchase price and the purchaser would in fact be prepared to pay more for the product than the asking price. This excess of the level of satisfaction over the asking price is described as consumer surplus. Some of the pricing techniques discussed in Chapter 8 include an element of consumer surplus. There are a number of very cogent reasons why consumer surplus is deliberately not included in the SNA, yet if we try to measure the impact of degradation on welfare we are forced back towards pricing techniques which include consumer surplus. These prices are not strictly consistent with the prices used in the SNA and thus present accounting problems in trying to assimilate them within an SNA based framework, as explored in Chapter 10.

1.87. Even without making adjustments to the macro-economic aggregates, investigating possible monetary valuations for degradation can be revealing. It broadens the understanding of the impact of degradation on those who suffer from it. It opens the door to undertaking cost benefit analysis such as may be undertaken for example in project specific valuations. Statisticians will wish to know the current thinking on the topic for this reason if no other.

9 Chapter 10: Making environmental adjustments to the flow accounts

1.88. This is the chapter leading up to the derivation of aggregates adjusted to some degree or other for the impact of the economy on the environment. It discusses three sorts of adjustments, those relating to depletion, those concerning defensive expenditure and, lastly, degradation.

1.89. The first section examines how depletion of environmental assets could be incorporated in the SNA. The basis of the proposition is that just as part of the gross domestic product (GDP) represents the consumption of fixed capital and is deducted to give a measure of net domestic product or income which is more in keeping with the notion of preserving a capital base, so that part of GDP which represents the consumption of natural capital should likewise be deducted to reach a "depletion adjusted" set of aggregates.

1.90. The second section is concerned with defensive expenditure. It discusses why simply deducting defensive expenditure from GDP gives figures which are unsatisfactory from an accounting point of view. It goes on to suggest how, purely within the context of a satellite account, the work described in Chapter 5 to identify environmental protection expenditure could be used to reach a solution where all defensive expenditure was treated in the same way in the accounts, regardless of whether it is a market oriented enterprise which undertakes it, government as producer or households as consumers.

1.91. The third section discusses extending the SNA to show the possible implications of appending valuations to aspects of degradation which are currently unpriced. It is the furthest removed from current national accounting practices and thus also the most controversial and most tentative section. It describes work that is currently only in the research stage and is not yet, and maybe will not be, incorporated into the work programme of most statistical offices.

1.92. The chapter moves from actual accounting into the area of hypothetical accounting. Its aim is to try to quantify the impact in monetary terms of the use of sink functions beyond their assimilative capacity. The economic paradigm whereby cost would be incurred up to the point where it was matched by economic benefit does not operate because the costs would be incurred by one set of agents (producers) and the benefits would fall to another (consumers, future generation and non-human species). What actually happens is that costs are avoided by the producers and damage is suffered by consumers, widely interpreted. One approach is to try to estimate what it would cost producers to avoid over-using the sink functions. The other is to try to estimate some of the damage done by the over-use. In effect, this is trying to estimate the value which could be placed on the service function for humans.

1.93. For short-term practical implementation, experience since the publication of the interim version of the SEEA in 1993 suggests two main options for valuing degradation. The first of these relies on cost-based estimates and in turn can be divided into two types. The second option relies on damage-based estimates.

1.94. The first cost-based option is to assume that the valuations represent real costs which have actually been paid by producers and consumers, and to calculate what the national accounts would have looked like if this assumption held true. The calculations produce aggregates based on the idea that the costs involved are those required to maintain a given environmental standard. The aggregates this leads to are denoted as being "environmentally adjusted" in keeping with the terminology of the 1993 SEEA.

1.95. The second cost-based option is to assume that the valuations represent costs and benefits which, if they were taken into account by producers and consumers, would affect their behaviour. The solution to the overuse of environmental functions is not to change the accounting system but to change the economy and its demand on the environment. The effects are therefore modelled using the conventional national accounts, to produce a similar range of aggregates, known as "greened economy" aggregates.

1.96. The damage-based option tries to estimate the loss of welfare caused by the effect of residual generation on human health and thus, but not exclusively, on human capital. The rationale for this route to adjusting macro-aggregates is the furthest removed from the normal SNA conventions and impinges on the realm of welfare measurement.

10 Chapter 11: Policy application and uses

1.97. Chapter 11 looks at the techniques developed in the preceding chapters and shows how these may be used to inform policy analysis and decision making.

1.98. The chapter begins by looking at how the causes of environmental degradation can be examined, mainly using the techniques from chapters 3 and 4. This is the material of particular interest to those wishing to examine how to "decouple" the traditional pattern of residual generation from economic production.

1.99. Environmental degradation can be combatted by a number of means, some compulsory and some voluntary. The accounts for environmental protection expenditure from Chapter 5 can be used to explore many of the associated issues, including the options to extend the extent of environmental protection expenditure undertaken in the economy. Increasingly, rather than introducing environmental standards by legislation, government seeks to achieve these by means of market instruments such as imposing new taxes and reducing subsidies as well as introducing permits and licences to restrict the unlimited use of environmental resources. These applications often use economic models in conjunction with the accounting structures described in Chapter 6. This allows for a more comprehensive assessment of the effects of introducing new environmental legislation, such as the impact on employment or unanticipated environmental benefits.

1.100. Sustainability concerns not just the use of environmental media as sinks but also the use of natural resources. Environmentally responsible policies must consider the use of natural resources and other issues associated with the maintenance of national wealth. In addition, policy-makers will be interested in knowing who benefits from the income generated by natural resource exploitation and the efficiency with which these resources are managed.

1.101. Although the consequences of environmental degradation are often not incorporated within the accounting system, analysis looking at the merits of alternative policies can be more firmly based if the costs and benefits of the different proposals are examined in a common metric. This is where the techniques described in Chapter 9 can be used. More tentative at present is the extension of such work to more comprehensive measures of sustainable income based on the techniques described in Chapter 10.

1.102. While the SEEA does not attempt to define a given set of indicators of sustainable development, compiling such sets is now common in many countries and international organisations. Often the SEEA framework can provide relevant information and as an example the list prepared by the United Nations Commission on Sustainable Development is examined in this context. Working with the SEEA as a background, a set of indicators can be chosen which is more consistent than a set of independently selected indicators, and which provides better linkages between indicators of environmental pressures and responses.

11 Annexes

1.103. Altogether nine annexes are included in the handbook. Eight of these give details of the various classifications used in the compilation of the accounts described in the various chapters.

1.104. Annex 9 describes the technical relationship between the SEEA accounting framework and that of the 1993 SNA. It shows where the SNA has been extended but not changed, and those few cases where change is recommended solely in connection with a satellite account. It also describes those instances where the text of the SNA is perhaps not as clear as it might be in respect of environmentally related transactions and offers a more precise clarification. Lastly it contains reference to techniques which are mentioned in the SNA but described in greater detail in this handbook.

E Implementing the system

1 The relation between the SEEA and environmental statistics

1.105. As an integrated accounting system, the SEEA stands apart from individual sets of environmental statistics in a number of ways. While sets of environmental statistics are usually internally consistent, there is, for good reason, often no consistency from one set of statistics to another. Environmental statistics are often collected with a particular regulatory or administrative purpose in mind and the way in which they are structured is specific to this need.

1.106. In contrast, the SEEA is an integrated system of accounts in which, to the fullest extent possible, there is consistency from one account to another in terms of concepts, methods, definitions and classifications. In addition, implementation of such an integrated system aims for consistency across time. This is of the utmost importance in developing the comparable time series estimates which are necessary in the policy process. The final important distinction between environmental statistics and the SEEA is the SEEA's explicit goal of compatibility with the economic information of the SNA. This adds considerable value to both the environmental and the economic information, as it facilitates analysis of both within a common framework.

1.107. The SEEA may stand apart from sets of environmental statistics in important ways, but it also relies upon them for the basic statistics required in its implementation. Ideally, these statistics would be readily available in a format that allowed their direct incorporation into the system. For example, data on residual emissions from industrial sources would ideally come classified according to the industrial classification used in the SEEA. This would allow their simple incorporation into physical and hybrid flow accounts. In most countries, it is unlikely as yet that most sets of environmental statistics will already be so structured.

1.108. It is reasonable to expect that over time the implementation of the SEEA will result in changes to the way in which environmental statistics are collected and structured in a given country. For this to happen there must exist (or be established) a spirit of collaboration and respect between environmental accountants and statisticians. The former group must understand that collecting data for environmental accounts may be a secondary concern for statisticians responsible for providing information to, for example, a regulatory program. The latter group must be convinced of the importance of having highly structured and consistent data within an accounting framework. In this regard, it can be helpful to explain how such data can improve the likelihood of environmental information being considered more fully in the economic decision-making process. The SEEA can serve as a guiding framework for the development of environmental information systems more compatible with economic statistics.

2 Flexibility of implementation

1.109. It is important to recognise that although the SEEA is conceived as a complete system which is internally consistent, it has been designed such that it can be implemented equally well in part or in whole. Depending upon the specific environmental issues faced, a country may choose to implement only a selection of the accounts included in the SEEA. Even if a country desires eventually to implement the full system, it may decide to focus its initial efforts on those accounts that are most relevant to the issues it wishes to address. For example, a country with few natural resources may not wish to pursue questions related to resource depletion and, therefore, would not undertake to compile asset accounts. Even those countries which are resource rich may concentrate first on those resources where there is seen to be a risk to sustainability or there is discussion about the way in which government appropriates revenue from their exploitation.

1.110. Countries with high levels of material throughput may find it useful to build physical flow accounts for materials but again this may be done on a selective basis, for example working first on accounts for specific materials and perhaps later building complete physical input-output tables.

1.111. If a country imposes strict environmental standards, with significant cost to producers and consumers, then environmental protection expenditure accounts may be an early priority. Those where there is as yet little active environmental protection may prefer instead to concentrate on the calculation of residuals and their impact in order to discover how urgent the problem of introducing environmental protection is.

1.112. Countries where environmental depletion or degradation has reached the point where it constrains economic activity may be interested in knowing what percentage of their current gross economic output might be consumed by the loss of natural capital. For such countries, the extended aggregates presented in Chapter 10 would be of considerable interest.

1.113. These examples are illustrations only of the flexibility of application which is intended by the way in which the SEEA is structured. It is important to bear in mind, though, that no matter what elements of the system are implemented, they must be done in a way that is internally consistent and mutually complementary.

1.114. Box 1.1 shows the accounts of the SEEA cross-classified against the three broad environmental issues dealt with in the handbook (degradation, defensive expenditure and depletion). It indicates in which chapters the main discussions of the issue takes place and which chapters are pre-requisite reading (indicated in curly brackets). The table will be of use to those wishing to have an overall view of how the various accounting techniques described in the SEEA can be used to address major environmental issues.

Box 1.1 The environmental issues and accounts discussed in the SEEA

	Degradation	Defensive expenditure	Depletion
Physical accounting based on environmental statistics and economic classifications	***Chapter 3:*** Studies of production in physical terms using the supply and use framework of the SNA Addition of the concepts and similar accounts for natural resource and ecosystem inputs and residual outputs		***Chapter 7:*** Asset accounts compiled in physical terms; linkage between stock and flow information Extension of the asset boundary of the SNA to include a wider set of environmental assets
Hybrid accounting linking the physical accounts above with economic (monetary) flows in strict accordance with SNA data	*{Chapter 3 and}* ***Chapter 4*** Hybrid supply and use tables Derivations of input-output tables and consequential analyses	*{Chapter 3, 4, 5 and}* ***Chapter 6*** Examination of the SNA sequence of accounts and development of a hybrid matrix of all flows (NAMEA) Sectoral accounts and ownership issues	
Monetary accounting including more detail than SNA data but strictly consistent with it		***Chapter 5*** Identification of environmental protection expenditure and other defensive expenditure ***Chapter 6*** Identification of economic instruments to encourage responsible resource management (taxes, licences etc)	***Chapter 7:*** Valuation of resource stocks Translation of the link between stocks and flows into changes in wealth and income
Monetary accounting allowing variation in the SNA accounting rules	*{Chapters 3,4 and}* ***Chapter 9:*** Valuation techniques applicable for degradation ***Chapter 10*** Possible adjustments to macro-aggregates to allow for degradation	*{Chapters 5,6 and}* ***Chapter 10:*** Possible adjustments to macro-aggregates to allow for defensive expenditure	*{Chapter 7 and}* ***Chapter 10*** Possible adjustments to macro-aggregates to allow for depletion

3 *The progression of the system*

1.115. The description of the accounting system begins with the physical and hybrid flow accounts. This is an appropriate starting point, since there is access to the basic environmental flow data required to compile such accounts (for example, natural resource consumption, residual emissions) in many countries and the environmental issues surrounding these flows are widely considered important. Physical accounts are an appropriate starting part for the system as well in that they are almost always a necessary precursor to monetary accounts. Thus, even for countries whose ultimate goal is the production of accounts in monetary terms, the starting point will generally be accounts in physical terms.

1.116. The second category of accounts, in which existing SNA flow accounts are presented in greater detail to make apparent environmentally related transactions, represents the basic point of entry into monetary environmental accounting. Countries interested in learning about the economic importance of environmental transactions without modifying existing SNA aggregates can look to the accounts presented in this category.

1.117. The third category of accounts, asset accounts in physical and monetary terms, has its own internal logic (it could in fact have been placed earlier in the handbook without disrupting the general logic of the structure). Like the overall handbook, the description of the asset accounts gives physical accounts as the point of entry. Once the concepts related to the compilation of the accounts in physical terms have been presented, the discussion in Chapter 7 turns to the methods that can be used to place a value on environmental assets. Again, this reflects the notion that physical accounts are generally the starting point even if the ultimate goal is accounts in monetary terms.

1.118. The final category, in which SNA aggregates are modified to account for depletion, degradation and defensive expenditure, is the logical culmination of the handbook. After describing how the environment can be accounted for in purely physical terms, in combined physical/monetary (hybrid) terms and in monetary terms within the existing SNA, it is appropriate for the handbook to conclude by considering how to account for the environment in purely monetary terms by modifying the existing SNA.

4 *Comparing accounts in physical and monetary terms*

1.119. The interaction between the environment and the economy manifests itself in physical terms. The materials and energy extracted from the environment are physical entities and the changes induced in the environment as a result of economic activity (depletion and degradation) are physical in nature. For this reason, the most direct measures of the interaction between the environment and the economy are physical. If a country's goal in undertaking environmental accounting is to better understand the details of this interaction, it will likely be well served by accounts in physical terms.

1.120. Despite their strengths, it is important to note that physical accounts suffer from important limitations. One such limitation is the general lack of relative weights that could allow aggregation of measures expressed in physical terms. Only in a few instances are such weights available.[4] The majority of physical measures cannot be meaningfully aggregated at this time, making it challenging to interpret the large amount of information that can be produced from physical accounts.

1.121. Purely physical accounts also suffer from a lack of economic context. Knowing the residual production of a given industry is certainly valuable information, but many would argue that it is more valuable if it can be compared against the industry's economic performance. For example, residual emissions

[4] A well known example is the use of global warming potentials to express emissions of greenhouse gases in terms of carbon dioxide equivalent units.

could be compared against the value of economic output to determine the residuals emitted per unit of production. This would allow meaningful inter-industry comparisons and would enrich the use of the physical measures in an economic policy context. The purpose of hybrid accounts is exactly to provide this kind of economic context for physical measures. While improving upon purely physical accounts from an economic perspective, hybrid accounts do not solve the problem of aggregating physical measures.[5] For this, one must turn to accounts expressed in monetary terms.

1.122. The use of relative prices to weight disparate measures in monetary accounts allows the compilation of aggregate measures. By reducing the number of variables one is required to consider, this can greatly simplify the interpretation of the information contained in environmental accounts. It also offers the advantage of direct comparison of information in environmental accounts with that from economic accounts. For many users the ability to compare, say, the rate of growth of GDP with the rate of growth of environmental degradation is an attractive feature of accounts in monetary terms.

1.123. While attractive, the monetary approach is not without limitations. In particular, it is empirically and conceptually challenging to implement. The techniques available for doing so remain in their early stages of development. They have been created mainly for use in micro-level, cost-benefit studies and their application in a national accounting context is in its infancy. A great deal of data may be required to implement some of the approaches and these data may not exist completely in many countries. In addition, the techniques can be controversial. Even among those researchers who accept that valuation is a valid approach, there is debate over the most appropriate techniques to use. Some argue that valuation of the environment is to be avoided in any case, either on ethical grounds or for reasons of prudence. The latter argument goes that given our inadequate understanding of the environment we risk sending the wrong signals by unintentionally omitting key environmental inputs in valuations.

5 Integration in the SEEA framework

1.124. The SEEA is presented as an integrated system of environmental accounts. The interpretation of the term "integrated" is a matter of debate however. Some commentators argue that the only truly integrated accounts of the SEEA are those that are expressed uniquely in monetary terms. They argue that true integration comes only when all measures in the accounts are harmonised through the application of the same set of relative prices. Only then can each and every measure in the system be compared meaningfully against the others.

1.125. Others take the view that it is sufficient to consider the accounts integrated if they share common concepts, methods, definitions and classifications; it is not necessary, according to this view, that they share common units of measure in addition to these other characteristics. Advocates of this view argue that meaningful comparison of measures from various accounts is possible so long as the measures "line up" with one another. There is no need that the measures actually be combinable into monetary aggregates. In support of this position, they note that the SNA itself includes non-monetary data in some instances (for example, on employment) and that business accounts can include both physical and monetary measures.

1.126. It is not the place of this handbook to take sides on issues that are still the matter of international debate. For this reason, the SEEA does not advocate one perspective on integration over the other. The system is presented in the remainder of the handbook in as neutral a fashion as possible so that users may make their own minds up about the meaning of "integrated" in the SEEA context.

[5] Another potential disadvantage of hybrid accounts may be noted. This is the possibility that these accounts may lead to the mistaken impression that a resource's or residual's relative importance in, or impact on the environment is implied by its economic importance in a production process.

6 *Limitations of present work*

Time and space

1.127. The development of environmental accounts is closely linked to the concepts embodied in the SNA. As such, environmental accounts are most suitably compiled for national areas on an annual basis. Environmental issues which are seasonal (such as shortages of water in the summer) or local (such as a reduction in air quality in a particular location) do not lend themselves easily to analysis in the accounts. Although quarterly and regional accounts are feasible in theory, in practice few countries have the data from which to compile such accounts.

1.128. Even where an issue is persistent throughout the year, some environmental effects are highly ephemeral, for example an emission of biological oxygen demand, while others are very long-lived, such as the generation of certain radio-nucleotides. The result is that a year-based account may give the wrong emphasis to the former and ignore the latter except in the year of generation.

1.129. Limited attention is given to some time and space issues in the handbook. The considerations of importing and exporting demands on the environment are discussed in Chapter 4 and the question of accumulating "environmental debt" in Chapter 10. These are both areas where further consideration and elaboration will be fruitful.

Accuracy

1.130. The techniques described in this handbook have been carefully conceived and in many cases carefully worked out. Nevertheless it is important to be aware that there are still many uncertainties concerning the basic data. Some of these may be scientific in origin. The critical threshold of some residuals may be as yet unknown or even the fact that some residual is critical may be unsuspected. The exact shape of the relationship between cause and effect may be as yet measured only over a relatively narrow range of observations and so projections about what may happen outside that range may be in error. Some uncertainties may be statistical. There is less experience in building at least some areas of environmental data bases than, say, some areas of economic or social statistics. As techniques of data collection improve the data base is likely to improve and reveal weaknesses in present data sources which, even if suspected, may not be quantified.

1.131. All this leads up to the proposition that any analysis based on the techniques described here should pay attention to the fact that in many cases giving a picture of the likely direction and possible magnitude of the environmental impact of some phenomenon may be as much as the data will bear. Those compiling accounts are urged to emphasise the quality (or lack of it) in their estimates as honestly and openly as possible for the benefit of those using the results. It is however worth noting that different types of analyses require different levels of accuracy. The fact that a high degree of uncertainty about the results remain may not invalidate some general conclusions being drawn.

Non-environmental changes

1.132. The SEEA accounts link the economy and the environment. Most of the focus is naturally on the technical interaction between the two realms. However, there are other factors which can have major consequences for the demand placed on the environment by the economy. Over time, populations increase and so does the general level of prosperity. Both factors will increase demands on environmental functions.

On the other hand, technological developments may come to the rescue by finding more environmentally efficient ways of conducting economic activities.

Coverage

1.133. The system of accounts described in this handbook makes links to economic activities as measured by economic statistics. Despite the efforts at bringing the considerations of physical environmental statistics and economic statistics closer together, it is still difficult to incorporate all environmental concerns into an accounting framework. Some issues relevant to sustainability may not be easily measured in this context. For example, while the SEEA is well suited to measuring the flows of residuals associated with economic activities, it is less well suited to studying the impact of these flows on the health of humans and non-human species.

Catastrophes

1.134. Another issue not well treated is that of catastrophes. Some of these such as flooding and erosion, previously seen as natural events, are now more often seen as the consequences of environmentally careless behaviour in the past. Some which are not environmental in origin such as the wreck of an oil tanker can have serious environmental consequences. Here too there may be economic actions with environmental consequences as well as further economic consequences. In future it may be desirable to try to bring some of these into the field of environmental accounting also.

7 An assessment of the current position

1.135. As has already been made clear, the handbook very much represents work in progress. Development work continues in a number of areas and the handbook itself is likely to need revising again in the not too distant future. Three instances can be cited where present work may make the relevant sections here quickly out of date.

1.136. Very few countries have developed a broad range of accounts, and no country has yet developed the full set of accounts. Applications and links between elements of the accounts have therefore not yet been fully explored.

1.137. Environmental issues change as scientific knowledge about harmful substances and practices improves. The classifications, weights and analyses will have to remain open to review in the light of better knowledge. Further, our understanding of the extent to which emissions are damaging will evolve as we gain more sophisticated information about the susceptibility of areas to the release of emissions.

1.138. Some of the techniques, in particular those used to attribute values to environmental goods and services, have not been widely used or accepted and will be subject to further development.

Chapter 2 The accounting structure of the SEEA

A Introduction

1 Objectives of the chapter

2.1. This handbook describes a set of accounts covering environmental and economic phenomena. It is important to have an overview of the system as a whole in order to see where and how consistency between different accounts is ensured. If in the course of implementing a particular account, the conventions suggested in this handbook are modified, it is helpful to understand what the consequences would be for other aspects of accounts, even if these are not to be implemented.

2.2. The purpose of this chapter is to provide an overview of the accounting aspects running through the following chapters in order to make clear how the various accounts conceptually form part of an integrated single system. It concentrates solely on the accounting aspects. Issues of classification, implementation, data availability and practical experience are in the subsequent chapters which elaborate one or more accounts.

2.3. Some readers may wish to acquire this overview of the whole system at the outset. Others may wish to explore particular aspects of the system first and return to this chapter later to place their investigations in a wider context. Yet others may simply wish to use this chapter as a quick cross-reference to show where detailed accounting aspects are described. It is intended that the chapter should serve each of these purposes for different readers or, indeed, the same reader at different times.

2 The need for an accounting approach

2.4. Economic accounts and environmental statistics have each developed as an independent area subject to their own conventions and classifications. Economic accounting is done almost entirely in monetary terms and although the economy operates within the natural environment, the inputs from the environment have until recently been seen to be "free". As a result, the impact of the environment on the economy has not been readily identifiable within the economic accounts. Sets of environmental data are often compiled with specific regulatory or administrative purposes in mind and, therefore, use a variety of concepts, methods, classifications and units of measurement according to the need they serve. For this reason, disparate sets of environmental statistics are generally not integrated with one another, or with sets of data relating to the economy or society.

2.5. An accounting approach is designed to bring a more systematic discipline to the organisation of environmental statistics. It does this by:

encouraging the adoption of standard classifications in environmental statistics;

encouraging the development of comprehensive and consistent data sets over time; and facilitating international comparisons.

2.6. As with the main national accounts, the SEEA accounts provide a score-keeping function from which key indicators can be derived and a management function in that they can be used in the analysis of policy options. The accounts provide a sound basis for the calculation of measures which may already be included in sets of sustainable development indicators, but they may also be used to develop new indicators, such as environmentally-adjusted macro-aggregates which would not otherwise be available.

2.7. As with most information systems, the potential uses of the environmental accounts are greatly enhanced once a consistent and coherent time series has been established. This would require that the accounts be seen as part of the wider national accounts and that they be produced on a routine basis.

3 Environmental accounts and the SNA

2.8. The need for an internationally agreed accounting system for monetary flows in the economy has long been accepted and the SNA has been widely used in most countries of the world for many years. Figures such as gross domestic product (GDP) and national income derive from the SNA. The fact that they are derived from an internationally recognised standard helps to ensure not only their comparability across countries but also their credibility. One goal of this handbook is to start to establish the same international acceptance of environmental accounting.

2.9. In principle it would be possible to establish a set of environmental accounts which was quite independent of the SNA. However, from the outset consistency with the SNA has been a prime motivation behind the development of the SEEA. For environmental policy to be most effective, it must be articulated and implemented within an economic context and those making economic policy are familiar with the framework of the SNA. Integrating economic and environmental accounts thus seems the preferred manner in which to ensure that economic and environmental policies are also integrated.

SNA satellite accounts

2.10. The guidelines in the SNA originated fifty years ago and have been revised several times since, most recently in 1993. One aspect of the latest revision was the greater attention paid to capital stocks and flows and in particular to the place of natural resources within the set of economic assets. This was done to facilitate the linkage to environmental accounting but it was also felt that it was not appropriate at that time to go further in incorporating environmental accounting in the central system because work in the area was still maturing. Although much progress has been made since then, major new developments are still likely and so the interface between the economy and the environment is still shown in terms of a “satellite” account.

2.11. It has become common to refer to internal and external satellite accounts. An internal satellite account is simply a rearrangement of the existing SNA transactions. No new flows are added but those which are there may be presented and aggregated differently and in some case separated out from existing records by a process of “deconsolidation”. An external satellite account, on the other hand, extends the scope of the system by including stocks, flows and transactions which are not covered by the existing SNA. (See also Annex 9).

A satellite account for the environment

2.12. The SEEA should be seen as a satellite account to the SNA with features of both internal and external satellite accounts. The full system comprises four categories of accounts, as outlined briefly below (see Chapter 1 for a fuller discussion).

2.13. The first category of accounts in the SEEA considers purely physical data relating to flows of materials and energy and marshals them as far as possible according to the supply and use and input-output frameworks of the SNA. The accounts in this category also show how flow data in physical and monetary terms can be combined to produce so-called "hybrid" flow accounts. Emissions accounts for greenhouse gases are an example of the type included in this category. The accounts of this category are outlined in Chapters 3 and 4 of the handbook.

2.14. The second category of accounts takes those elements of the existing SNA which are relevant to the good management of the environment and shows how the environment-related transactions can be made more explicit. For this it is necessary to go beyond the supply and use tables and look at the whole system of the SNA flow accounts including income distribution and redistribution. Environmental protection and resource management is discussed in Chapter 5. The place of environmental taxes and permits to use environmental resources is discussed in Chapter 6.

2.15. The third category of accounts in the SEEA comprises accounts for environmental assets measured in physical and monetary terms. Timber stock accounts showing opening and closing timber balances and the related changes over the course of an accounting period are an example. These accounts, including how natural resources contribute to income and the measure of wealth in the national balance sheet, are described in Chapter 7.

2.16. The final category of SEEA accounts considers how the existing SNA might be adjusted to account for the impact of the economy on the environment. Three sorts of adjustments are considered; those relating to depletion, those concerning so-called defensive expenditures and those relating to degradation. Chapters 9 and 10 cover this material. It is more provisional than the rest of the system and has, for reasons explained in Chapter 10, less widespread acceptance.

Implications for statistical systems

2.17. In order to investigate the economy/environment interface in quantifiable terms a degree of integration is necessary between the environmental and economic data sets available to a statistical office. In order to represent environmental data in a context derived from economic data, a number of principles, concepts and classifications used by the SNA require modification, elaboration or extension. These broadly concern:

the types and descriptions of activities that are treated as part of production or consumption;

the classifications used to describe production and consumption;

the type and descriptions of assets to be included within the accounts;

the methods used to value stocks of environmental assets and flows of environmental goods and services;

specification of whether, and if so how, changes in the value of assets affect the measurement of income generated during production.

2.18. Establishing these integrating mechanisms is important and is described in each of the relevant following chapters and in the annexes to the handbook. Specific examples drawing on work done are portrayed in various chapters as appropriate but especially in Chapter 8 where the implications for each of five main environmental assets (minerals and energy, water, forests, fish and land) are discussed.

The analytical potential of the system

2.19. Devising an accounting structure which relates various environmental and economic phenomena in a coherent and consistent manner is not in itself a sufficient justification for the SEEA. To merit a place in the work programme of a statistical office, the system has also to lend itself to the development of indicators calling on a wide range of data which can provide insight and guidance to policy makers in both the economic and environmental areas. This is the subject matter of Chapter 11.

B Physical flow accounts

2.20. The SEEA sets out to expand the view of the economy by considering the interaction between it and the environment. The SNA considers both value at a point in time, stocks, and changes in these values over time, flows. The SEEA is also concerned with stocks and flows but considers these measured in physical terms as well as with values placed on them. The starting point for developing the system is to examine flows within and between the economic and environmental spheres in physical terms.

1 The economy/environment interface

2.21. It is not possible to establish either a simple physical boundary between the economy and the environment or a simple monetary one. It is necessary to look at the sort of flows of interest within the economy, the flows backwards and forwards between the economy and the environment, and flows within the environment.

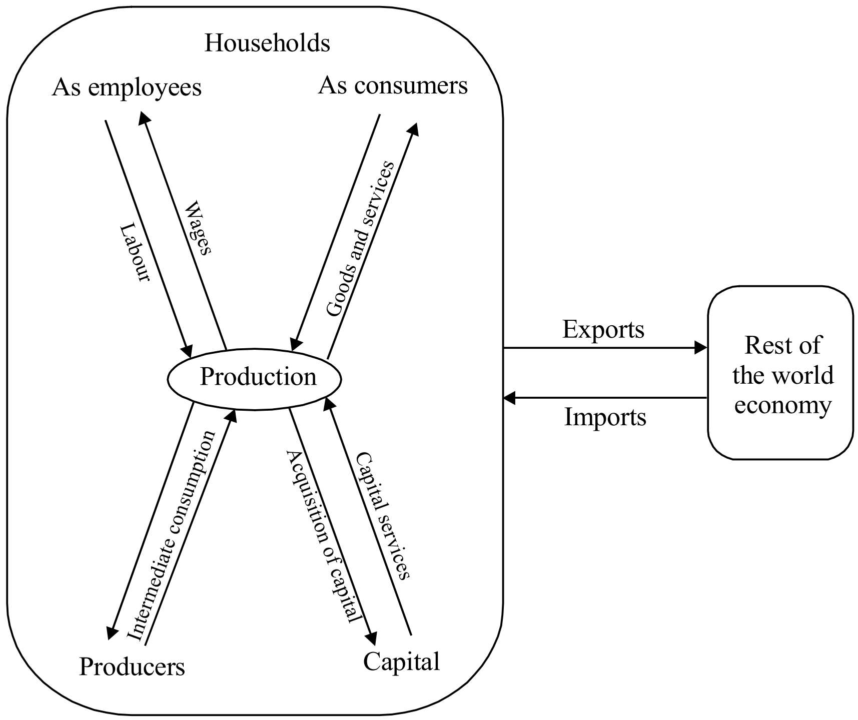
Flows within the economy

2.22. The economy can be identified with the collection of activities that use materials, land, energy or human skills to produce goods and services that can be exchanged for money (or for other commodities) including the use of these commodities by their final purchaser. This is sometimes portrayed as "the circular flow of income" whereby income is generated by individuals providing labour to enterprises, receiving compensation for their employment in return, and then spending their income to purchase the goods and services which their labour has helped to create. These flows are shown in the upper left hand part of Figure 2.1.

2.23. Like many paradigms, this is somewhat over-simplistic. Some of the goods and services made in the economy are used to make other goods and services, for example cloth being turned into clothes. These are described as intermediate consumption. Some are acquired as capital goods, used to make other goods and services over a long period, for example weaving machines. These flows are shown in the lower left hand part of Figure 2.1.

2.24. No economy actually operates in isolation from the rest of the world. Other economies also supply products, as imports, and absorb some national production in the form of exports. As well as the entirety of the national economy, shown in the large enclosure on the left of Figure 2.1, an enclosure for the rest of the world economies is also included on the right hand side of the figure with the flows of imports and exports linking the two enclosures.

Figure 2.1 A picture of flows within the economy and with other economies



Flows between the economy and the environment

2.25. The flows of products, whose measurement forms the basis of the SNA, are also measured within the SEEA, though in the SEEA they are recorded in physical terms as well as in monetary ones. The essence of the SEEA, though, is to measure other flows which relate to the interaction of the economy and the environment and to examine how these flows are connected with the flows of products.

2.26. The economy draws inputs from the environment. These consist of natural resources such as mineral deposits, fish and timber and also the ecosystem inputs which are necessary for life, particularly water and oxygen to breathe and permit combustion. The economy also uses the environment as a sink for unwanted waste material using soil, land, water and air as depositories for solid. liquid and gaseous waste. In the SEEA all these forms of waste materials are describe collectively as "residuals". (This word is not ideal but no alternative has been found to have better acceptance.) Thus Figure 2.1 can be elaborated to include flows of natural resources and ecosystem inputs from the environment to the economy and flows of residuals in the opposite direction.

2.27. Just as there is an interaction between the national economy and the economies of the rest of the world, so there is an interaction between the national economy and the environment of the rest of the world. This includes not only the environment of other countries but the open seas, upper atmosphere and so on often referred to as the global commons. Such flows take place when units belonging to the national economy operate abroad. National airlines flying to another country consume oxygen from and discharge residuals to the rest of the world environment. Tourists consume ecosystem inputs and leave residuals behind. Flows between the rest of the world economy and the national environment also take place and need to be registered.

Flows within the environment

2.28. The all-enveloping nature of the environment means that there are flows between that part we may mark out as being the "national" part and that for the rest of the world also. Flows down water courses and air currents are two obvious means of transporting residuals from one area to another. For completeness, therefore, these flows within the environment should also be recorded.

2.29. Assembling all these elements, Figure 2.1 can be expanded to Figure 2.2, a figure which also appears in Chapter 3.

2.30. There are, of course, flows within the economies of the rest of the world and between these and the environment of the rest of the world but, within this handbook, we assume that it is accounts on a national basis which are of primary interest and so there is no provision for recording these flows within the rest of the world.

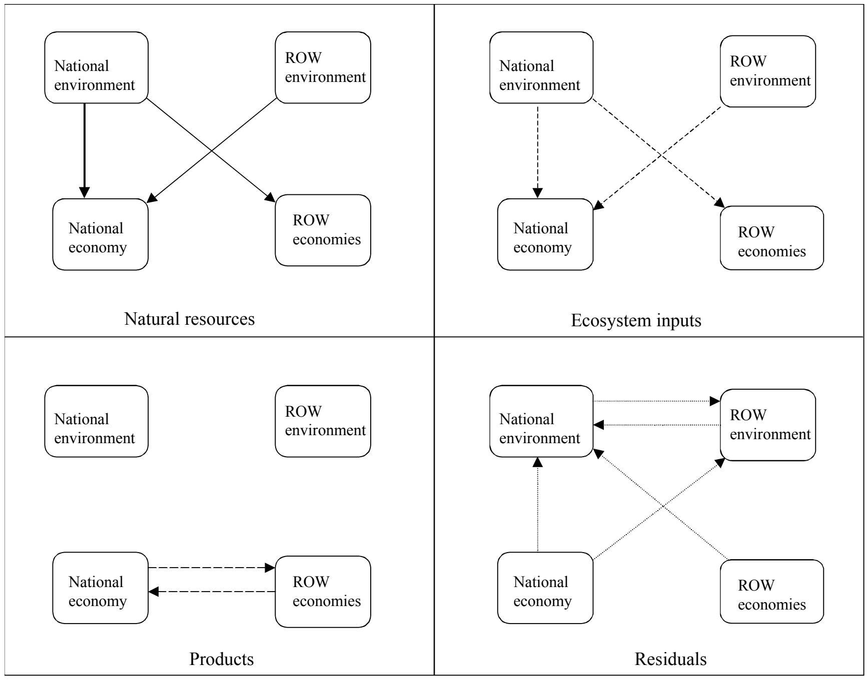
2 The types of flows of interest

2.31. Four different types of flows are distinguished in the SEEA. ***Products*** are goods and services produced within the economic sphere and used within it, including flows of goods and services between the national economy and the rest of the world. ***Natural resources*** cover mineral and energy resources, water and biological resources. ***Ecosystem inputs*** cover the water and other natural inputs (e.g., nutrients, carbon dioxide) required by plants and animals for growth, and the oxygen necessary for combustion. ***Residuals*** are the incidental and undesired outputs from the economy which generally have no economic value and may be recycled, stored within the economy or (more usually at present) discharged into the environment. "Residuals" is the single word used to cover solid, liquid and gaseous wastes. Physical flow accounts consist of merging accounts for products, natural resources, ecosystem inputs and residuals, each account being expressed in terms of supply to the economy and use by the economy.

2.32. Although the main flows of interest are between the economy and the environment, we also need to consider whether it is the environment in and above the national territory which receives residuals and whether it is the national economy which generates them. Thus it is desirable to consider the national economy and the national environment and also the economy and the environment for the rest of the world.

2.33. Flows from the national environment to the national economy consist of resources and ecosystem inputs. The national economy emits residuals to the national environment and to the environment of the rest of the world. In addition the environment receives residuals from the rest of the world economy and the rest of the world environment. Flows between the two environments are residuals transported by wind and water; residuals going from one economy to the other environment relates to economic activity taking place abroad, for example international travel. In addition products flow between the national economy and the economy of the rest of the world as imports and exports.

Figure 2.2 A picture of the flows between the economy and the environment



2.34. All physical flows are expressed in physical units. These may be particular to the substance concerned or may, for example, be a more general measure such as tonnes if aggregation is across a disparate set of substances. Tonnes are assumed to be the unit of choice in the example here as they are in many cases.

3 Flow accounts for products

2.35. Products are supplied by the economy and used by it also. An identity which is central to the SEEA (and in fact to the SNA also) is that when flows of products are measured *ex post*, total supply and total demand (or use) must exactly balance. New goods and services are supplied either by production in the current period from resident producers or come from producers in the rest of the world as imports. Thus:

Total supply = domestic production + imports

These goods and services are either:

(i) used by industries in the course of making other goods and services (intermediate consumption);

(ii) bought by households to satisfy their wants (household final consumption);

(iii) bought by government to satisfy the needs of individual households or of the community at large collectively (government final consumption);

(iv) bought by industries for use in making other goods and services in future periods (capital formation); or

(v) they leave the economy to be used in another (exports).

Thus:

Total use (demand) = intermediate consumption + household final consumption + government final consumption + capital formation + exports

2.36. In fact some demand is met not from current production but by using up items which exist in inventories. Traditionally, changes in inventories appear in the total demand equation, appearing as a positive entry when items go into stocks and as a negative entry when they are withdrawn. We thus separate capital formation into two parts, fixed capital formation which relates to the acquisition of capital goods to be used repeatedly in future production (machinery and buildings, for example) and changes in inventories. Thus the composite equation reads

Domestic production + imports = Intermediate consumption + household final consumption + government final consumption + fixed capital formation + changes in inventories + exports.

2.37. This identity must hold for any product or group of products as long as they are measured in units which are consistent for every component. Thus although the identity above is most familiar to national accountants when expressed in monetary terms, it must also hold when expressed in a common physical unit. Table 2.1 summarises the information for all activities in SEEAland. Producers supply output and demand intermediate consumption; capital accumulation and consumption both place demand on products; imports are supplied by and exports demanded by the rest of the world.

Table 2.1 Supply and use table for products

Million tonnes

	Production	Final consumption	Capital formation	Rest of the world	Total for the economy
Supply	551			150	701
Use	442	39	119	101	701

Source: SEEAland data set (abridged version of tables 3.6 and 3.7).

4 Flow accounts for natural resources

2.38. Natural resources are demanded by the economy but are supplied only by the environment. They may be demanded by producers as intermediate consumption or for final consumption (fuel wood for example). It is assumed that even if natural resources are exported in a natural state, they have passed through the economy (for example, transported from the site of origin to a port) and thus are classified as products. An exception is made when natural resources are extracted by non-resident units, for example fish caught by foreign vessels. Capital goods also may contain natural resources but it is unlikely that they will be in a natural, unprocessed state except for inventories. For simplicity, this example assumes zero inventories. A simplified natural resource account is given in Table 2.2.

Table 2.2 Supply and use table for natural resources

Million tonnes

	Production	Final consumption	Capital formation	Rest of the world	Total for the economy	Total for the environment
Supply						264
Use	261	2		1	264	

Source: SEEAland data set (abridged version of Table 3.4).

5 Flow accounts for ecosystem inputs

2.39. The accounts for ecosystem inputs are similar to those for natural resources but supply by the rest of the world and use by the rest of the world occurs when units are operating in another territory, for example national aircraft flying in foreign territory. A simplified supply and use table for ecosystem inputs is given in Table 2.3.

Table 2.3 Supply and use table for ecosystem inputs

Million tonnes

	Production	Final consumption	Capital formation	Rest of the world	Total for the economy	Total for the environment
Supply						147
Use	121	24		2	147	

Source: SEEAland data set (abridged version of Table 3.5).

6 Flow accounts for residuals

2.40. Most residuals are a flow from the economy to the environment. They result from both production and consumption, including the disposal of capital and other durable items acquired in earlier periods. Table 2.4 presents a summary table, also drawing on the example in Chapter 3. Residuals may be gaseous, liquid or solid and may be released to the air, water or land (including landfill sites). Scrap which is sold for reprocessing is not classified as a residual but as a product. However some residuals, such as paper and glass products, are recycled without payment to the disposer. This amount is shown as a demand by producers for residuals (7 million tonnes in this example). The amount of waste put into landfill site is shown as a demand by capital (land) for residuals (26 million tonnes here).

2.41. In addition, there are residuals which are transferred out of the domestic environment. Part relates to emissions from transport equipment operating outside the domestic environment. These are residuals flowing directly from the national economy to another environment or from another economy to the national environment. The greater part of the flows of residuals between the domestic environment and the environment of the rest of the world, though, are carried by environmental media and thus show as transfers between the domestic environment and another environment or vice versa. The economy generates 415 million tonnes of residuals but only 42 million tonnes is either absorbed by the economy or exported. There is thus a net flow of 373 million tonnes from the economy to the environment.

Table 2.4 Supply and use table for residuals

Million tonnes

	Production	Final consumption	Capital formation	Rest of the world	Total for the economy	Total for the environment
Supply	280	48	73	14	415	
Use	7		26	9	42	373

Source: SEEAland data set (abridged version of tables 3.8 and 3.9).

7 Summary physical flow accounts

2.42. The four tables above can be assembled into a single table as in Table 2.5. Because matter can be neither created nor destroyed, it is possible to calculate a balancing item for each column which shows the balance of accumulation of material in the economic sphere.

2.43. For production there is no net accumulation other than what producers acquire as capital. The accumulation by consumers relates to products bought this period but not yet used and discarded, that is consumer durables. Together these two items account for a net accumulation of material in the economy of 89 million tonnes. Of this, 51 million tonnes have been imported from abroad leaving a net impact of 38 million tonnes drawn into the national economy from the environment.

2.44. Other forms of physical accounts are also possible. Two of these, material flows analysis (MFA) and physical input-output tables (PIOT) are also discussed in Chapter 3. In addition, Chapter 3 discusses alternative conventions for the measurement of residuals both in respect of biological metabolism and the treatment of waste going to landfill sites.

Table 2.5 Summary physical flow accounts

Million tonnes

	Production	Final consumption	Capital formation	Rest of the world	Total for the economy	Total for the environment
Supply						
Products	551			150	701	
Natural resources						264
Ecosystem inputs						147
Residuals	280	48	73	14	415	
Net accumulation	0	17	72	-51	38	-38
Total supply	**831**	**65**	**145**	**113**	**1154**	**373**
Use						
Products	442	39	119	101	701	
Natural resources	261	2		1	264	
Ecosystem inputs	121	24		2	147	
Residuals	7		26	9	42	373
Total use	**831**	**65**	**145**	**113**	**1154**	**373**

Source: SEEAland data set (abridged version of Table 3.13).

8 Determining suitable classifications

2.45. While the classifications of industries and expenditures used within the SNA cater for a wide range of interests, the focus of the SEEA is on those events and activities which link the environment and the economy. This means that, for example, a finer breakdown may be required for industries which have a significant effect on the environment, and that expenditures on environmental protection need to be classified in terms of their effect on different environmental assets (such as air, water or soil). One topic discussed in detail in Chapter 3 is the appropriate headings from standard classifications for industries and products for use in environmental accounting. The functional classifications of consumption are also covered and new classifications for natural resources, ecosystem inputs and residuals are introduced. More details on these are given in the annexes to the handbook.

9 Physical flow accounts, national borders and accounting periods

2.46. Physical flow accounts describe amongst other things how one country interacts physically with the rest of the world. These physical flows represent the direct impacts of the economy of one country on the environmental state of another country. The impacts are caused by three different types of cross-border flows, (i) material flows in connection with international trade, that is the import and export of products or residuals and the supply of natural resources and ecosystem inputs to units resident in another country, (ii) economic activity of one country which takes place outside its own environment, in particular international transport and tourism, and (iii) cross-border transfers of residuals. Such transfers may be borne by environmental media such as (polluted) air and surface water but may also result from pollution generated by international transport. It should be noted that international transport may be carried out by residents as well as by non-residents.

2.47. Cross-border residual transfers are important for determining the net total accumulation of residuals in the environment of one country and are particularly relevant for the analysis of environmental degradation problems which are of a non-global nature. The transfers have important implications for the valuation of environmental damages covered in Chapter 10, since the environmental damages generated by the national economy may differ from damages experienced by the domestic environment.

2.48. Besides these direct physical relationships, the physical flow accounts can be used to analyse the indirect impact of one economy on the environment of other countries. Examples of indirect effects are the resources used by or residuals arising from the production of goods and services which are imported to the domestic economy.

2.49. There can sometimes be a long time lag between an economic activity and the residual emissions reported in the flow accounts by an economic sector. For instance metal mines can give rise to contamination of fresh water long after the mine is closed. This discontinuity between the time of the economic output and the emission of the residual is also found in landfill sites and most notoriously in nuclear waste production. In these cases, accumulation of residual may have to be accounted for as a liability that will generate negative effects in future periods.

C Introducing matrix style accounts

1 Physical supply and use tables

2.50. A device used throughout this handbook is a matrix form of presentation for various accounts. This starts with a supply and use table in Chapter 3 and is elaborated through succeeding chapters. By reading either across the rows or down the columns, one can see the information which would be entered in a double entry system by being recorded twice. The matrix form of presentation thus ensures that the consistency of the accounts is preserved while presenting all the material in a very compact form. In practice, however, when a significant degree of detail is required, the matrix format becomes very large and therefore clumsy to display concisely, especially since it contains a large number of empty cells. For practical presentation of results an alternative format may be used, especially when information is required in the form of a time series.

2.51. Table 2.6 shows a simple matrix for the supply and use table for products in physical terms. The top row shows how products are used either in the formation of other products (that is as intermediate consumption), for consumption, capital formation, or exports. The first column shows how the supply of products is made up from domestic production or imports.

2.52. The interest in portraying this information in matrix format is that the total across the first row is equal to the total down the first column (701 million tonnes). As the SEEA is elaborated, more rows and columns will be added to the matrix and more cell entries until there is a balance for all the rows and column in the matrix.

Table 2.6 A simple supply and use table for products in physical terms

Million tonnes

	Intermediate consumption 442	Final consumption 39	Capital formation 119	Exports 101
Production 551				
Imports 150				

Source: SEEAland data set.

2.53. We can elaborate this table immediately by adding rows and columns for natural resources, ecosystem inputs and residuals. This is shown in Table 2.7. The first step is to annotate the columns shown in Table 2.6. Then, by expanding the number of rows in the table to match the columns, we can show where residuals arise. We add new rows for natural resources and ecosystem inputs but since there are no flows to these items, we can save space by not including columns for these.

2.54. In order to ensure that the row totals and the column totals for each row and column pair match, an extra column is needed showing the material balance or net accumulation in the economy (if positive) or the environment (if negative). In a more extended table, such as that shown in Table 3.11, information on the rest of the world (ROW) can specify whether the flows concern the rest of the world economy or the rest of the world environment and determine a material balance for each. However, both may be either positive or negative depending on the predominant flow between the national and foreign economy or environment.

Table 2.7 A simple supply and use table for all physical flows

Million tonnes

	Products	Industries	Consumption	Capital	ROW	Residuals	Material balance
Products		Intermediate consumption 442	Consumption 39	Capital formation 119	Exports 101		
Industries	Production 551					From industry 280	
Consumption						From households 48	17
Capital						From capital formation 73	72
ROW	Imports 150					Residuals generated by non-residents 6	-46
Natural resources		To industry 261	To households 2		To ROW 1		-264
Ecosystem inputs		To industry 121	To households 24		To ROW 2		-147
Residuals		To industry 7		Waste to landfill sites 26	To ROW 6		368

Source: SEEAland data set (abridged version of Table 3.11).

2 *Monetary supply and use tables*

2.55. The structure of the supply and use tables in monetary terms as described in the SNA is essentially similar to that shown in Table 2.6. It relates to products only since none of natural resources, ecosystem inputs or residuals carries monetary values. It is thus a moot point whether they appear with zero value or do not appear at all.

2.56. The standard SNA supply and use matrix can be adapted for use in environmental accounting by using the same classifications as described for the physical ones, depending on the central product classification (CPC) and the international standard industrial classification (ISIC) in both cases. Classifications of government and household consumption are also compatible, with both systems drawing on the classification of functions of government (COFOG) and the classification of individual consumption by purpose (COICOP). Despite these familiarities, however, there are a number of important differences to note.

Value added

2.57. The first difference is that the monetary accounts resolve the supply/use identity by means of a term entered in the supply part of the table described as value added. This is the excess of the returns a producer receives over the costs he incurs in terms of inputs of products (intermediate consumption). From this amount he pays his labour force and retains an element of operating surplus to cover his use of all sorts of capital, produced capital such as machines and buildings, financial capital such as bank loans and shareholders equity and, in fact, the natural resources which he uses up in the course of production. The attribution of value added to these different sorts of capital is discussed below and at length in Chapter 7. It is sufficient for the moment to note that value added forms the balancing item to the supply and use identity in monetary terms and is introduced to explain the excess of the value of outputs over the cost of inputs whereas in physical terms, the generation of residuals may be thought to form the balancing item, explaining the shortfall of outputs compared to inputs.

Services

2.58. For industrialised economies, the monetary tables are dominated by the role of services; in physical terms, although services absorb products, in general they do not supply any because their output is weightless. (Some exceptions exist, such as restaurants supplying food and drink and computer software which is delivered on physical media but the weight of these items is very small compared to the weight of goods in the economy). Government consumption also consists of services so it is less conspicuous in physical tables than in monetary ones.

2.59. This comparison carries over to the question of “price per kilo”. Many of the items which are most important in physical flows are building materials which tend to have rather low unit prices whereas electronic equipment is relatively low in volume terms but high in value terms because it has a much higher value to weight ratio. Thus it is the case that whereas in physical tables it is the weight of materials which determines their share of the total, in monetary tables it is a combination of the volume and the unit price. The price differential conveys information about relative scarcity. The scarcer the product, relative to the demand for it, the higher the price. Anything which is so abundant as not to be scarce has no monetary value.

Prices

2.60. It is appealing to think that a set of monetary supply and use tables is simply a physical set with each row multiplied by the appropriate unit price but statistical life is seldom so simple. The same good sold in different outlets may often carry a different price, a discount outlet being noticeably cheaper than a fashionable department store. Here the reactions of the price statistician and the national accountant are different. For the price statistician, if the good is physically identical, then the difference between the amounts paid in the discount store and the department store is simply a price difference. The national accountant, however, disagrees. The department store provides a higher level of service than the discount store and thus the higher price is really due to the fact that it includes the costs of a more congenial and convenient location, staff trained to provide informed information on similar brands and so on. Goods in different outlets and at different prices are, to the national accountant, different products even if their physical characteristics are identical because they come "packaged" with different amounts of services.

2.61. The difference between the value of a good as it leaves the factory and the price the consumer pays is due to two elements. The first of these is the "service margin" just described. The second is the level of tax the consumer must pay at the time of purchase. This may be a form of VAT, for example, or an excise tax payable on such products as cigarettes, alcoholic drink or petrol. The value of the good as it leaves the factory is described as being "at basic prices"; the value when the margins and taxes have been added as "at market prices".

2.62. The value added across all production activities constitutes a measure of gross domestic product (GDP) at basic prices. For most purposes, however, GDP is usually quoted at market prices. Following the discussion above on the difference between basic prices and market prices, this means that it is necessary to add to GDP at basic prices a measure of the taxes paid by purchasers at the point of purchase. The "service margins" which form part of the difference between basic prices and market prices on particular goods are grouped together to form an industrial activity of their own (wholesale and retail trade) and so are already included in GDP at basic prices.

2.63. The question then arises about the price valuation used to achieve a balance between the supply and use tables. In fact, a balance at either price can be achieved and generally both types of balances will be made. A balance at market prices is usually the easiest to achieve. Items on the use side of the account are most naturally collected in market prices since this is the price the consumer knows. Items on the supply side can be converted to market prices by adding the appropriate level of service margin and tax for each type of product.

2.64. The alternative is to leave the supply side in basic prices and to reduce the use side to the same by creating separate estimates for service margins and taxes. This is often complicated. Not only do different outlets carry different service margins, different customers may pay different tax rates, for example businesses may be able to reclaim the VAT on some or all of their purchases; households seldom can.

2.65. Nor is the situation any easier with services. One kilowatt-hour of electricity is identical to any other but the price charged to different classes of customer is quite different and may depend not only on whether they are businesses or private people but on the level of total usage of electricity or on the time of year. Similar problems of determining prices appear for many services, telecommunications and airline tickets being obvious examples.

2.66. The environmental statistician does not have to know the exact methodology used to circumvent these measurement problems but it is important to have a broad grasp of the difference between basic prices and market prices and to know which applies to the monetary data being used. Monetary flows at basic prices have a more homogeneous unit price and are thus appropriate when used in conjunction with physical flows.

On the other hand, they may not always exist at the detail needed or the frequency required since for many sorts of economic analysis, data at a higher level of aggregation or at market prices may be adequate.

The SNA supply and use table

2.67. Table 2.8 shows the simple monetary supply and use table which corresponds to Table 2.6. Figures in million tonnes are replaced by data in billion currency units. Two new items are added to the first column, trade and transport margins and taxes less subsidies on products. In total, trade and transport margins are shown as zero but the additions to the valuations of individual products is significant when disaggregation is effected. The total of the first column is 1 719.4 billion currency units. This represents total supply at market prices and is also the total of the first row.

2.68. The second column contains a new item, that for value added. The size of value added is determined precisely in order to ensure that the sum of the second column is exactly the same as the sum of the second row. The total of 1 286.4 billion currency units is the value of national production at basic prices.

Table 2.8 A simple supply and use table in monetary terms

Billion currency units

	Intermediate consumption 664.0	Final consumption 506.4	Capital formation 146.0	Exports 403.0
Production 1 286.4				
Trade and transport margins				
Taxes less subsidies on products 70.0				
Imports 363.0				
	Value added 622.4			

Source: SEEAland data set.

3 A hybrid supply and use table

2.69. The SEEA makes extensive use of a particular form of matrix accounting which includes in the same table monetary flows relating to products and physical flows relating to natural resources, ecosystem inputs and residual generation. Such tables are referred to as "hybrid" tables because they contain data in different units, tonnes and currency units in this case. However, even though the units are mixed, the different data sets are presented according to common classifications and definitions. Any form of national accounts matrix can exist in a hybrid form, thus there can be hybrid supply and use tables, hybrid input-output tables and hybrid social accounting matrices.

2.70. A hybrid supply and use table can be formed by superimposing Table 2.8 on the product part of Table 2.7 to give the composite table shown in Table 2.9. The top left part of the table (that enclosed by the heavy dotted margin) shows product flows in both physical and monetary. The rest of the table refers to flows of natural resources, ecosystem inputs and residuals. These are observed in physical terms only. Hybrid accounts occur frequently throughout this handbook, but Table 2.9 is the only example where the physical and monetary data in respect of products are shown together. This is because in practice a breakdown by product and industry is used and carrying two sets of figures throughout the table becomes clumsy and space consuming. Further, much of the analytical interest is in linking the physical environmental flows with monetary economic flows. Thus the usual format of the hybrid account is to contain monetary data only in respect of products, though it should be remembered that the corresponding physical flows exist even if these are not shown explicitly.

2.71. Further sub-matrices of the same dimensions can be calculated showing, for example, the relationship between residual generation from industry and the corresponding inputs in either physical or monetary terms. Sometimes these coefficients are available from external sources and are used to construct the residuals sub-matrix; sometimes the information about residuals is available separately and the coefficients are derived once the other sub-matrices are complete. Part 4 of Section B in Chapter 4 on energy accounts describes this situation in greater detail.

2.72. Another point to note in connection with this table is that it can be constructed not just for all natural resource and ecosystem inputs and residual outputs, but it can be constructed paying attention to only a limited number of inputs and residuals, possibly only one of each. A common case in point is the generation of carbon dioxide from fossil fuel combustion. A particular instance of this is described in part 5 of Section B in Chapter 4 on emissions accounts.

Table 2.9 A simple hybrid supply and use table (SEEAland data set)

Monetary data (*in italics*) in billions of currency units; physical data (non-italic) in millions of tonnes

		Economy: 1. Products (Physical)	Economy: 1. Products (*Monetary*)	Economy: 2. Industries	Economy: 3. Consumption	Economy: 4. Capital	Economy: 5. ROW (products)	*Total economy*	Residuals: 10. National destination	Residuals: 11. ROW destination	9. Material balance	Total use
Economy	1. Products			Products used by industry	Products used for consumption	Products used for capital	Products used by ROW (exports)					
	Physical			442	39	119	101				0	701
	Monetary			*664*	*506*	*146*	*403*	*1 719*				
	2. Industries	Products supplied by industry 551	*1 356*					*1 356*	Residuals generated by industry 275	Residuals generated by industry in ROW 5	0	831
	3. Consumption								Residuals generated by consumption 47	Residuals generated by consumption in ROW 1	Net material accumulation by consumption 17	65
	4. Capital								Residuals generated by capital 73		Net material accumulation by capital 72	145
	5. ROW (products)	Products supplied by ROW (Imports) 150	*363*					*363*	Residuals generated by non-residents 6		Net material accumulation by ROW economy - 52	104
	Value added			*692*				*692*				
	Total economy		*1 719*	*1 356*								
Natural resources	6. National environment			Natural resources supplied to industry 256	Natural resources supplied to consumption 1		Natural resources extracted by ROW 1				Net accumulation of natural resources in the national environment - 258	0
	7. ROW origin			Natural resources supplied to industry 5	Natural resources supplied to consumption 1						Net accumulation of natural resources in the ROW - 6	0
Ecosystem inputs	8. National environment			Ecosystem inputs to industry 118	Ecosystem inputs to consumption 23		Ecosystem inputs to ROW economy 2				Net accumulation of ecosystem inputs in the national environment - 143	0
	9. ROW origin			Ecosystem inputs to industry 3	Ecosystem inputs to consumption 1						Net accumulation of ecosystem inputs in the ROW - 4	0
Residuals	10. National origin			Residuals re-absorbed by production 7		Waste to landfill sites 26				Cross boundary residual out-flows 4	Net accumulation of residuals in the national environment 373	409
	11. ROW origin								Cross boundary residual in-flows 8		Net accumulation of residuals in the ROW 1	9
	Total supply	701		831	65	145	104		409	9	0	2 264

4 Introduction of the term NAMEA

2.73. The idea of a matrix presentation of monetary accounts augmented by the input of natural resources and ecosystem inputs and residual outputs in physical terms has been used extensively by Statistics Netherlands over several years. They used the description NAMEA for such a table, denoting a National Accounting Matrix with Environmental Accounts, and this term has come into common parlance as shorthand for any such augmented matrix. In practice most NAMEAs which have been compiled so far are hybrid supply and use tables but in concept any monetary table which has been "hybridised" in this way can be called a NAMEA. Thus the term NAMEA may apply to a table in which the monetary part corresponds to a supply and use table, to an input-output table or to a full social accounting matrix. Throughout this handbook, though, the term NAMEA is seldom used in order to be able to make explicit whether the hybrid tables under discussion are supply and use tables, input-output tables, matrices containing all national accounts flows or full national accounting matrices containing stock information also.

5 Supply and use and input-output

2.74. Even the simple supply and use tables given above have separate rows and columns for products and industries. It is products which are used for intermediate consumption, capital formation or exports but it is industries which use intermediate consumption, imports, and environmental resources and generate both value added and residuals.

2.75. A number of analyses depend on a matrix where the same classification is used for supply and use. It is thus necessary to collapse the product and industry dimensions so that the matrix presentation is simplified to a single row and column. Such a table is an input-output table.

2.76. The supply and use table is emphasised in this handbook and in the SNA because it corresponds to data as observed. Many industries manufacture more than one product and it is impracticable to ask them to separate all their costs and value added into that part pertaining to each product. However, what we cannot obtain by observation, we can construct analytically. The means of doing this are discussed in Chapter 4 and the resulting table is presented in Table 4.14.

2.77. The advantage of the input-output format comes from the analytical uses of the table. We can, for instance, calculate the implicit contribution of electricity to all products by tracing and cumulating the input of electricity in every stage of the production process. If we consider electricity generated by the combustion of fossil fuel, we can calculate approximately how much fossil fuel is needed for any product. Further, if we know, for example, that 60 per cent of electricity use comes from national production and 40 per cent is imported, we can start to calculate the approximate total demand on fossil fuel and not just that used for electricity generation within the national economy.

D SNA flow accounts

2.78. As noted before, the SEEA was conceived as a satellite account to the SNA. This means that the format of the accounts and the conventions underlying them are heavily influenced by those of the SNA. Some understanding of the SNA is desirable in order to fully understand the implications of the SEEA. For the physical flow accounts and the establishment of hybrid supply and use tables described in the preceding sections, an understanding of the goods and services account which reconciles production with final expenditure is sufficient. However, while this account describes the final outcome of economic activity in a period, it does not explain how the income generated by production becomes available to different types of units in the economy and how they decide to spend or invest this income. To understand this it is necessary to consider the "sequence of accounts" of the SNA which explain the steps whereby income, once generated, is distributed, redistributed and finally used. With this as background, we can examine in depth particular parts of the system which are interesting from an environmental perspective. This is the "internal satellite account" aspect of the SEEA.

1 The SNA sequence of (current) accounts

2.79. Each step of income distribution, redistribution and use is described in a separate account. Each account has a name and leads to a balancing item which ensures that the sources and uses of funds are equal. These balancing items are of analytical interest in themselves and are often quoted in isolation from the underling sequence of accounts. Domestic product and national income are two such balancing items.

2.80. It is the balancing items which link successive accounts since the item which is the last entry on the uses side of one account is the first item on the sources side of the next account in sequence. The following description of the accounts focuses on the establishment of these balancing items.

2.81. The identity described in connection with Table 2.8 whereby ***value added*** is defined as the balancing item between production and intermediate consumption, is described in the SNA as the production account. Value added across all production activities constitutes a measure of ***gross domestic product*** (GDP) at basic prices. For most purposes, however, GDP is usually quoted at market prices. Again as noted in connection with discussion on Table 2.8, it is necessary to add to GDP at basic prices a measure of the taxes paid by purchasers at the point of purchase less any subsidies received at that point. These taxes and subsides are recorded in the generation of income account.

2.82. The next account is the account for the distribution of primary income. This shows how value added is distributed, part to the employees of production activities and some to the owners of financial capital and land as payments of rent, interest and dividends, collectively called property income. Value added adjusted for property income yields ***primary incom***e. For the economy as a whole, there may be property income and compensation of employees payable to the rest of the world and receivable from it. Taking these into account yields ***national income***.

2.83. The next stage in redistributing income is by means of transfers. These are payments made without a *quid pro quo* or in other words payments made which are not related to the exchange of a good, service or asset. The largest type of transfer payment is taxes on income, wealth etc., that is current taxes other than those related to production and consumption. The secondary distribution of income account shows how primary income adjusted for payments and receipts of transfers gives ***disposable income.***

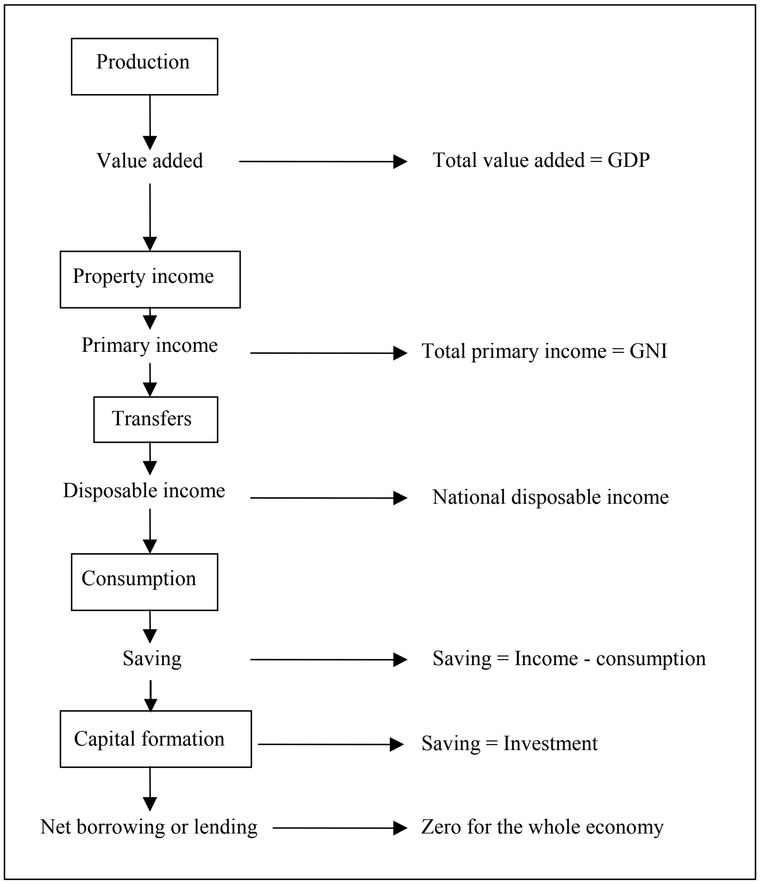
2.84. Disposable income can only be spent or saved. The next account, the use of disposable income account, shows how ***saving*** is derived by deducting current consumption from disposable income.

2.85. Income which is saved is used either for the acquisition of fixed capital (loosely called investment). Any surplus is lent to other units; any deficit is made up by borrowing. These transactions are shown in the capital account.

2.86. The financial account shows how ***net borrowing and lending*** is reconciled across the economy as a whole since, including transactions with the rest of the world, one person's net borrowing has to be another's net lending and in total they must sum to zero.

2.87. The very abbreviated discussion is shown schematically in Figure 2.3. Further details can be found either in the 1993 SNA or in other national accounts material.

Figure 2.3 Schematic view of the SNA sequence of accounts



2 Relevance of the accounts in the SEEA

2.88. There are at least three aspects of these accounts which are relevant to the full accounting system of the SEEA.

The first aspect concerns the payments of taxes since the impact and effectiveness of eco-taxes are clearly of concern for environmental policy.

The second aspect relates to the establishment of property rights and the payments of property income, some of which are in respect of environmental assets.

The relationship between income, consumption, saving and investment towards the end of the sequence of accounts cuts straight to the heart of the discussion about sustainable levels of income and wealth.

2.89. In order to explore these aspects fully, however, it is necessary to examine the role of "sectors" in the accounts. Without accounts for sectors, it is not possible, for example, to portray the impact of taxes on the accounts of businesses, households and government or the relevant contribution of households vis-à-vis businesses in their contribution to and suffering from environmental problems.

3 The sectors of the national accounts

2.90. Each transaction in the accounts involves two parties, one who makes a payment and one who receives it. All the resident units in the economy can be classified into one of four groups. These groups have significantly different purposes in the economy, different main sources of income and different patterns of expenditures.

2.91. ***Financial and non-financial enterprises***, (businesses in a non-technical term) are involved in production and in capital formation (investment) to permit them to continue production in the future.

2.92. ***Households*** provide labour to enterprises and government and spend the money they earn on the goods and services produced in the form of current consumption. The main capital formation of households is the purchase of houses.

2.93. ***Government*** raises taxes from both enterprises and households and uses the revenue generated to provide services to individual households, the community at large and enterprises alike. Government also undertakes capital formation.

2.94. There is another small sector relating to ***non-profit institutions serving households***. These cover, for example, charities providing food and shelter to the needy and educational services. It is probable that the main way they affect the environment is through raising public awareness of environmental problems but there may be some environmental remedial action undertaken by such groups.

2.95. Lastly, non-resident units which interact with the national economy can be grouped together into a *de facto* fifth sector, called the "***rest of the world***". Balance of payments accounts are in fact a set of accounts consistent with the SNA for the rest of the world transactions only.

2.96. Not all developing countries have yet implemented sector accounts though it is hoped that with the introduction of the 1993 SNA more of them will do so. The importance from the point of view of monitoring how the government functions and implements (or fails to implement) policy can hardly be exaggerated. The responsibilities of the ownership of natural resources can also be monitored only with the aid of sector accounts which allow the owners and users of these resources and the transactions relating to them to be identified.

4 A full accounting matrix

2.97. A supply and use table can be extended to show all these flow accounts in matrix format also. Such a matrix is called a national accounting matrix. An example of such a matrix is given in Table 2.10.

2.98. The conventions for this matrix are the same as in the previous tables examined. There is a match in coverage between the rows and columns and total value for each row matches the total of the corresponding column of elements of the supply side. Each row consists of the elements of the use side of an account and the corresponding column the supply. Balancing items ensure this equality and are recorded at the intersection of the column for one account and the row for the succeeding account. Transactions which redistribute income or saving are shown on the diagonal element of the account concerned. They do not (here) affect the total level of the successive balancing items but do affect how the income is allocated once that stage in redistribution is complete. Illustrative arrows have been added to the central part of Table 2.10 to assist in understanding how the sequence of accounts follows through the accounts.

Table 2.10 A schematic national accounts matrix

		Goods and services (products)	Production (industries)	Distribution of primary income account	Secondary distribution of income account	Use of income account	Capital account	Financial account	Rest of the World
		1	2	3	4	5	6	7	8
Goods and services (products)	1		Intermediate consumption			Final consumption	Capital formation		Exports
Production (industries)	2	Output							
Distribution of primary income account	3		Value added →	Property income ↓					
Secondary distribution of income account	4			Balance of primary income →	Current transfers ↓				
Use of income account	5				Disposable income				
Capital account	6					Saving	Capital transfers		
Financial account	7						Net lending or borrowing	Acquisition and disposal of financial assets	
Rest of the World	8	Imports						Net lending to or borrowing from the ROW	

2.99. Table 2.10 is simply a skeleton matrix. In practice the rows and columns are disaggregated according to the transactions of interest. In addition, more transactions with the rest of the world will be recorded. For example, property income payments from the rest of the world will appear in the row for distribution of primary income account and the column for the rest of the world and the payments to the rest of the world in the diagonally opposite cell. Such items will affect the level of balancing items in the account where they appear.

2.100. Just as the monetary supply and use matrix can be portrayed in hybrid form by the addition of columns for residual generation and rows for the use of environmental flows, so the national accounts matrix can be similarly extended. (It is this conception of the hybrid account which gave rise to the acronym NAMEA, indicating a national accounting matrix with environmental accounts.) Table 6.5 in Chapter 6 shows a hybrid national accounts matrix which appends the environmental information to the matrix in Table 2.10 and also shows the more complex recording for the rest of the world account indicated in the previous paragraph.

5 Identifying environmental transactions within the accounts

2.101. With an understanding of the way in which the SNA treats payments between sectors, it is possible to consider how to identify those of interest from the environmental point of view. One such case concerns environmental taxes. Another concerns the acquisition of property rights over, and payments to make use of, environmental assets. These are discussed briefly below.

Environmental taxes

2.102. The first task is to determine which categories of payments to government described in government accounts as taxes should, or could, be considered to be "environmental" in nature. The guiding principle, agreed by a number of international agencies is that an environmental tax is one whose tax base is a physical unit (or proxy of it) that has a proven specific negative impact on the environment.

2.103. The next task is to decide whether something appearing in the government accounts as a tax will be treated as a tax in the SNA or, perhaps, as a fee for a service. Even if the SNA treats the payment as a tax, there is still further identification necessary. Taxes appear under one of four headings in the SNA. They are associated with products, with production, with income or with the ownership of capital. Taxes on products and production are recorded in the production account and generation of income account. If there are any subsidies with environmental impacts given to producers or in respect of products, these will be recorded in the same accounts.

2.104. Taxes on income are one item within the current transfers included in the secondary distribution of income account. Taxes on capital are recorded as one item in capital transfers in the capital account. By identifying the location of environmental taxes within the system, the impact on national income and on subsequent balancing items can also be investigated.

2.105. There is detailed discussion of the identification and quantification of environmental taxes in Chapter 6.

Property rights and property income

2.106. The item for property income in the distribution of primary income account consists of actual payments made or due to the owner of an asset by a different user. Most property income takes the form of interest and dividends in respect of financial assets. However, rent on land is also included here as is rent paid in respect of other natural resources. There is an issue concerning the implicit value of resource rent when an asset is used by the owner and this is discussed in Section F below.

2.107. Property income in general and rent in particular relate to payments which fall due on an annual basis or more frequently. Increasingly, there is interest in the practice of securing the right to use an asset for an extended period of time or even in perpetuity. Such acquisitions come under the heading of property rights. Of particular interest in the environmental context is the right to use environmental media such as the entitlement to emit gases to the air conferred by emissions permits and the right to extract natural resources conferred by fishing quotas.

2.108. This is an area which was explored during the revision of the SNA which was completed in 1993. There is now much greater scope to recognise and include transactions in property rights than in the earlier version of the SNA. Although new types of contracts continue to emerge and there is still some discussion about how these should be handled within the SNA, there is discussion in Chapter 6 on how to record longer established permits.

E A set of accounts for environmental protection expenditure

2.109. The previous section showed how a subset of a particular transaction can be located and measured within the system. Often, though, the subject of an internal satellite account will be broader than this and the goal will be rather to identify all transactions within the system which have a bearing on the topic of interest. Chapter 5 discusses how such a set of accounts might be established. Although that chapter addresses environmental protection expenditure and resource management more generally, it is environmental protection expenditure where there is most experience to date and so this is described here also, in brief, as a prototype for these sorts of internal satellite accounts.

2.110. The environmental protection accounts aim to measure what is being done to protect the environment, in terms of environmental protection and management activities, products to protect the environment and expenditure on these goods and services. These items are already covered within the main SNA accounts but reformatting and disaggregation are required to highlight them and to present specifically environment-related economic accounts. The sorts of environmental protection activities to be covered such as investment in clean technologies or restoring the environment are defined in the classification of environmental protection activities and expenditure (CEPA 2000).

2.111. There are two main aspects of compiling a set of environmental protection expenditure accounts. The first is to adapt the principles of determining a supply and use table to a specific range of activities and products. The second is to investigate the level of national expenditure on environmental protection and to examine how this is financed.

1 Compiling a supply and use table

Identifying the activities of interest

2.112. The starting point is to consider which activities are typical for environmental protection. Four main groups of activities are considered; those which are specifically intended to ameliorate the environment, those where the environmental benefits are largely incidental to their main function, those directed to management and exploitation of natural resources and those aimed at minimising natural hazards. The extended classification of such activities is examined in depth in Section C of Chapter 5.

Identifying the producers

2.113. The next consideration is to determine whether these activities are undertaken by units whose main activity is providing environmental protection services or by non-specialist producers as secondary activities. Both of these are described as "external" services because they are provided by one enterprise to a user external to that enterprise, either another enterprise, government or households. In addition, some enterprises may undertake environmental protection activities on their own account and these in-house or ancillary activities are called "internal".

Ancillary activity

2.114. One feature of satellite accounts like this is that activity which is treated as ancillary in the SNA (i.e. which is not separately shown) is externalised in the satellite account. Thus, to take a very simple example, instead of a producer employing a cleaner and cleaning materials which are aggregated without distinction with other compensation of employees and intermediate consumption, they are treated as the components of a production account for the activity of cleaning and the whole of the value of this cleaning activity is then treated as intermediate consumption by this same producer.

2.115. This process increases both output and intermediate consumption but since they each increase by the same amount, the value of value added, and thus GDP, is not affected. It does, however, permit cleaning activities across the whole economy to be compared regardless of whether they are performed on own account or purchased and this is the rationale for the alternative treatment of ancillary activity.

Identifying the products of interest

2.116. The next requirement is to determine which goods and services are typically used for environmental protection. Clearly environmental protection services are included. It is also common to define "cleaner and connected products" which, though they may not be acquired only for their environmental effects, do produce environmental benefits at the same time. The purchase of cars with catalytic converters is one such example. Together, these goods and services are thought of as being supplied by an environmental goods and services industry, sometimes referred to in short as the "environmental industry". The identification of this group of producers which cuts across conventional classifications of industries and products is also discussed in Section C of Chapter 5.

2.117. Clean products are not necessarily valued at their full cost but only as the difference between the "clean" version and a "dirty" version. The "cleaning" is thus an extra cost recorded in effect as another type of margin and the "dirty" product in the same way as any non-environmentally related product.

Identifying the users of the products

2.118. Some users are obvious from the nature of the products they employ. Other users are more difficult to identify. Unlike the accounts for the whole economy, there are no built-in identities to help cross-check the level of the various components. Rather, looking at estimates from both the supply and use side in order to ensure a total coverage of all relevant items is intrinsic to the nature of building this sort of satellite account. Information on the use of environmental products may come from a wide variety of sources, some used in the regular compilation of national accounts and some more specialised.

Assembling the supply and use table

2.119. Once all these sets of transactions have been identified, they can be assembled into a supply and use table as indicated in brief in Table 2.11. The more detailed table is shown as Table 5.6 in Chapter 5.

Table 2.11 Supply and use table for environmental protection services

Millions of currency units

	Government services	Specialist services	Ancillary services	Cleaner and connected products	Total
Output at basic prices	3 000	6 500	4 000	1 000	14 500
Imports				50	50
Taxes and margins	120	150		150	420
Total supply at market prices	**3 120**	**6 650**	**4 000**	**1 200**	**14 970**
Intermediate consumption	0	4 900	4 000	600	9 500
Government consumption	1 800				1 800
Household consumption	1 320	1 650		600	3 570
Capital formation		100			100
Total use at market prices	**3 120**	**6 650**	**4 000**	**1 200**	**14 970**

Source: SEEAland data set.

2 National expenditure on environmental protection

2.120. The total use of environmental protection products may not be identical to the amount of national resources devoted to environmental protection. There may, for example, be subsidies given by government to producers to pursue more environmentally friendly practices. There may be grants received from abroad to assist in ameliorating environmental damage. Households may make transfers to non-profit institutions with environmental goals. Governments may use environmental taxes to fund particular environmental activities.

2.121. For these reasons, a set of complementary tables can be compiled which show the total level of national expenditure on environmental protection when these designated transfers have been taken into account. In addition, a distinction can be made between those units providing the financing and those undertaking the expenditure.

2.122. Tables which elaborate these aspects of environmental protection are developed in Section D of Chapter 5. They are based on proposals given in Chapter XXI of the SNA and draw on transactions included throughout the sequence of accounts of the SNA.

F Stocks of assets in the SEEA

2.123. Section D gave an outline of the SNA flow accounts. These articulate the relationship between production and consumption and show how the identity between them is brought about via the mechanism of income. Accumulation involves stocks of assets as well as flows. This section discusses the role of assets in the SNA and the consequences for environmental assets.

1 Defining assets

2.124. In the SNA an asset is defined as an entity (i) over which ownership rights are enforced by institutional units, individually or collectively, and (ii) from which economic benefits may be derived by their owners from holding them or using them over a period of time. This definition is wide enough to cover many assets of an environmental character, for example cultivated biological resources, some non-cultivated biological resources such as fish stocks and natural forests, and a number of naturally occurring entities such as land and mineral deposits. However, it is not exhaustive as far as environmental resources are concerned. Land too remote or poor, fish stocks of no interest to mankind for food and mineral deposits whose profitability is uncertain are excluded either because no economic benefit is involved or because no ownership is enforced (or possibly both).

2.125. For the SEEA, the asset boundary of the SNA is expanded to cover all environmental entities which are of interest and measurable. The environmental assets covered by the SEEA are grouped into the following broad categories:

- Natural resources;
  - Mineral and energy resources;
  - Soil resources;
  - Water resources;
  - Biological resources;
- Land and associated surface water;
- Ecosystems.

2 An asset account in physical terms

2.126. For an asset where we can measure the stock in physical terms, we start with the simplest possible identity. The stock of the asset at the end of the year is equal to the stock at the start of the year adjusted for the changes which have taken place during the year. These changes may be additions or deductions and will be of somewhat different nature for different assets. They will reflect the intervention of people, for example the slaughtering of animals and the harvesting timber, natural environmental processes such as the birth and death of wild animals. These changes may be regular, as in these examples, or may be very irregular such as losses caused by natural disasters, hurricanes, earthquakes, floods and so on. Table 2.12 shows an illustrative asset account.

2.127. Formally, we may further subdivide the increases and decreases in stock levels into those which are due to economic impacts and those which are not. Economic impacts cover decisions by economic agents to harvest or extract resources, residuals generated by the economy and so on. Non-economic changes include natural growth and the effects of natural disasters. The boundary is not absolute. Some so-called natural disasters can be traced to human actions, for example floods whose impacts are exacerbated by human activity. There may be different opinions about whether to record the discovery of new mineral deposits as the result of human activity or not. The decision of what to treat as "economic" and what as "natural" may be driven by the type of analysis required. For the moment we suppose that such a division can be made without pursuing the exact demarcation further.

3 Asset accounts in the SNA

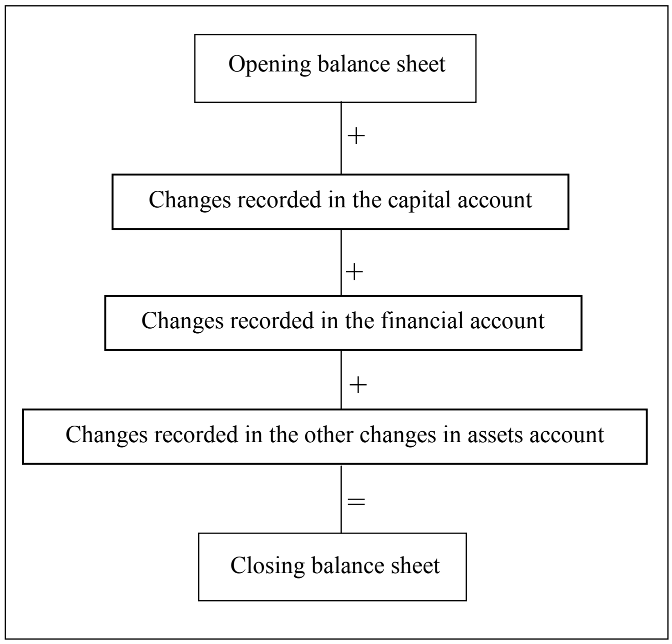
2.128. There are two accounts in the SNA other than the sequence of accounts discussed in Section D which are important for measuring stocks of assets. The first of these is the balance sheet which is typically compiled at the start and end of an accounting period, usually taken to be a year. The second is called the other changes in assets accounts. This covers flows which are not transactions, that is, events which happen outside the market place covered by the sequence of accounts. Many of the changes in environmental assets are recorded here, such as discoveries of sub-soil deposits and natural growth of non-cultivated assets. This is also the place where the effects of natural disasters and price changes are recorded.

Table 2.12 Illustrative physical asset account

Opening stock
Increases during the year
New discoveries of minerals
Natural growth of plants and animals
Land reclamation
Decreases during the year
Extraction of minerals
Soil erosion
Loss of capacity of reservoirs due to silting
Harvesting of plants and animals
Natural death of plants and animals
Loss of animals due to drought
Closing stock

2.129. The term accumulation accounts is used in the SNA to cover both these accounts and also the capital and financial account. These are linked in the way shown in Figure 2.4. All the changes in the value of assets between the opening and closing balance sheets must appear either in the capital account, the financial account or the other changes in assets account. This relationship emphasises the role of the last account as a sort of catch-all for anything not previously recorded.

Figure 2.4 Schematic view of the SNA accumulation accounts



2.130. The entries recorded in the capital account cover the acquisition and disposal of non-financial assets. All non-financial assets are covered, including those environmental assets which fall within the SNA asset boundary. This includes purchases of land, for example, but because land is always recorded as being exchanged between resident units, for the economy as a whole these sales and purchases will cancel out. At the level of individual sectors, however, they will show up.

2.131. The set of accumulation accounts are very similar to the notion of an asset account but are compiled for an economic unit or sector, covering all the assets they own, rather than for asset types.

4 Placing a value on assets

2.132. The SNA recommends that market prices be used wherever practicable to place a value on an asset. Unfortunately this is not always possible. Some purpose-built produced assets may not have a market value other than the cost of construction and the market in second-hand assets is frequently too shallow to give realistic market prices. In such cases, alternative methods of valuation have to be sought. One of these is to call on economic theory which states that at any point in its life, the value of an asset should be equal to the value of future income streams to be provided by the asset discounted to the present period. This can be applied to produced assets and also to environmental assets. It is an important means of apportioning the returns to an enterprise among the various assets at its disposal.

2.133. That said, it is sometimes extremely difficult to place a valuation on each type of asset separately. The price of a house usually includes both the value of the man-made habitation as well as the land on which it stands. Similarly the value of a forest covers the value of the standing timber, the potential of the trees to regenerate in the future and the land on which the trees stand. In addition there may be a significant value to be placed on forest products other than timber and on the recreational use provided. This combination of assets is of no great importance for the SNA since, as noted above, accumulation accounts are compiled for all the assets of a single owner rather than for each asset of the same type across all owners. Finding a way to attribute value to different assets, or even different aspects of the same asset, is thus more of a concern for the SEEA than for the SNA.

5 The decline in the value of an asset

2.134. The value of an asset often declines in use. For produced assets, this decline is measured in the SNA as the consumption of fixed capital. Colloquially it is referred to as depreciation or amortisation. It is the difference between gross capital formation and net capital formation. The classic definition of income is the amount which can be spent in a period while remaining as well off at the end of the period as at the beginning. The consumption of fixed capital is an allowance to ensure that the run-down of fixed capital is taken into account when calculating income according to this definition. If consumption of fixed capital is higher than the acquisition of new fixed capital, then this situation is not sustainable just as extracting biological resources faster than natural growth is unsustainable.

2.135. The balancing items in the sequence of accounts, described in Section D, are always prefixed by the word “gross” or “net”. The difference is always the consumption of fixed capital. This is the difference between gross domestic product (GDP) and net domestic product (NDP) also. In principle, whenever an income concept is called for, it should be the net version of the aggregates in question which is cited. In practice, it has long been common to use gross measures because some countries did not make estimates of consumption of fixed capital. However, in the environmental context, it would make no sense to worry about the decline in value of environmental assets and not the decline in value of produced assets so the use of net measures becomes even more important.

6 Valuing natural resources

2.136. The principles for valuing produced assets and calculating the decline in their value can be applied to natural resources in like manner. Natural resources provide a stream of services to the economy as they are used. The value of these services represents the resource rent of the asset. The decline in value of the resource (ignoring price effects and disasters) can be called the consumption of natural capital, parallel to the consumption of fixed capital.

2.137. The SNA supports this valuation and the calculation of the decline in the value of the natural resource but leaves the value of the decline in the other changes in assets account under a category of “economic disappearance”.

2.138. Just as natural resources are reduced by extraction, there may also be additions to stocks. For biological resources, this happens through natural growth. For sub-soil reserves of mineral and energy resources, increases in the known stock levels are the result of mineral exploration and reappraisal. The techniques used to value the stock of a resource and its decline can also be used to put a value on the increase in the level of a resource stock. These increases in value are also recorded in the SNA in the other changes in assets account under a category of “economic appearance”.

2.139. The various options of the SEEA treatment of extractions and additions are discussed in detail in Chapter 10.

7 *Incorporating asset accounts in the matrix presentation*

2.140. It is possible to modify Table 2.10 to include an asset account for produced assets though some sleight of hand is needed with the arithmetic built into the matrix presentation. Capital formation needs to appear twice in the accounts, once in the capital account to explain how saving is used and once in the asset account. The entry on the capital account needs to be by sector and that in the asset account by type of asset but the matrix format lends itself to this sort of classification transformation. In addition, consumption of fixed capital needs to appear explicitly to reduce the balancing items to a net basis and to reduce the value of stock in the balance sheet. Table 2.13 shows how this can be achieved.

Table 2.13 A national accounts matrix with asset account included

		Goods and services (products)	Use of products	Generation of primary income	Use of assets	Distribution of primary income account	Secondary distribution of income account	Use of income account	Capital account	Financial account	Rest of the World economy	Produced assets and land
		1	2a	2b	2c	3	4	5	6b	7	8	6a
												Opening stock levels
Goods and services (products)	1		Intermediate consumption					Final consumption			Exports	Capital formation by asset
Use of products	2a	Output										
Generation of primary income	2b		Gross value added									
Use of assets	2c			Consumption of fixed capital								Consumption of fixed capital
Distribution of primary income account	3			Net value added		Property income						
Secondary distribution of income account	4					Net balance of primary income	Current transfers					
Use of income account	5						Net disposable income					
Produced assets and land	6a								Net capital formation by sector			
Capital account	6b							Net saving	Capital transfers			
Financial account	7								Net lending or borrowing	Acquisition and disposal of financial assets		
Rest of the World economy	8	Imports								Net lending to or borrowing from the ROW		
												Closing stock levels

2.141. The fist step is to subdivide the row and column for the capital account into two, one which continues to refer to the capital account (now called 6b) and one to the asset account (6a). Column 6a contains new entries above and below the previous extent of the table to show the opening and closing balance sheets of the stock of produced assets and land. The entry for gross capital formation in row 1 is moved to be in column 6a, showing any addition to the stock level.

2.142. The previous row and column for the production account is split to show the use of products, generation of income and use of assets entries separately. Consumption of fixed capital is entered into the intersection of the use of asset row (2c) with the generation of income asset column (2b). Instead of having a matching entry for the consumption of fixed capital in column 2c, there is an offsetting entry in row 2c under column 6a (the asset account column). Column 2c remains empty but since row 2c now has a total value of zero, the rules for balancing the matrix are satisfied.

2.143. In order to balance rows and columns 6a and 6b, we need to enter a value for net capital formation in row 6a and column 6b. These three manipulations have had three desired effects. The first is that all balancing items appear net. The second is the appearance of an asset account where the opening stock is modified by the addition of gross capital formation and the deduction of the consumption of fixed capital. The third is the reformulation of the capital account where net saving and net capital formation replace their gross equivalents.

2.144. It is possible to both simplify and expand Table 2.13. The 1993 SEEA also made extensive use of a table where an asset account was superimposed on a set of flow accounts. There, however, the flow accounts were restricted to the supply and use tables. This simpler version can be reached by consolidating rows and columns 3 to 5 and 6b and 7. Countries which have not implemented the full sequence of the SNA accounts are restricted to this version but do not then have the possibility to see flows such as those relating to resource rent and environmental taxes in their full context.

2.145. Although not shown explicitly in Table 2.13, it is possible to include an entry for the other changes in assets in column 6a outside the box containing the sequence of accounts and immediately above the closing stock level. Further, just as the supply and use table, the input-output table and the national accounts flows matrix can all be presented as hybrid tables by the addition of environmental flows, so Table 2.13 can be presented in a hybrid form. In addition to the environmental flows, stocks of environmental assets can be shown alongside the stocks of opening and closing stock levels above and below the flows part of the table. Table 20.7 in Chapter XX of the 1993 SNA shows how a complete integrated set of flow accounts and balance sheets are reconciled in one national accounting matrix.

G Integrating environmental adjustments in the flow accounts

2.146. The fourth and last main category of accounts in the SEEA presents accounts that attempt to measure, exclusively in monetary terms, depletion and degradation of the environment and how this would modify the conventional measures of economic activity. However, although the idea is simple, implementing it is not. There are theoretical, practical and institutional reasons why a statistical office may not implement this part of the SEEA or at least not yet. These issues are important and are discussed at some length in Chapter 10. Here the discussion focuses solely on the theoretical components of this sort of extension to the SNA.

2.147. Valuing inputs into the economic system is the first and easier step. Since these inputs are incorporated into products which are sold in the market place, in principle it is possible to use direct means to assign a value for them based on market principles. Even within the SNA, such valuations are sometimes made though the results are placed in the other changes in assets account rather than in the flow accounts. Thus another way of looking at the process of incorporating the use of environmental inputs into the system is to relocate some of the other changes in assets items into the accounts portraying transactions.

2.148. Use of environmental assets as inputs to a production process becomes a matter of concern only if use now threatens the availability of the resource in future. Thus these issues are those of measuring depletion to resource stocks. They are treated in the first part of this section below.

2.149. Because residuals are an output rather than an input, there is no direct way to assign a value to them. All the indirect ways of valuation depend to some extent or another on "what if" scenarios. What if production processes changed to limit residual emission? What if the damage caused by residuals were valued? Such questions quickly lead from a purely statistical approach into the realm of modelling.

2.150. Some actions are already taken to limit residuals generation or to mitigate the impact of those which are emitted. These expenditures are sometimes referred to as defensive expenditures. Considering how to ensure that increased defensive expenditure does not simply show up as increased economic growth is the subject of the second part of this section. Various possible approaches to valuing residuals which are not prevented or negated by defensive expenditure are the subject of the final part of the section.

1 Showing depletion in the accounts

Valuing natural resources

2.151. The question of valuing natural resources was discussed above. Natural resources, like produced assets, provide capital services to the production process and these are remunerated in the gross operating surplus generated. The gross operating surplus is that part of value added that remains after deducting the compensation of employees and the other taxes less subsidies on production. This operating surplus can be partitioned to show how much is due to produced assets and how much to natural assets. The part due to natural assets is the resource rent. The other part we will call economic rent though to be accurate it should really be called other economic rent. The value of the stock of the assets, whether produced or non-produced, can be equated with the present discounted value of the rent they will yield over their effective life. This is the basis of the valuation of assets used for balance sheet purposes when direct market prices are not available.

2.152. Economic rent can be partitioned into a part which represents the decline in the value of the asset, sometimes referred to non-technically as the cost of "using up" the asset, and the remainder which represents the return to the owner of the asset. If there were no return to the asset, there would be no incentive to acquire it in the first place. Conceptually, resource rent can also be partitioned into a part representing the decline in the value of the resource and a part representing the return to using the resource in production. If a renewable resource is not subject to depletion, there is no decline in the value of the resource and the whole value of the extracted resource represents a return to its use in production.

2.153. In the SNA, the decline in the value of the produced assets is described as the consumption of fixed capital and it is deducted from gross operating surplus to derive net operating surplus. Net operating surplus thus covers the return to the produced asset plus the whole of the resource rent. The argument in favour of adjusting the national accounts aggregates for the use of natural resources is that a further deduction should be made from net operating surplus to allow for the decline in the value of the natural resource. Such an adjustment would give a figure for depletion adjusted operating surplus. This would follow through the sequence of accounts and result in other depletion adjusted aggregates, notably domestic product and national income but also saving.

2.154. Two questions arise. The first goes back to the proposition that it is possible to partition resource rent into one part representing the decline in the value of the asset and one part representing the return to the use of the asset in production which is regarded as income.

2.155. The SNA prior to the 1993 version assumed that natural resources were so abundant that there was no decline in their value (or even that they were so abundant that they had no value) and that the whole of the resource rent could rightly be treated as income.

2.156. The opposite view is taken by some commentators. The whole of the resource rent should be taken as a decline in value of the stock of the resource and none of it regarded as income. This is also equivalent to saying that the present value of the stock is calculated as the sum of future services without discounting and the use of natural resources is treated as intermediate consumption.

2.157. The majority (but not unanimous) opinion is that a position in between these two is to be preferred. It should be a matter of investigation whether the stock is declining and if it is, there is a case for making an adjustment to operating surplus and other balancing items in the accounts.

2.158. The second question concerns how to treat additions to natural resources. In the case of biological resources, most commentators think it reasonable to say that if the harvest in any year is no greater than natural growth in that year, then the stock of the asset has not declined and the whole of the harvest can be regarded as income. (This position assumes that the composition of the resource is stable; clearly a different conclusion could be reached if some species or some age cohorts become scarce.) This conclusion is consistent with the first and third positions above about partitioning the resource but not the second. Here, the case is that the measures of income in the SNA all relate to income from production and since natural growth of non-produced assets is by definition not a production process, the increase in value of the resource stock due to natural growth cannot be regarded as income and so cannot be offset against a charge on income for the use of resources.

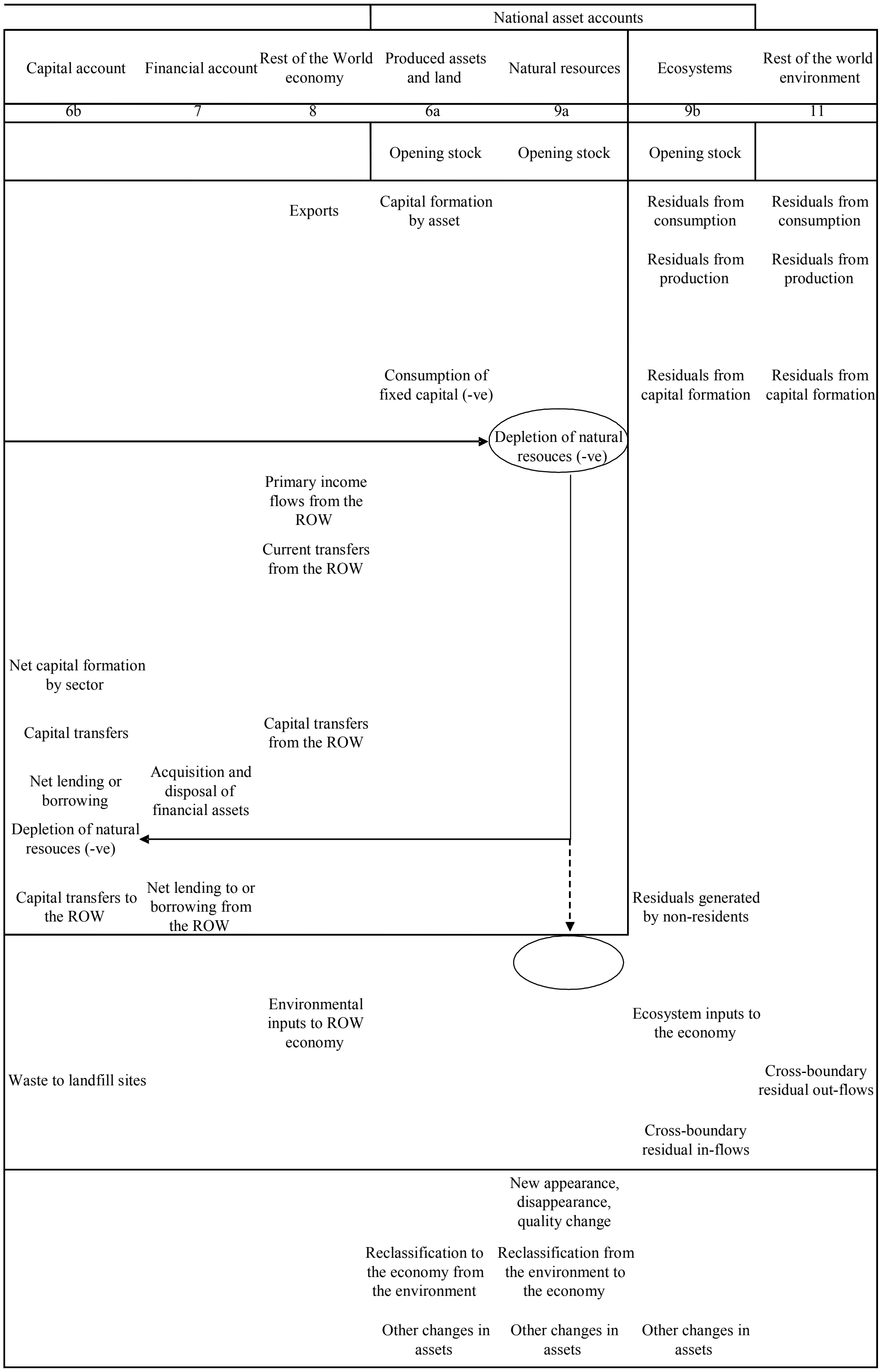
2.159. If depletion is to be calculated net of natural growth in the case of biological resources, how should discoveries of sub-soil assets be treated? Here opinion is much more divided, a main cause of which is the recognition that unlike biological resources, mineral deposits are not renewable on a human time scale. One solution is to say that in this case, the whole of the extractions should be deducted from net operating surplus with no offsetting element due to new discoveries.

2.160. Another response is that clearly mineral discoveries are the result of production and that the resulting asset should be a "developed natural asset" which incorporates the value of both the mineral exploration and the mineral deposit. This asset is characterised as a produced asset and any decline in value of the stock is a deduction from income but it will show in the calculation of the consumption of fixed capital and thus in net domestic product without any further deduction being necessary. (The consumption of fixed capital relating to the developed natural asset does not necessarily have to be merged indistinguishably with that for other fixed capital but can be shown separately as illustrated in the Economic and Environmental Satellite Accounts released by the USA's Bureau of Economic Analysis in 1994).

2.161. The middle way is to argue that while mineral deposits themselves are not renewable, known and proven deposits are renewable since mining companies typically establish not the totality of reserves but just enough to warrant opening the mine. As the known stocks are depleted, so they search for more. This is how some countries have had a "stock" of oil sufficient for 10 years for over twenty years. This argument suggests offsetting discoveries against extraction.

Table 2.14 Incorporating depletion in the hybrid matrix

			National economy							
			Goods and services (products)	Use of products	Generation of primary income	Use of produced assets	Use of natural resources	Distribution of primary income account	Secondary distribution of income account	Use of Income account
			1	2a	2b	2c	2d	3	4	5
National economy	Goods and services (products)	1		Intermediate consumption						Final consumption
National economy	Use of products	2a	Output							
National economy	Generation of primary income	2b		Gross value added						
National economy	Use of produced assets	2c			Consumption of fixed capital					
National economy	Use of natural resources	2d			Depletion of natural resources					
National economy	Distribution of primary income account	3			Depletion adjusted (dp) value added			Property income		
National economy	Secondary distribution of income account	4						Dp balance of primary income	Current transfers	
National economy	Use of income account	5							Dp disposable income	
National economy	Produced assets and land	6a								
National economy	Capital account	6b								Dp saving
National economy	Financial account	7								
National economy	Natural resources	9a								
	Rest of the World economy	8	Imports					Primary income flows to the ROW	Current transfers to the ROW	
	Natural resources	9a								
	Ecosystems	9b		Ecosystem inputs to production						Ecosystem inputs to consumption
	Residuals	10		Residuals re-absorbed by production						
	Rest of the world environment	11		Environmental inputs to production						Environmental inputs to consumption
	Other changes in assets	12								


National asset accounts
Capital account
Financial account
Rest of the World economy
Produced assets and land
Natural resources
Ecosystems
Rest of the world environment
6b
7
8
6a
9a
9b
11
Opening stock
Opening stock
Opening stock
Exports
Capital formation by asset
Residuals from consumption
Residuals from consumption
Residuals from production
Residuals from production
Consumption of fixed capital (-ve)
Residuals from capital formation
Residuals from capital formation
Depletion of natural resouces (-ve)
Primary income flows from the ROW
Current transfers from the ROW
Net capital formation by sector
Capital transfers
Capital transfers from the ROW
Net lending or borrowing
Acquisition and disposal of financial assets
Depletion of natural resouces (-ve)
Capital transfers to the ROW
Net lending to or borrowing from the ROW
Residuals generated by non-residents
Environmental inputs to ROW economy
Ecosystem inputs to the economy
Waste to landfill sites
Cross-boundary residual out-flows
Cross-boundary residual in-flows
New appearance, disappearance, quality change
Reclassification to the economy from the environment
Reclassification from the environment to the economy
Other changes in assets
Other changes in assets
Other changes in assets

Incorporating depletion or extraction in the accounts

2.162. Conceptually the changes which need to be made to the accounting matrix to incorporate a depletion adjustment are very similar to the changes made to accommodate the asset account and the allowance for consumption of fixed capital described in the previous section. The resulting matrix is shown in Table 2.14. The row and column 9a are moved within the monetary boundary and another row and column, 2d are introduced to show the use of these assets. All the balancing items are now prefixed by ‘dp’ to show they are now depletion adjusted rather than simply net. (This example assumes that the third option in the last paragraph is adopted. If instead only extraction of mineral deposits is to be shown in the flow accounts, there will still be an entry below the flow accounts matrix for discoveries.)

2.163. Based on the numerical example of the SEEAland data set, and assuming these data are realistic for an economy well endowed with natural resources, some illustrative numbers are given in Table 2.15 below. A more detailed version of the same information is given in Table 10.4 in Chapter 10.

Ownership

2.164. There is an interest not only in the total level of extractions being made from the environment, but to whom the benefits of extractions are accruing. The question of the allocation of resource rent between the extractor and the owner is discussed in Chapter 10. In many countries government retains ownership as guardian for the public and what are described as taxes may sometimes represent the economic return to government as owner of the asset. It is the desire to be able to follow through the beneficiaries of resource rent which leads to dealing with environmental accounting within the full SNA system and not just within the context of a supply and use table.

Table 2.15 Illustrative figures for domestic product adjusted for extraction and depletion

		Billion currency units	Index (GDP=100)
1	Gross domestic product	692.4	100
2	Consumption of fixed capital	104.4	
3=1-2	Net domestic product	588.0	84.9
4	Decline in the value of resource stocks due to extraction	58.6	
5=3-4	Extraction adjusted domestic product	529.4	76.5
6	Decline in the value of resource stocks due to extractions net of discoveries/natural growth	12.8	
7=3-6	Depletion adjusted domestic product	575.2	83.1

Source: SEEAland data set.

Ecosystem inputs

2.165. Ecosystem inputs cover the use of water, oxygen to breathe and permit combustion and other natural inputs required to sustain plant and animal growth. If it were possible to place a value on the stock of these inputs, it would in principle be possible to treat them exactly in line with natural resources. However, this is neither practical nor especially interesting. On the whole it is the quality of air which is of concern rather than the physical quantity. This is sometimes true also for water though there are increasing situations where there is a real scarcity of water. If such situations persist, it is probable that water will come to attract a market value and in that case can be incorporated in the accounts following the principles outlined above.

2 *Accounting for defensive expenditure*

2.166. The scope of defensive expenditure is not well defined and is potentially extensive. In order to be specific, the discussion in the handbook centres around the subject of environmental protection expenditure while recognising that there may be other types of expenditure with as good a claim to be "defensive" as this.

2.167. A number of commentators suggest that defensive expenditure should be simply left out of national accounts calculations. Others suggest it be reclassified from final consumption to intermediate consumption. Chapter 10 looks at these propositions and explains why they are not plausible in accounting terms. Basically, it is not possible to delete an element from the accounting matrix, or reallocate it, without working through the consequences to ensure that the final system still balances for each row and column pair.

2.168. A symmetric treatment of environmental protection expenditure by government and industry cannot be achieved by simply omitting some part of the accounting system. However, we can achieve a form of symmetry by reclassifying some of the existing transactions.

2.169. Roads represent fixed capital formation. They are subject to extensive repairs and maintenance to keep them in a good state. The 1968 SNA took the position that repairs and maintenance would be sufficient to ensure a road lasted for ever and thus there was no consumption of fixed capital allowance for roads in that version of the system. Gross capital formation was taken to be also a measure of net capital formation and all repairs and maintenance were treated as intermediate consumption[1]. There is another possible way to reach a similar position though, one which was in use in a number of Scandinavian countries before they adopted the 1968 SNA. This was sometimes known as the " gross gross" method of recording capital formation (Aukrust, 1994). Under this, all repairs and maintenance were recorded as part of gross capital formation and that part which would otherwise be counted as current repairs were treated as a form of consumption of fixed capital thus eliminating the double counting just introduced.

2.170. The gross gross approach to recording of environmental protection expenditure is one way to achieve a symmetric treatment of such expenditure by government and industry. If the expenditure undertaken by an industry is treated as both capital formation and consumption of fixed capital, the level of output of the industry on its other products will not alter. GDP will increase by the amount of the environmental protection expenditure but net domestic product will not change. The change in classification of government current environmental protection expenditure to capital formation will not affect GDP, though some final consumption will now appear instead as fixed capital formation. On the other hand, net domestic product will fall by the amount of this expenditure just reclassified. In this way we have a symmetric recording of environmental protection expenditure between industry and government and the gap between GDP and NDP is increased by the whole amount of this expenditure, by increasing GDP by the current expenditure by industry and reducing NDP by the current expenditure by government.

2.171. Total expenditure on environmental protection expenditure in the SEEAland data set is of the order of two per cent of GDP. About half is in the form of intermediate consumption and one third in final expenditure. If the suggestions above are implemented, then GDP increases by about one per cent and NDP decreases also by about one per cent. The combined effect is to increase the gap between GDP and NDP by

[1] This position was changed in the 1993 SNA recognising that even with regular maintenance roads eventually need complete renewal. This is not the present point at issue though.

about two per cent, a figure roughly commensurate with the change caused by including a depletion adjustment to the accounts. Details of these calculations are given in Table 10.5 of Chapter 10.

3 Accounting for degradation

2.172. There are two problems raised by the question of how to incorporate the effects of degradation in the national accounts. The first is how to place a value on degradation; the second how to locate this valuation in the accounts.

2.173. One answer to both problems is not to change the accounting system but change the economic system the accounts are trying to measure. The goal is not really to measure degradation "perfectly" but to devise policies which reduce the causes of degradation. This leads to asking how much it would cost to avoid the generation of residuals by changing production and consumption patterns. Any non-trivial change in these patterns will have consequences throughout the whole economy so a full answer must call on the techniques of modelling to calculate the effects.

2.174. The other approach is to look at the damage caused by residual generation. In so far as pollution reduces the productivity of assets this should be taken care of in the measurement of consumption of fixed capital and the depletion of natural resources. For example, if the excessive use of pesticides or fertilisers eventually reduces the fertility of the soil, the agricultural yield will fall, affecting GDP directly, and the value of the land will also fall reflecting the decrease in the expected future yields. The impact on human health cannot be captured in this way however. Chapter 9 looks at the possibility of deriving an estimate for the damage to health caused by residuals. Such an approach is a divergence from the standard SNA approach which makes no attempt to measure welfare derived from consumption, it simply records the costs as a (hopefully) objective measure of minimum satisfaction gained. However this too, like the modelling approaches mentioned above, is an important development for statisticians in government to be aware of.

2.175. It is very instructive to make estimates of the costs of avoiding residual generation and the benefits to be gained (that is the avoidance of damage) and most of Chapter 9 is concerned with the possible techniques which may be used and their comparative strengths and weaknesses. Many of the uses will be in the context of particular projects or situations and indeed this may be the context in which valuation of degradation is used. It is possible, though, to contemplate how a global adjustment for the valuation of residuals would affect the accounting framework developed above and the implications for macro-aggregates.

Cost-based estimates of valuing degradation

2.176. There are two main types of cost-based estimates. The first of these is the maintenance costing technique advocated in the 1993 SEEA. It is a fairly straightforward application of the accounting techniques used in Chapter 5. It attempts to answer the following question:

> *What would the value of net domestic product have been for the same level of activity if all the costs of environmental degradation had been incurred and internalised within market prices?*

2.177. The problem with this approach is that if the question is posed in respect of significant changes in environmental standards, the resultant price rises involved are likely to bring about a change in behaviour which would affect the level of demand for those products. In turn this would show up either as a change in the level of output of those products or a change in the technology of production to reduce dependence on the newly expensive products. Nevertheless, for marginal changes in standards, this technique may be used to give an upper bound on the impact on NDP from moving to more rigorous environmental standards. The aggregates from such an exercise are referred to as "environmentally adjusted". In principle this adjustment can be applied to either gross or net measures of domestic product or national income so that a family of measures is available. They are referred to here as eaNDP, eaNNI etc. (In the 1993 SEEA, eaNDP was referred to simply as EDP. More exact abbreviations are used here to make clear whether gross or net concepts are implied.)

2.178. The second type of cost-based estimates, known as "greened economy modelling" attempts to resolve the problems raised by maintenance cost approaches for the non-marginal cases of changes in environment standards. They attempt to answer the following question:

> *What level of GDP could be achieved if producers and consumers faced a different set of relative prices in the economy due to the existence of actual prices for environmental functions?*

2.179. The philosophy underlying this approach is that the only way to achieve given environmental standards is to change the patterns of economic behaviour. It is thus a modelling approach whereby the least cost solution to achieving these standards over a given time path is determined within a CGE (computable general equilibrium) model where the levels of output, demand, prices and incomes can all be altered and all implied costs are fully internalised. Again there is a similar family of aggregates resulting which are designated by the prefix "ge" as in, for example, geGDP. These measures are to be seen as forward looking estimates and not *ex-post* accounting measures.

2.180. A particular application of greened economy model aims not just to determine a set of values for output, demand and so on which satisfy the national accounting balances but to determine levels of output which lead to levels of income which are sustainable over a given time period. It attempts to answer the following question:

> *What level of income and environmental functions can be sustained indefinitely?*

2.181. Built into the model is a very firm commitment to maintain environmental standards to the point of restricting economic activity as necessary to achieve this. It is thus the only measure which addresses the question of long-term sustainability directly but is the most complex in terms of the model specification. The main aggregate from this approach is referred to as SNI, sustainable national income.

Damage based methods of valuing degradation

2.182. Damage based measures derive from the impact of actual residual generation. The starting point is the table of residuals generated as in Chapter 3 and then the impact on different "receptors" is estimated. When the damage is inflicted on economic assets, the impact should be captured in measures of consumption of fixed capital and environmental depletion but this may not always be the case in practice. One of the biggest impacts, though, could be on human health. In line with an extended Hicksian definition of income, "damage-adjusted income" is derived from net domestic income by deducting all damages arising from the impact of residual generation including those to health. It attempts to answer the question:

> *What is the impact on the level of NDP of environmental impacts on natural and man-made capital and on human health?*

2.183. "Damage-adjusted income" is thus a first step on the way to converting GDP type-measures to welfare indices. Many other aspects of welfare are deliberately ignored. In terms of current account transactions no attention is paid to consumer surplus, utility considerations, or the value of household services, for example. In terms of an extended measure of wealth, both natural capital and that aspect of human capital relating to health are covered, at least in terms of changes. However, no extension to social capital or a more comprehensive form of human capital including education is made. More importantly, no inclusion is made for the services which result from an undamaged environment or the remaining services that an already polluted environment still provides. The damage-adjustments to macro-aggregates suggested here are thus better seen as measures of the difference to macro-aggregates that inclusion of this one aspect of welfare would cause, rather than an alternative estimate of the level of those aggregates.

Accounting aggregates

2.184. If the approach of the 1993 SEEA is followed on the maintenance cost approach to degradation, new estimates for intermediate consumption and capital formation will result without this extra expenditure being resolved in accounting terms. It can be used as an upper bound on the adjustments which would be necessary to the accounts for marginal changes to environmental standards. A full resolution, though, requires a modelling approach to determine where the extra supply for the newly demanded products comes from and what the consequences throughout the rest of the economy are.

2.185. This comes close to the 'greened economy" solution. Here no new accounting techniques are required. It is the economy itself which is being changed, not the accounting system.

2.186. The damage based approach is radically different from all other techniques suggested in the handbook since it moves away from pure market valuation as the means of quantifying economic flows. As indicated above, it is better seen as a way of making a comparative statement between two observations than as a way of giving an estimate for direct comparison with GDP or NDP as measured in the SNA.

4 Depletion and degradation

2.187. Many people concerned about the impact of the economy on the environment are more worried about the links brought about by excessive generation of residuals than with the use of natural resources. Whereas ten years ago it may have been true to say that the industrial countries cared about pollution and developing countries cared about resource use, there is no longer such a clear divide (if there ever was). Today all countries are concerned about the levels of residual generation especially in major urban areas and concern is also rising about the use of water as both an input and sink for activities.

H Background information

1 The SEEAland data set

2.188. All the numeric tables in this chapter use data from the SEEAland data set. SEEAland is a fictitious country which is resource rich, having oil and gas deposits, a large fish stock and extensive natural forests. It is industrialised and so produces a relatively significant quantity of various residuals. It boasts international transport carriers, which absorb ecosystem inputs from other countries and discharge residuals into their environment, and also a two-way tourist industry. Although SEEAland has some of the characteristics of a number of European countries which have implemented many of the parts of the SEEA described in the handbook, it has no known geographical location. The land area, size of population and exchange rate of its currency are equally unknown.

2.189. The economic accounts for SEEAland are consistent as far as they exist but are not complete. Information on the goods and services matrix exists in physical and monetary terms as detailed in tables in chapters 3 and 4. Information on environmental protection expenditure is given in Chapter 5 but there are no accounts for resource management activities.

2.190. Chapter 6 contains a full accounting matrix for SEEAland but at no point are all the property income flows (especially those relating to financial assets and liabilities) and transfers spelled out. Only those items relevant to environmental accounting are itemised.

2.191. The accounts are fully detailed in respect of the accounts for resource extraction industries and some related industries such as fish farming and mineral exploration. These appear in tables in chapters 7, 8 and 10.

2.192. All tables which are drawn from the SEEAland data set have this indicated as the source of the table. Partly for reasons of space, and partly to draw attention to the subject under discussion, different tables include different features of the data set. Nevertheless, they are all intended to be mutually consistent and coherent. Table 2.16 is intended as a reference table which brings together the main features of the tables running through later chapters. In some cases totals are shown without any corresponding components. These are where totals are sufficient to establish the integrity of the data set but the underlying detail is not particularly relevant to environmental issues so no disaggregation is available.

Table 2.16 Reference table for the SEEAland data set

	Flow accounts	Extraction of oil and gas		Forestry		Capture Fishery		Aquaculture	
		Use	Resource	Use	Resource	Use	Resource	Use	Resource
	Production account								
1.	Output		133 167		2 444		6 642		6 434
2.	Intermediate consumption	19 124		826		2 863		5 438	
	Of which environmental protection services								
	cleaner and connected products								
	Other								
3.	**Gross value added**	**114 043**		**1 618**		**3 779**		**996**	
	Taxes on products								
	Of which environmental taxes								
	GDP at market prices								
	Extended generation of income account								
4.	**Gross value added**		**114 043**		**1 618**		**3 779**		**996**
5.	*less* compensation of employees	6 738		413		1 390		431	
	less other taxes less subsidies on production	3 193		- 19		71		0	
	of which taxes on production	*3 210*		*0*		*95*			
	subsidieson production	*- 17*		*- 19*		*- 24*			
6.	***equals*** **gross operating surplus**	**104 112**		**1 224**		**2 318**		**565**	
7.	*less* services of produced biological fixed capital								
8.	*less* services of other fixed assets	45 858		668		1 486		368	
9.	*plus* returns to produced biological fixed capital								
10.	*plus* returns to other fixed capital		20 938		290		516		128
11.	***equals*** **net operating surplus**	**79 192**		**846**		**1 348**		**325**	
12.	*less* harvest of natural biological resources			242		82			
13.	*less* extraction of subsoil assets	58 254							
14.	*plus* returns to natural biological assets								
15.	*plus* returns to subsoil assets		28 870						
16.	*plus* natural growth of biological assets				0		0		
17.	*plus* discoveries of subsoil assets		16 631						
18.	***equals*** **depletion adjusted operating surplus.**	**66 439**		**604**		**1 266**		**325**	
	Distribution of primary income account, Secondary distribution of income account, Use of income account								
19.	**Depletion adjusted operating surplus**		**66 439**		**604**		**1 266**		**325**
	Imports								
	Exports								
20.	Compensation of employees								
	Taxes on products								
	Of which environmental taxes								
	Taxes less subsidies on production								
21.	Property income	45 500							
	Specific taxes on income from extraction	4 200							
	Taxes on income								
	Of which environmental taxes								
22.	Consumption expenditure								
	of which environmental protection services								
	cleaner and connected products								
23.	**Depletion adjusted saving**	**16 739**		**604**		**1 266**		**325**	
	Capital account								
24.	**Depletion adjusted saving**		**16 739**		**604**		**1 266**		**325**
25.	Gross fixed capital formation	30 778		269		1 087		304	
	Of which environmental protection services								
	purchase and sale of property rights								
26.	Consumption of fixed capital	-24 920		- 378		- 970		- 240	
27.	Change in inventories			- 120				311	
28.	Land improvement			0					
29.	Harvest of natural biological resources			- 242		- 82			
30.	Depletion of subsoil resources	-29 384							
31.	Natural growth of biological assets								
32.	Discoveries and reappraisals of subsoil resources	16 631							
33.	**Net borrowing or lending**	**23 634**		**1 075**		**1 231**		**- 50**	

Million currency units

Other industries		Owner of subsoil assets (government)		Households		Rest of the world		Nature		Total		
Use	Resource	Use	Resource	Use	Resource	Use	Resource	Use	Resource	Use	Resource	
	1137 713										1286 400	1.
635 749										664 000		2.
										8 900		
										600		
501 964										**622 400**		**3.**
										70 000		
										2 000		
										692 400		
	501 964										**622 400**	**4.**
324 453										333 425		5.
755										4 000		
1 195										*4 500*		
-2 440										*-2 500*		
176 756										**284 975**		**6.**
140										140		7.
193 118										241 499		8.
	140										140	9.
	115 226										137 099	10.
98 864										**180 575**		**11.**
										324		12.
										58 254		13.
												14.
											28 870	15.
									263		263	16.
											16 631	17.
98 864								**263**		**167 761**		**18.**
	98 864								**263**		**167 761**	**19.**
							363 000				363 000	
						403 000				403 000		
					333 425						333 425	20.
			70 000								70 000	
			3 000								*3 000*	
			4 000								4 000	
			45 500								0	21.
			4 200								0	
										68 000	68 000	
										2 000	*2 000*	
		159 000		347 400						506 400		22.
		1 800		*2 970*								
				600								
98 864		**-35 300**		**-13 975**		**-40 000**		**263**		**28 786**		**23.**
	98 864		**-35 300**		**-13 975**		**-40 000**		**263**		**28 786**	**24.**
112 300										144 738		25.
										100		
										3 000	*3 000*	
-77 892										-104 400		26.
1 071										1 262		27.
										0		28.
										- 324		29.
										-29 384		30.
								263		263		31.
										16 631		32.
63 385		**-35 300**		**-13 975**		**-40 000**		**0**		**0**		**33.**

2 Further information on specific accounting issues

2.193. The chapters which follow are intended to contain sufficient background to the different accounting issues so that someone without a detailed knowledge of the SNA can follow the argument. This explanation though is never as extensive as that given in the SNA and interested readers may wish to follow up on particular subjects. References to the SNA are frequent whether by chapter number or paragraph. (SNA chapters have Roman numbering.) In addition, and especially for those readers familiar with the SNA, Annex 9 contains a list of the accounting links between the SEEA and the SNA. Box 1.1 in Chapter 1 shows the links between the accounting issues and subsequent chapters.

Chapter 3 Physical flow accounts

A Chapter overview

1 Objectives

3.1. The economy as we know it cannot function without drawing in natural resources from the environment and using the environment to absorb the unwanted by-products of economic production. Measuring the flows of particular resources into the economy and emissions from it can therefore provide instructive information. It can show, for example, whether the amount of material passing through the economy is increasing, and whether it is increasing faster than the rate of growth of the economy or whether it is increasing in per capita terms. This can be especially useful in the case of trying to minimise the generation of dangerous wastes, for example.

3.2. Measuring physical flows is a non-trivial task. It requires large amounts of basic data, consistent classifications and units of measure and an agreed framework within which data can be structured at different levels of disaggregation. It also requires an understanding of the purposes for which the resulting tables can be applied. All of these are topics for this chapter.

3.3. Not only is information on physical flows directly useful, but working in physical terms does not in most cases require in-depth knowledge of economic accounting. For this reason, both the production and use of physical flow accounts may be more accessible to those who are orientated more towards the natural sciences than towards economics. While it is usually possible to compile data in physical terms without the corresponding economic values, compiling monetary accounts is facilitated by a foundation of physical accounts.

3.4. There are, of course, limitations to compiling data in purely physical terms. First, the scientific uncertainty surrounding physical estimates of natural resource or residual flows can sometimes be as large as the uncertainty surrounding economic measures. Second, in some cases physical estimates require the same information required for estimates of economic values. For instance, the quantity of oil classified as reserves depends on the future path of costs, oil prices and technology. Chapter 4 discusses the ways in which physical and monetary flow data can be combined to best exploit the advantages of both.

3.5. Concern for the use of the environment began with worry about the potential scarcity and accelerating use of natural resources. Increasingly, it has shifted to the question of waste emissions into the environment and the relation between these emissions and the economic processes which generate them. Emissions may be gaseous, liquid or solid and may be released to any of the environmental media (air, land or water) either directly or after having passed through a treatment process of some sort (a waste water treatment plant for example). Throughout this manual, the term "residuals" is used to describe wastes of all types. Formally, residuals are the incidental and undesired outputs from production and consumption processes that generally have no value (though the latter is not an absolute criterion). They may be collected, treated and temporarily stored within the economy but ultimately are released to the environment. A main object of this chapter is to measure the generation of residuals in physical terms and their passage from the economy to the environment.

This is done within the context of the other physical flows between environment and the economy and within the economy.

2 Accounting for physical flows

3.6. The accounting principle underlying the measurement of physical flows is simple. If we measure the total flows of a substance supplied to the economy, this must be equal to the total used by the economy and vice versa. This can be viewed also as saying that the sum of flows from all origins equals the sum of flows to all destinations. The simplest sort of account, a material balance, simply displays this equality for a substance or groups of substances.

3.7. Within the economy, however, substances are transformed. Suppose we consider someone with an axe felling trees in a forest. It is self-evident that the volume of timber existing at a moment in time is not altered by the activity but the standing timber is converted to felled timber which, presumably, will be put to some productive use, plus a small amount of chippings, which might also be used, say for firewood. Another person, panning for gold in a nearby river, changes earth into a pile of earth plus, hopefully, a small amount of gold which he will put to economically productive use (if only by selling it). In the process, though, he has utilised the river water and may have polluted it with other substances from the earth he removed from its original location. In a more sophisticated form of these activities, fuel consuming machinery may be used to fell trees and move earth. In this case the fuel for the machines becomes an input to the activity and the combustion process transforms the fuel into residuals released to the atmosphere to become an additional form of output.

3.8. However complex the process, though, if we scrupulously account for all inputs and outputs, we must be able to establish a balance because the first law of thermodynamics states that matter (mass or energy) is neither created nor destroyed by any physical transformation process whether of production or consumption. This law provides a logical basic principle for a physical bookkeeping system for the consistent and comprehensive recording of inputs, outputs and material accumulation. The environment also provides services which are essential for the continuation of life and desirable for a more enjoyable life. These are addressed in later chapters, but since they cannot be expressed in physical terms any more than economic services they do not enter into the accounting described in this chapter.

3.9. Following the material balance principle, the physical flow accounts are constructed in such a way that net material accumulation is equal to the excess of total inputs over total outputs. This identity may be expressed in terms of inputs and outputs, or in terms of supply and use. It also presupposes a “direction” of flows; what is an outflow to one area is an inflow to another and vice versa. The particular case of interest here is the flows between the economic and environmental spheres.

3.10. For an economy and an environment that is entirely self-contained with no flows to and from the rest of the world, the identity could be expressed simply as

Total inputs to the economy from the environment

= total outputs from the economy to the environment

plus net material accumulation in the economic sphere

Or equivalently as

Total inputs to the environment from the economy

= total outputs from the environment to the economy

plus net material accumulation in the environmental sphere

In this case, the net material accumulation in the economy is of equal but opposite sign from the net material accumulation in the environment.

3.11. In reality, though, flows with the rest of the world have to be taken into account. Before doing this, it is useful to consider a simple disaggregation of the substances whose flows are to be measured. Resources consist of two types of substances being drawn from the environment to the economy. Natural resources correspond to mineral and energy resources, soil, water and biological resources. Ecosystem inputs consist of the gases necessary for combustion and production processes and the inputs needed for biomass growth (carbon dioxide, water and nutrients). Products are generated within the economy and circulate within it. Residuals are those incidental and undesired flows which are generated during production and consumption. They may or may not remain within the economy for some time but eventually are expelled from the economy into the environment.

3.12. If we consider the national economy and the national environment and also the economy and the environment for the rest of the world, we can draw up Table 3.1 showing the types of flows of interest.

3.13. The largest entries are in the upper left hand segment of the table showing the interactions between the national economy and the national environment. Natural resources and ecosystem inputs flow from the environment to the economy and residuals flow in the opposite direction.

3.14. The upper right segment of the table shows the flows from the national economy and environment to those of the rest of the world and the lower left show the flows from the rest of the world to the national economy and environment. Although these flows will typically be smaller than those in the upper left segment, they are important in examining the interaction between one country and another.

3.15. The only products shown in this table are those passing between the national economy and the economy of the rest of the world. These are imports and exports. Flows from the rest of the world environment to the national economy consist of natural resources and ecosystem inputs absorbed by national units operating abroad. These units may also emit residuals to the environment of the rest of the world. Symmetric entries occur for foreign units operating within the national territory. In addition there are flows of residuals between the national environment and the rest of the world environment transported by wind and water.

3.16. Except for the element where the first row and first column intersect, the other blank cells are not dealt with in this manual. They encompass flows within the national environment or within the rest of the world economies and environment and are thus beyond the immediate boundary of interest.

3.17. The top left element within the table consists of flows within the national economy. For many physical flow tables these flows are included but for some purposes they are consolidated out, as in Table 3.1, leaving only the flows into and out of the national economy visible.

3.18. Section B describes in detail the various accounting rules necessary to build up a set of physical flow accounts. Section C describes the basic principles underlying the compilation of supply and use tables in physical terms. Supply and use tables are shown for each of ecosystem inputs, natural resources, products and residuals separately and then in combination in a number of alternative formats.

Table 3.1 Typology of flows between the economy and the environment

From \ To	National economy	National environment	*Rest of the world economy*	*Rest of the world environment*
National economy		Residuals	*Products (Exports)*	*Residuals*
National environment	Natural resources Ecosystem inputs Residuals		*Natural resources* *Ecosystem inputs*	*Residuals*
Rest of the world economy	*Products (Imports)*	*Residuals*		
Rest of the world environment	*Natural resources* *Ecosystem inputs*	*Residuals*		

3 Elaboration of the accounts

3.19. A number of different accounts are elaborated in Section D to demonstrate the flexibility of the system in practice.

3.20. The first two examples deal with alternative ways of treating the recording of physical flows. The first example deals with the recording of recycling and waste handling and the second with the measurement of the growth of cultivated plants and forests.

3.21. Physical supply and use tables can be compiled for one or a group of substances by origin (supply) and destination (use) of the flows. They may cover a natural resource and its conversion to a product and residuals. If subsequent stages in the use of the product are similarly tracked, then a "product cycle" analysis can be derived. The third example in Section D shows such an elaboration for timber and forest industry products.

3.22. The other types of accounts are those used for material flow accounting (MFA) and physical input-output tables (PIOT). Conceptually there is little to distinguish these and each may be considered as a special case of supply and use tables for physical flows. However, they differ with respect to detail and focus. They may cover groups of substances or all substances entering, circulating in and leaving the economy. Both show the supply of products, natural resources and ecosystem inputs, and how these are transformed to other products, residuals and a balancing item, the net material accumulation in either the economic or environmental sphere.

3.23. MFA is typically simpler to produce with respect to the direct national flows. It concentrates in particular on flows of resources and residuals and less on flows within the economy. Full economy-wide MFA however, also requires information on so-called indirect flows and unused extraction. This material is less easy to estimate robustly. PIOT on the other hand, specifically elaborate the flows of products within the economy in a fair degree of detail so that the uses of resources and causes of residual generation can be identified closely. Examples of both MFA and PIOT are also given in Section D.

4 Scope and limitations of the accounts

3.24. While this chapter aims to give a comprehensive overview of the systems of physical flows in common use, it should be recognised that a complete implementation of the accounts here is very ambitious and by no means always necessary for particular studies. The examples given in Section D are intended to demonstrate what can be achieved with more modest implementations. These examples use the general principles outlined in the chapter but limit their applicability to specific environmental problems. This is likely to be the most useful way of approaching physical flows, especially for those embarking on the work for the first time.

3.25. While endorsing the use of physical flow accounts for purposes such as these and noting the economy-wide application as the conceptual setting for them, it is also appropriate to point out some aspects of environmental accounting which are less well covered by this form of physical accounting.

The limitations of aggregation

3.26. A comprehensive implementation of physical flow accounts may result in the recording of hundreds of different substances. As a consequence, communicating the results of the flow accounts requires some degree of aggregation. The economy-wide physical flow accounts presented in Section C require the aggregation of all physical flows using a common unit of measure (usually weight). While the result of this complete aggregation of various materials might serve as a measure of the overall physical size of the economy, it immediately raises questions of interpretation. The implication of an upward or downward movement in such a measure is difficult to determine because the simple aggregation of flows by weight does not account for the other characteristics of the individual materials being aggregated. In particular, it says nothing about their relative impact on the environment. A downward trend in total material flows might be the result of, for example, less use of construction materials that account for a significant share of total material flows in most countries but are relatively benign from an environmental perspective. Such a decline could easily mask an increase in the flows of toxic chemicals, which are used far less in weight terms but have a far greater potential impact upon the environment and human health. Figure 3.1 shows that often the unit toxicity of material flows is negatively correlated to the corresponding volume or mass. Development of this sort would likely be considered undesirable despite the positive trend indicated by the aggregate physical flow measure.

3.27. One means of improving the interpretability of physical flow accounts without abandoning aggregation altogether is to aggregate groups of materials with common characteristics, such as those that contribute to a given environmental issue. For, example, all of the gases that contribute to the greenhouse gas effect can be combined into a single aggregate measure expressed in terms of carbon dioxide equivalent emissions. This can be done because scientists have developed a rigorous weighting system (known as the global warming potential) that allows each greenhouse gas to be expressed in terms of its warming potential relative to that of carbon dioxide. An aggregate measure of greenhouse gases has the advantage of compressing a considerable amount of information into a single measure without the risk of masking important changes in the flows of the individual gases that make up the aggregate.

3.28. Several other weighting procedures which take potential environmental impact into account and which are internationally applied are available:

the conversion of halogenated hydrocarbons that contribute to the depletion of the ozone layer into CFC-11 equivalents according to their ozone depleting potential (ODP);

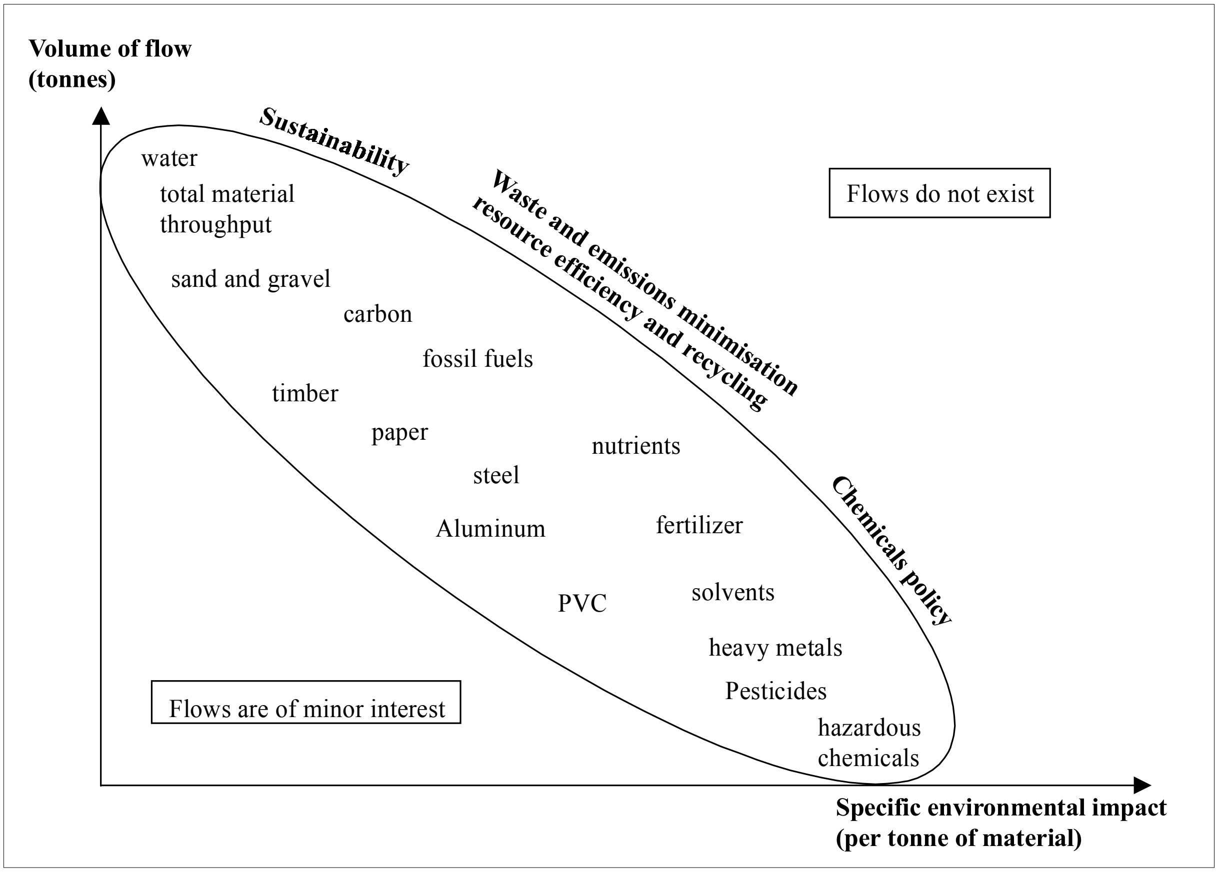
the conversion of sulphur and nitrogen oxides and ammonia into acidification equivalents (H^+ ions) on the basis of their relative acidifying potential (AP);

the conversion of nitrogen containing residual flows (waste water discharges and air emissions of NO_x and NH_3) into kilograms of nitrogen in relation to their eutrophication potential (EP) in marine areas;

the conversion of phosphorous and nitrogen compounds (waste water discharges and air emissions of NO_x and NH_3,) into phosphorous equivalents according to their contributions to eutrophication potential (EP) in inland water bodies;

the conversion of toxic pollutants on the basis of predicted no observable effect concentrations (NOEC) with respect to ecosystems or acceptable daily human intakes (ADI).[1]

Figure 3.1 Environmental impact and volume of residuals



Source: Steurer, 1996.

3.29. In addition to aggregating materials according to environmental issue, or theme, it is often useful to convert the flow of a processed material used into an equivalent flow of the same material in its natural state to ensure double counting is eliminated and to identify so-called hidden flows. Further, different energy products can be meaningfully aggregated if they are denominated using a measure of energy content (Joules or tonnes of oil equivalent).

3.30. While the aggregation of materials according to environmental issue or some other shared characteristic offers a means of avoiding the disadvantages related to use of a single measure, it should be noted that the possibilities for doing so are somewhat limited. There are many more materials for which no weighting scheme is available than there are those for which one is available. The greatest promise for adding to this number is to increase the number of toxic materials for which the relative toxicity is known. This requires sophisticated research however and progress will likely be slow. In the meantime, when dealing with materials for which no weighting procedures are available analysts will be faced with two options: 1) aggregate all materials on the basis of weight and encourage users to use caution in the interpretation of the

[1] The applicability of this particular weighting procedure is limited since the NOEC is known for relatively few toxic compounds.

results; 2) build accounts on a material-by-material basis and avoid altogether the creation of potentially misleading measures, and, where possible, aggregate these materials by common characteristics.

The time and space dimensions

3.31. Problems caused by residuals relate not only to the flows in the current period but to the past and future periods because of the ability of residuals to cumulate. The effect of the same level of current flow of a residual may be quite different depending on the level already accumulated at the beginning of the period. The question of measurement of stocks as well as flows is addressed in Chapter 7 but it can be noted here that measurement of stocks is easier for natural resources than it is for residuals because the technical characteristics of a unit of a natural resource do not alter depending on the stock level in the same way as the impact of a unit of a residual does. The damage inflicted by the ambient concentrations of a residual often increases non-linearly with the amount of residual generated. (The price of a natural resource does of course alter to reflect increasing scarcity whereas in general there are as yet few prices relating to the use of the environmental media as sinks.) The accounts described in this chapter detail only the quantity of residuals generated in a single period and do not reveal the consequences of cumulating this amount with past or future amounts of the same (or other) residuals.

3.32. Some environmental concerns relate to particular events, such as the wreck of an oil tanker or a flood. Often the impact at national level over a whole year may not be very significant but it is very significant at the given time to the particular locality. While in principle accounts such as those described in this chapter could be compiled for smaller areas and shorter periods, it is unlikely that all the data and staff resources to do this will be available. Some of the impacts of mechanical disruptions, hydrological changes and structural landscape alterations may be captured in the sorts of accounts on land use or land cover described in the section on land accounting in Chapter 8.

3.33. However, comprehensive translation of residual flows into consequences in terms of changes in quality as well as quantity of assets is considered to be beyond the scope of the SEEA. It is unlikely that a comprehensive description of cause-effect relationships can be laid down in a bookkeeping system since these are often characterised by non-linear and multidimensional factors. In the SEEA the steps that can be taken to bridge the gap between cause and effect are the following.

The accounts can be disaggregated spatially to concentrate on a particular environmental domain or "eco-region" or can be constructed for wider areas to take into account all relevant cross border pollution flows.

The accounts can provide a linkage of residuals to different environmental problems or themes. This is discussed in more detail later in this chapter and in the next. Sometimes policy targets are even formulated on the basis of these types of aggregates. Internationally applied examples are the targets related to greenhouse gas emissions, emissions connected to ozone layer depletion and acid rain.

One particular consequence of residual emissions of major concern is the impact of residuals on health. In order to study the health impacts, it is necessary to make the conversion from residual emission in a given period to the present level of ambient concentration. The technique used is known as estimating "dose-response" functions. Chapter 9 discusses in detail the question of estimating damages.

Accuracy considerations

3.34. Lastly, a word should be said about the limits to the accuracy of physical accounts. The estimates of environmental residuals can represent differences between quite large items for supply and use. It is not always the case that physical measures are more accurate than monetary ones. While most statisticians are conscious of the accuracy problems surrounding economic accounts, it is easy to think that physical accounts are somehow more amenable to exact measurement. In some cases this is so but in some cases physical measures will be obtainable only by dividing a monetary value by a price, both of which may be subject to measurement error. Nor can all conversion factors be estimated precisely and so it should be realised that there will inevitably be an element of inaccuracy within the accounts.

B Accounting rules

3.35. In order to compile physical flow accounts, we must establish various sets of accounting rules: what units are most suitable; what types of flows are to be measured; and the origin and destination of the flows.

1 Units

3.36. Physical flows are made up in quantity units, which describe the physical characteristics of the material, energy or residuals in question, and a specific physical flow can be made up in alternative units depending on the physical characteristic that is taken into consideration. Obviously, the appropriateness of one particular unit depends on the purpose and intended use of the flow account. Standard units of quantity for products as recommended by the World Customs Organisation are listed in Box 3.1. These standard units are recommended in the collection and reporting of international merchandise trade on the basis of the Harmonised System. However, for physical flow accounting, weight (kilograms) and volume (m^3 or litres) are the most frequently used physical characteristics. As far as goods are concerned, the units for weight can be used either net (exclusive of packaging) or gross (inclusive of packaging). While information on gross weight can be useful in relation to analysis of transport needs, separate accounting for the goods and the related packaging is normally to be preferred.

Box 3.1 Standard units

Weight	kilograms (kg)
	Carat (carat)
Length	metres (m)
Area	square metres (m^2)
Volume	cubic metres (m^3)
	litres (l)
Energy	Joules
	tonnes of oil equivalent (toes)
Electrical energy	1,000 kilowatt-hours (1,000 kWh)
Number (units)	pieces/items (u)
	pairs (2u)
	dozens (12u)
	thousands of pieces/items (1,000u)
	packs (u(set/pack))

Source: Customs Organisation, 1996.

3.37. Throughout this chapter the unit of tonnes is usually cited but the option to work in other units when appropriate should be kept in mind. This is especially the case with energy flows where joules or tonnes of oil equivalent (toe) are the most common unit used.

2 Types of flows

3.38. If we consider the flows between and within the economic and environmental spheres, we need to identify flows from the environment to the economy; flows within the economy and flows from the economy back to the environment. In addition we may wish to consider some flows whereby material is relocated or transformed by economic activity but without leaving the environmental sphere. Four different types of flows are distinguished in the SEEA. ***Natural resources*** cover mineral, energy resources, water, soil and biological resources. ***Ecosystem inputs*** cover the water and other natural inputs (e.g., nutrients, carbon dioxide) required by plants and animals for growth, and the oxygen necessary for combustion; this excludes water, nutrients or oxygen supplied as products by the economy. ***Products*** are goods and services produced within the economic sphere and used within it, including flows of goods and services between the national economy and the rest of the world. ***Residuals*** are incidental and undesired outputs from the economy that have a value of zero (or a negative value) to the generator. "Residuals" is the single word used in the SEEA to cover all solid, liquid and gaseous wastes. They may be recycled or re-used, or (more usually at present) discharged into the environment. It is important to note that residuals may have a positive value for a unit other than the generator; for example, household waste collected for recycling has no value to the household but may have some value to the recycler. Scrap materials that have a value realisable by the generator (discarded equipment for example) are treated as products and not as residuals. This topic is discussed further in the first example in Section D.

Natural resources

3.39. As just noted, natural resources cover mineral, energy resources, water, soil and biological resources. At the moment when they are sold on markets, they enter the economic sphere and should thereafter be characterised as products in the same way as processed resources or materials.

3.40. The set of natural resources considered in the physical flow accounts closely corresponds to those environmental assets described in Chapter 7 (excluding cultivated biological assets which are regarded as products). The sub-set of asset types which are relevant in connection with physical flows is shown in Annex 2. Usually, the classification for physical flow accounts for natural resources will be more specific than indicated by the classification shown in Annex 2. For example, fossil fuels (classification code EA.111) can be subdivided into coal, lignite, peat, crude petroleum and natural gas; metallic minerals (EA.112) can be subdivided into gold ore, silver ore, iron ore and so on, while aquatic resources (EA.143) might be subdivided according to various species of fish.

3.41. While the asset classification shown in Annex 1 can be used as a starting point for the classification of the physical flows of natural resources, it is sometimes instructive to use a cross-cutting classification. For example it may be desirable to show which energy flows relate to non-renewable energy (EA.11) and which to renewable energy in the form of biomass (EA.14). Some types of renewable energy like solar, hydro and wind energy are not included explicitly in the asset accounts but are relevant in relation to the physical flow accounting of natural resources. These types of energy may be included in the accounts under the heading renewable energy as an extension of EA.11.

Ecosystem inputs

3.42. There is an important distinction to be made between ecosystem inputs and ecosystem services. Ecosystem services are much wider and include the assimilative capacity of the environment and the provision of biodiversity. Ecosystem inputs are restricted to the substances absorbed from the ecosystem for purposes of production and consumption such as the gases needed for combustion and production processes as well as oxygen, carbon dioxide, water and nutrients. Unlike natural resources, ecosystem inputs are not easily identifiable in any of the products to which they contribute. Care must be taken not to count as ecosystem inputs any chemical substances, water, feeding stuff etc. which are a result of production.

3.43. Although the ecosystem inputs are well-defined in principle and should be regarded as distinct from the output from the production processes which use them, pragmatic reasons might lead to an accounting procedure whereby the volume of ecosystem inputs is set equal to the harvest of biomass resulting from the absorption of ecosystem inputs. This is discussed in greater detail in the second example in Section D.

Products

3.44. Products are defined in the SEEA to be consistent with the SNA. The SNA defines products as the results of production (1993 SNA, paragraph 2.49) including both goods and services. Cultivated biological assets are also regarded as products. Obviously when measuring physical flows it is goods and not services which are of main interest. However, the supply of some services may also involve the delivery of goods as is the case in the supply of hotel and restaurant services and the provision of government services.

3.45. Products can be classified according to different criteria and objectives and a number of international standards exist (for example the Harmonised Commodity Description and Coding System, the Standard International Trade Classification, and the Central Product Classification). The 1993 SNA introduced the Central Product Classification (CPC) for this purpose. It should be noted that the CPC has been developed primarily for economic analysis and that supplementary classifications may be used for the analysis of physical characteristics. For example, the chemical abstract system (CAS) together with a toxicity database can be used to identify harmful effects of chemicals. However, in order to ensure international comparability and coherence with the SNA it seems appropriate to ensure that any supplementary classification introduced in the physical flow accounts can be re-aggregated to the CPC. Annex 3 illustrates various parts of the CPC that are of interest in relation to physical flow accounting.

Residuals

Coverage

3.46. Residuals are the incidental and undesired outputs from production and consumption processes within the economy. The term "residuals" is used throughout the SEEA to designate such flows whether they are to land (including soil), air or water. The distinction between flows to these three "sinks" is made when, as is often the case, it is relevant.

3.47. The consumption of goods as intermediate inputs by service industries produces residuals, for example the tailpipe emissions from a bus that is powered with diesel fuel. The consumption of the service in general generates little in the way of residuals except, for example, a bus ticket thrown away by the passenger. Like services, goods generate residuals in the course of production but also when they are finally consumed and discarded. In physical accounting unlike in monetary accounting, it is the time of discard which is important not the time of acquisition of the goods. This presents an inconsistency when comparing monetary and physical accounts. For example, consumer durables are recorded as "consumed" in their moment of purchase in the monetary accounts but at the moment they are disposed of in the physical flow accounts.

3.48. It is important to note at which stage the residuals are generated and attributed. For example, food scraps coming from a restaurant will be treated as residuals coming from production; those coming from a carry-out service or from home catering are treated as residuals coming from consumption. The food consumed in a restaurant represents a physical flow from a service industry to households just as the consumption of food from a carryout service does.

Landfill sites

3.49. Residuals are often disposed of in landfill sites and there are different ways in which these flows can be handled. The approach adopted in the SEEA is to say that the operation of managed landfill sites is a productive activity; the landfill sites themselves are treated as a sort of physical capital formation. Because managed landfill sites are generally regarded as entities within the economic sphere, disposing of residuals at such sites is regarded as a flow of residuals within the economic sphere. When materials subsequently leak from a site into the surrounding air, soil or water (including from sites created before rigorous prevention measures were in effect), a flow of residuals from the economy to the environment should be recorded. The discussion of borderline issues below includes an alternative treatment of residuals disposed of in landfill sites.

Recycling, re-use and treatment of residuals

3.50. Increasingly, residuals are not discarded directly to the environment, but remain in the economic sphere to be ***recycled*** into new materials, ***re-used*** directly or ***treated*** prior to disposal to render them less harmful to the environment and human health.

3.51. Recycling is defined as the re-introduction of residual materials into production processes so that they may be re-formulated into new products. For example, the re-introduction of old newsprint into a paper mill as an input into the production of new newsprint is considered recycling. Re-use, on the other hand, occurs when a residual material is re-introduced into a production (or consumption) process and used as an input in its original form. Glass bottles that are returned to the place of manufacture to be re-filled with new beverage products are an example of the re-use of residuals. Recycling and re-use can occur spontaneously through market forces if an economic agent (other than the generator) sees an opportunity to generate revenue from sale of the residual. When market forces do not exist or are insufficient to incite the spontaneous recycling or re-use of residuals, government policy may be used to encourage these activities if they are thought to be socially desirable.

3.52. Treatment of residuals occurs when they are sent from the generator to an enterprise that specialises in processing them to change them either qualitatively or quantitatively before disposing of them in the environment or in a landfill site. Residual treatment is generally costly to the generator and does not generally result in a saleable material for the enterprise undertaking the treatment. For these reasons, it is usually mandated by government policy.

3.53. Collection and sorting of residuals for recycling and re-use can be carried out both by formal enterprises and, especially in developing countries, by individuals working in the informal sector. Pre-disposal waste treatment is generally carried out only by formal enterprises. Within the national accounts, a formal enterprise collecting and sorting residuals to extract items to recycle or re-use undertakes production. The value of this production is the value for which the items are sold, plus any supplementary service charges received from the generators of the waste. This must cover any costs involved (the running costs of the trucks to collect the residuals for example). Where individuals in the informal sector collect and sort residuals to find recyclable or re-usable products for sale, in principle this also should be recorded as production of an informal nature giving rise to mixed income. Units engaged in treating and disposing waste also undertake production, the value of which is equal to the revenues they generate by charging residual generators for the service they provide or the costs of production.

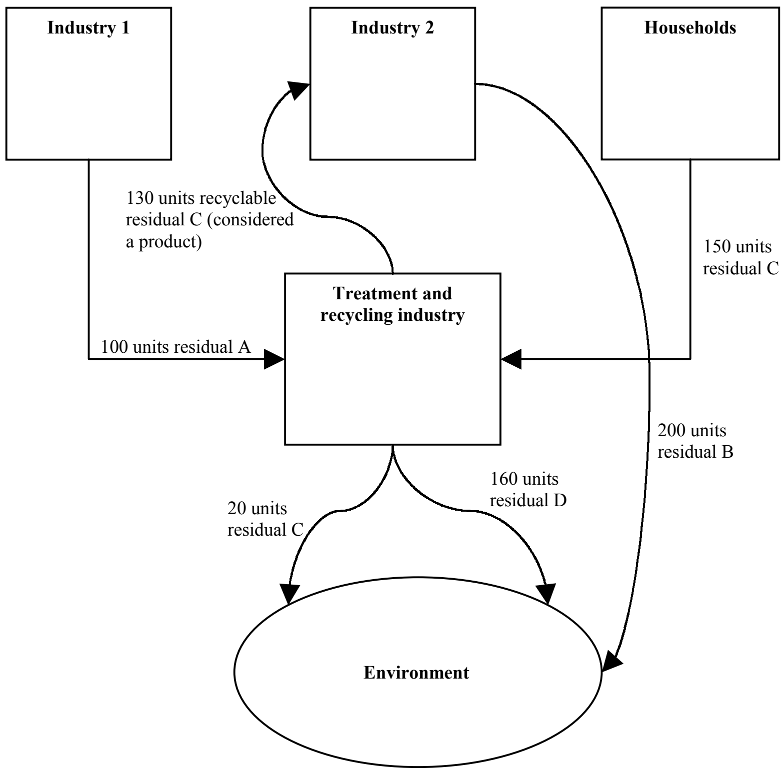
3.54. In the SEEA, recycling, re-use and treatment of residuals are all regarded as taking place within the economic sphere; that is, the residual flows associated with these activities occur within the economic sphere. The residual flows from the original generator are recorded as supply of residuals and the quantities that remain within the economy for recycling, re-use or treatment are shown to be “used” by industries.

Gross* versus *net residual flows

3.55. It is useful to distinguish the concept of ***gross residual flows*** from that of ***net residual flows***. Gross residual flows refer to the quantity of residuals generated by all units in the national economy during an accounting period (including leakages from managed landfill sites). Net residual flows refer to the quantity of residuals that is ultimately rejected into the environment (or into a landfill site) following any recycling/re-use or predisposal treatment.

3.56. One way of looking at the question of gross *versus* net residual flows is from the perspective of aggregate flows of residuals. Figure 3.2 presents a simple economy/environment system that is helpful in demonstrating how the flows in question can be calculated.

Figure 3.2 Residual flows in a simple economy/environment system



3.57. The economy portrayed in Figure 3.2 is very simple. It comprises just two goods-producing industries (1 and 2), a "residual treatment and recycling" industry plus households (for the sake of simplicity, the rest of the world is ignored). Figure 3.2 presents the residual flows within this simple economy and between it and the environment. As can be seen, industry 1 produces 100 units of residual A, all of which are sent to the treatment and recycling industry. Industry 2 produces 200 units of residual B, all of which are disposed of directly to the environment. Households produce 150 units of residual C, all of which are sent to the treatment and recycling industry. The treatment and recycling industry itself produces 130 units of recyclable residual C (which is no longer considered a residual but a product), which are purchased by industry 2. It also produces 160 units of residual D and 20 units of residual C which are disposed of in the environment.

3.58. Looking at this system from the perspective of aggregate residual flows, it is possible to see that the gross residual output of the economy (that is, the sum of all residuals produced by all economic units) is:

100 units A + 200 units B + (20 +150) units C + 160 units D = 630 units

3.59. It is important to recognise that there is an element of double counting of residuals in this gross flow. This is because all residuals that the treatment and recycling industry accepts and that are not diverted back into the economy for recycling/re-use must ultimately be disposed of again. These residuals are therefore counted twice in gross residual output; once for the original generator and then again for the treatment and recycling industry. The double counting of residuals in the economy portrayed in Figure 3.2 is equal to 120 units (that is, 100 units A + [150 – 130] units C). In order to eliminate this double counting and determine the amount of residuals ultimately disposed of in the environment, it is necessary to calculate net residual output. This is equal to gross residual output less the amount of residuals "used" by the treatment and recycling industry (630 – [100 + 150] = 380 units).[2] It will be noted that the difference between gross and net residuals (630 – 380 = 250 units) is greater than the double counting of residuals. The difference is made up by the 130 units of recyclable residual C that the treatment and recycling industry sells back to industry 2 as a product. Thus, the total double counting of *materials* in the system (residuals plus products) is equal to 250 units (120 + 130), which is exactly the difference between gross and net residual flows.

3.60. Another way of approaching gross and net residual flows is from the perspective of homogenous residuals. Here again, gross flows are equal to the sum of the flows of each homogenous residual from all economic units. Net flows are, as before, equal to gross flows less the amount of the residual "used" by the treatment and recycling industry. In the case of the economy in Figure 3.2, the following homogenous residual flows can be identified:

	Gross flow (units)	*Net flow (units)*
Residual A	100	100 – 100 = 0
Residual B	200	200 – 0 = 200
Residual C	150 + 20 = 170	170 – 150 = 20
Residual D	160	160 – 0 = 160

3.61. Some commentators argue that the concepts of gross and net residual flows are most meaningful in the context of homogenous residual materials or thematically related groupings of homogenous residuals (greenhouse gases for example). They note that comparing gross and net residual flows from an aggregate perspective can be of limited analytical interest, especially if one's interest is in studying the relative potential environmental impact of residuals before and after recycling/re-use and treatment. This is because the process of treating residuals before they leave the economy changes them such that net flows differ not only in quantity from gross flows but also in composition. This can be seen easily in the example portrayed in Figure 3.2. The figures immediately above show that the relative composition of the aggregate gross and net residual flows is very different. The gross flow comprises 16% residual A, 32% residual B, 27% residual C and 25% residual D. The net flow, in contrast, comprises 0% residual A, 53% residual B, 1% residual C and 42% residual D. Note that in the absence of the kind of information on homogenous residuals that has been included in Figure 3.2, nothing about difference in composition between gross and net flows can be reported. For this reason, simply recording gross and net residual flows in the aggregate reveals very little about their relative potential environmental impact, other than the fact that net flows are generally smaller than gross flows.

3.62. Comparing gross and net residual flows of homogenous wastes, on the other hand, is useful in understanding how effective the economy is in diverting specific harmful residuals from the environment. It can also be used to study the tradeoffs inherent in residuals treatment. For example, when solid residuals are incinerated, large amounts of various gaseous residuals are created, in addition to smaller amounts of new solid residuals (mainly ash), plus some liquid residuals. Compilation of the gross and net flows of homogenous residuals associated with incineration would be valuable in an analysis of the environmental desirability of incineration.

[2] Note that in a more complex economy, other industries in addition to the treatment and recycling industry would likely absorb residuals. The calculation of net residual flows would then have to account for all absorption, not just that by the treatment and recycling industry.

3.63. The weakness of compiling gross and net residual flows on the basis of homogenous residuals is that the number of materials to track may well be very large. Modern economies produce thousands of individual residual materials and accounting for them all would be a mammoth task. It is therefore probable that countries would choose to analyse flows for a selected number of homogenous residuals (say those related to a specific environmental issue) rather than for all residuals in the economy.

3.64. In many of the physical flow accounts presented later in this chapter the concepts of gross and net flows are, for the sake of simplicity, used in the context of aggregate residuals. The reader should bear in mind that these example accounts are intended to demonstrate the structure and accounting rules of the physical flow accounts; they should not be interpreted as the only possible approach to such accounts. Indeed, in many instances, physical flow accounts for homogenous materials are those that countries will wish to construct.

Dissipative residual losses

3.65. The concept of residuals embraces so-called "dissipative losses" from, for example, car brakes and tyres, abrasion from roads, zinc from rain collection systems on roofs, as well as residuals corresponding to "deliberate disposals" of products such as fertilisers and pesticides. Pesticides, fertilisers and compost, thawing materials applied to roadways in winter, and seeds are all examples of products deliberately transmitted to the environment and that thus need to be included in the flows from the economy into the environment.

Classification

3.66. Although the criterion that a residual is an output from production or consumption without monetary value to the generator may be theoretically correct, in practice residuals are usually defined and described by means of specific lists of materials. This has a number of practical advantages. The necessary information on whether a potential residual has a price or not may not be available in many cases, whereas the results of waste statistics can be utilised directly when following the list approach. Further, the strict use of the price criterion means that depending on the market situation, a material can either be defined as a residual or as a product in different periods or even in the same period, which may disturb the interpretation of the flow of residuals. A possible basis for such a list of residuals is the European List of Waste (European Communities, 2000) which would have to be extended for this purpose to include other residual flows such as waste water, water vapour and air emissions.

3.67. Currently there exists no complete classification for residual flows. One complication is that the flows of residuals overlap each other. For example landfilled or incinerated residuals result in emissions of gaseous and liquid wastes to the surrounding environment. The problem is to know how to deal with this double counting in a residuals classification. Multi-impact emissions make it difficult to allocate residuals to theme-specific classifications without accepting that there is a degree of double-counting. One suggested solution is to have separate classifications for gaseous, liquid and solid residuals. Such a classification is shown in Annex 4. It should be noted, though, that this classification could lead to double counting in practice and that for certain purposes it might be better to list various types of residuals without specifying the media which receives the residuals as an integrated part of the classification.

3.68. A desirable characteristic of a residuals classification is that it should provide information on the way particular material flows might influence the environment or human health. In other words, in environmental accounting, attention should also be paid to the qualitative aspects of material and energy flows. Because of changing concerns about specific residuals, for example hazardous materials, such a classification must be held under constant review if it is to remain relevant to emerging issues.

Borderline problems

Landfill sites

3.69. While the treatment of residual flows to managed landfill sites described earlier is conceptually sound, data availability and legislation in force in a given country may raise a number of issues.

Not all landfill sites are licensed and controlled. Some may be so poorly managed that there is little point in regarding their use as other than a straightforward disposal of solid waste to the environment. This also applies to dumping in undesignated places. Material moved in the course of construction may not go to any sort of landfill site but equally may not pose any risk to the environment.

Where both controlled and uncontrolled landfill sites exist, it may be difficult to determine the quantity and nature of waste going to each. As more costs are imposed for disposing legally of waste containing dangerous substances, so the risk of illegal dumping is likely to increase.

Even when a site is well managed, the question arises of how to treat it when it is full and sealed. Does it remain within the economy as a continuing form of negative land improvement or should it be treated as transferred to the environment at the point when it closes down?

While tracking the leakages from landfill to the environment is desirable in theory, it may be very difficult to obtain such information in practice. Only if the conditions of operating a landfill site stringently prohibit any leakages could such flows properly be regarded as linked to economic activity; more often they will simply reflect the conditions applied to landfill sites at the time they were opened. Thus the consequences for these sorts of flows even when waste going to landfill is recorded as remaining within the economy is still somewhat ambiguous.

3.70. For all these reasons, in practice some accounts may simply treat all disposals of residuals to landfill as immediate discharges to the environment. This simplified treatment has some consequences for the recording of residual flows. In particular leakages from landfill sites (for example methane) will no longer appear as flows from the economy to the environment but as flow within the environment. If the simpler approach is adopted, some simplification of the guidance which follows on compiling various parts of the physical flow accounts will result. This is not mentioned in each instance. The reader should simply note that flows to and from landfills should be replaced by flows to and from the environment.

In situ *uses*

3.71. A number of environmental assets are only used *in situ* and not actually absorbed into the economy through use. For example, functions or services provided by the environment such as watercourses for navigation, land for transportation, land and water as a sink for pollution. In such cases the natural assets provide services but there is no physical flow out of the environment. There is thus no physical product (good) corresponding to the use of the asset though it may be that a service charge could be levied on the use. In this case, there will be an asymmetry between physical and monetary accounts with the first showing a zero entry and the second a non-zero value.

Hidden or indirect flows

3.72. Some activities lead to the displacement of environmental assets but not to their absorption into the economic sphere. These are referred to as indirect or hidden flows. The most obvious example is the overburden from mining operations. In the example described in Section C indirect flows are not shown but alternative presentations are shown in Section D.

Water

3.73. Water poses a number of problems since it is possible for it to fall into any of the categories described so far. Water which is naturally absorbed by plants and animals through rainfall or natural watercourses represents an ecosystem input. Water in aquifers which may be extracted for use in the economy is a natural resource. Water which has been abstracted from an aquifer or a water course and is supplied via pipes to households for a fee is clearly a product. Dirty water which is returned to the environment is a residual.

3.74. Water which is abstracted by a farmer for irrigation but which is in excess of the amount absorbed by his plants or animals, or water used for hydro-power without being "absorbed" by the economy, could be regarded as either a natural resource, a product or simply a type of hidden flow. If extraction rights exist, it seems appropriate to treat the original water body as a natural resource, and the extracted water as a product, whether the extraction rights are paid for or not. On the other hand, the fact that over-irrigation and hydro usage simply re-locates the water and does not remove it from the environment suggests treatment as a hidden flow. Different choices are possible, depending on the analysis required. For example, water which has been used for irrigation but not absorbed by plants may itself have absorbed dissolved substances. Thus although it is returned to the environment and can be regarded as a hidden flow, there has been a quality change which it may be desirable to capture.

3.75. Water absorbed by plants and animals is normally treated as an ecosystem input when the plants and animals are within the production boundary (cultivated). If the accounts for natural resource (or product) flows include all water extracted for irrigation and drinking water, this will give rise to some double-counting. This means that in principle the accounts should allow for this transformation of natural resources into ecosystem inputs or that the natural resource extraction should be reduced by the amount of ecosystem inputs. However, in practice this will seldom be a problem either because the size of the ecosystem inputs are marginal compared to the often huge amounts of natural resource flows of water or because the natural resource flows on one side and ecosystem inputs on the other are treated in separate accounts for separate purposes. Only in the case of a total accounting for all flows do explicit measures need to be taken to avoid double counting. This topic is discussed further in the second example in Section D. The whole question of classifying and measuring water flows is discussed in greater detail in the section on water in Chapter 7.

3.76. Water which is piped to a household is a product. Waste water which is discharged to the environment is a residual flow. In between, there is waste water in the sewage system between the point of generation and the point of treatment in a waste water treatment plant. Even though the waste water in the sewage system remains within the economic sphere, it seems difficult to justify calling it a product. But it is also unsatisfactory to classify it as a residual going first to the environment and then reabsorbed by the water treatment plant. The solution is to label the emissions at the point of generation as gross residual flows (in keeping with the discussion earlier, it is not the overall flow that should be so labelled, but the flows of the constituent materials in the waste water). The treated emissions (of the individual constituents) from the sewage plant are then to be labelled as net residual flows. Note that in addition to the net flows of the constituent materials that entered the treatment plant, there will also be new residual flows from the plant (for example, sewage sludge). These new residuals may be disposed of in the environment (or in a landfill site) or re-used in production (as an agricultural fertiliser for example).

Flows of residuals to the economy

3.77. Household or industrial waste may not be sent to a landfill site but may be dumped (possibly illegally) in open country or by the roadside. Tankers at sea may wash their tanks (also illegally) or lose their cargo through being wrecked. Efforts might then be made to recover these residuals from the environment and bring them back into the economy either for treatment or consignment to a landfill site. This is the only case where flows of residuals from the environment to the economy should be recorded. In numerical terms, the amount may be small but in respect of particular incidents (the wreck of an oil tanker near a protected coast, say) or in particular locations may arouse a sufficient degree of concern to merit identifying these flows explicitly. Note that this particular category of flows is not included in the detailed exposition of the physical flow accounts presented in Section C.

3 Determining origin and destination of flows

3.78. In order to set up physical flow accounts, it is necessary first to determine the boundaries whose crossing marks an inflow or an outflow. Physical flows can be set up in relation to individual units, groups of units or for the national economy and national environment. Our initial concern will be with the last of these. It is necessary to consider what constitutes the economic sphere and the environmental sphere, then flows within the economy, between the economy and other economies, between the economy and the environment (in both directions), flows between the national economy and another environment and vice versa, and flows within the environment. Once these boundaries are established, the typology of flows in Table 3.1 can be converted into schematic accounts.

The economy/environment boundary

3.79. The economic sphere is defined in relation to the flows covered in the SNA. This means that all flows related to the three types of economic activity covered in national accounts (production, consumption and accumulation) are included. All products originate within an economy, specifically as the outcome from productive activities. Products may incorporate natural resources. Products are destined to be used in the same period in which they are produced in the production of other products (intermediate consumption), to satisfy final needs (final consumption) or to be used as capital in production of other products over a period of time (accumulation). Each of the three activities can generate residuals, among others, by burning fuel, by contaminating water or simply by discarding products in whole or in part when they are no longer wanted.

3.80. The environmental sphere includes all physical entities other than products. Corresponding to each national economy there is a national environmental sphere which is associated with the national territory including the surrounding sea area covered in an exclusive economic zone (EEZ) agreement and the airspace over the country. Open oceans outside an EEZ and airspace outside a national territory are part of the environmental sphere but not part of any country's *national* environment. The environmental sphere provides resources to, and receives residuals from, one or more national economies.

The boundary with the rest of the world

3.81. The boundary of the economic system is established in relation to production by defining "resident" units. While there is a large overlap between resident units and those located within the geographic boundaries of a country they are not exactly the same. For administrative reasons, an exception is made for embassies, consulates or military bases belonging to foreign countries which are by convention regarded as resident units of their parent country and also for the operations of international organisations on the national territory (1993 SNA, paragraph 4.163). Units intending to operate in a country for less than a year are also regarded as non-resident. These may be specialised construction firms or aid relief agencies, for example.

3.82. For the purposes of these accounts, it is also important to consider where units operate as well as where they are resident. The majority are resident and operate in the national territory. Some resident units operate abroad. For example transport equipment used for international travel and freight operate a good deal of the time outside the national territory. When this is so, the residuals generated at that time are vented into the environment but not the national environment. The reverse situation occurs also of course. Some forms of transport also absorb ecosystem inputs in the form of air for combustion. Equally fishing vessels operated by non-residents may extract natural resources (legally or illegally) from national waters. Thus there may be both ecosystem inputs and natural resource flowing from the environment of one country to the economy of another.

3.83. Tourist activity requires careful consideration. If tourists come to the national economy and use local buses, say, the cause of the pollution generated by the buses may be international tourism but it is generated by a national, resident producer, the bus company. If the tourists use their own cars, filled with petrol bought before they cross the border, then this is similar to international transport services; the residuals are generated by units resident in one country into the environment of another.

3.84. It may not always be practical to determine how much foreign tourists contribute to the residuals generated in a country and if it is thought that the flows in from foreign tourists approximately balance the flows out by residents travelling abroad, it may be acceptable to ignore this. For countries where tourism is a major net contributor to the economy, though, it will be highly desirable to estimate what the contribution to national residual generation by tourists is, both when using non-resident facilities (foreign airlines, say) and when using national facilities (for example the demand for water in hotels).

3.85. Table 3.2 gives a specific example of the orders of magnitudes which may be involved when measuring the sources and destinations of pollution in a country which is rather densely populated and adjacent to other densely populated areas.

3.86. The borderline problems between products and residuals and between products and natural resources were noted above. Similarly, the borderline between the national territory and the rest of the world may be varied, or in particular ignored, for some studies. For example, for the contribution of a particular economy to global warming, it may be of interest to know the total extent of emissions without necessarily distinguishing how much is expelled to the national environment and how much elsewhere.

4 Types of flows

3.87. The next stage in preparing physical accounts is to identify which flows of which substances are to be included.

Flows of natural resources

3.88. All natural resources originate in the environmental sphere. Some remain there and so do not enter the physical flow accounts even though they should be recorded in stock levels. Those which are drawn into the economy become immediately transformed into products; that is, they exist within the context of a market which puts a monetary value on them. This is also the case in principle for resources harvested for own account use, for example fuel wood collected by households, the extraction of construction materials and water, even though in practice valuation may be difficult. Because natural resources are converted to products when they enter an economy, few natural resources are shown as entering the national economy from another country's environment directly; such resources are generally routed through the originating country's economy and are shown as imports of products not of natural resources. One exception is fish where non-residents may be entitled to fish in national waters without the catch ever entering the national economy. Another is extraction of water from a jointly owned catchment area or watercourse. Flows of natural resources are shown schematically in the upper left quadrant of Figure 3.3.

Table 3.2 The origin and destination of pollution in the Netherlands, 1998

Million tonnes

	NO_x	SO_2	NH_3	P	N
Origin of pollution					
Emissions by residents	645	211	170	106	1 059
From the rest of the world					
Non-residents in the Netherlands	39	12			11
Transfer by surface water or air	64	64	19	22	411
Total origin	748	288	189	128	1 481
Destination of substances					
Absorption by producers (recycling etc.)				22	120
To the rest of the world					
Residents in the rest of the world	261	117			82
Transfer by surface water or air	396	77	90	18	553
Accumulation in the Netherlands					
Acidification	92	94	99		
Eutrophication				89	726
Total destination	748	288	189	128	1 481

Source: Statistics Netherlands, 1999.

Flows of ecosystem inputs

3.89. Like natural resources, ecosystem inputs flow from the environment to the economy. The largest and most obvious flows are from the national environment to the national economy. Other flows include the consumption of ecosystem inputs by resident producers operating outside their national territory, for example international transport carriers and tourists. Flows relating to ecosystem inputs are shown schematically in the upper right quadrant of Figure 3.3.

Flows of products

3.90. As long as we are considering only those flows which cross one of the boundaries demarcating either economy and environment or nation and rest of the world, the only product flows to be recorded are those which constitute imports and exports, that is flows between the national economy and rest of the world economies or vice versa. These flows are shown schematically in the lower left quadrant of Figure 3.3.

Flows of residuals

3.91. There are three classes of residuals flows to be captured.[3] The largest and most significant flows are from the national economy to the national environment. In the case where net residual flows are less than gross residual flows because of treatment or recycling prior to disposal, it is important that it be only the net residual flows that are recorded as the economy to environment flow. It is thus important to have a comprehensive description of the activities of waste collection, recycling and waste treatment (for example, incineration or waste water treatment).

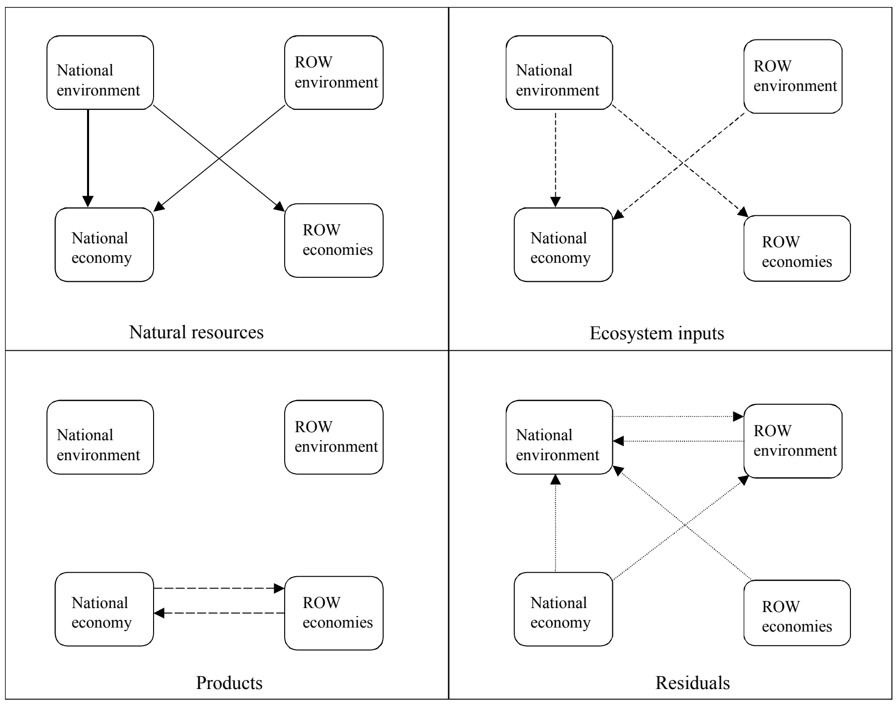
3.92. Secondly, the accounts capture part of the discharge from production which is made directly into a different environment. These sorts of flows were discussed in relation to the boundary with the rest of the world.

[3] As noted above, the small flows of residuals that can occur between the environment and economy (for example, when spilled oil from an oil tanker disaster is cleaned up) are not included in this exposition.

3.93. The last type of residual flow is the transmission of residuals from one environmental sphere to another by natural mechanisms; for example, residuals carried in air currents or flowing water bodies. These also need to be counted in calculating total flows to and from the national environment. Cross border pollution transfers are important for determining the total net accumulation of residuals in the national environment and are especially relevant for pollutants related to environmental degradation problems which are of a non-global nature. This has an important implication with respect to valuation discussed in Chapter 9. The physical flow accounts show that environmental damages generated by the national economy may differ from damages suffered by residents.

3.94. All three types of residual flows are shown schematically in the lower right quadrant of Figure 3.3.

Figure 3.3 The scope of physical accounting



C Basic supply and use tables for physical flows

3.95. In discussing the boundary between the economy and the environment, the idea was introduced of three sorts of economic activities; production, consumption and capital accumulation. Each of these involves products, the goods and services which are made by and consumed within the economy. Products which are consumed in the period they are created become either other products (intermediate consumption), or are transferred back to the environment as residuals. Products which are consumed over a period of time or at a point of time in the future are treated as capital accumulation.

3.96. The supply and use tables developed in this section include details of the flows of products within the economy and their relation to the absorption of natural resources and ecosystem inputs as well as the generation of residuals. By introducing the flows of products within the economy and the three types of economic activities, an extension is needed to the areas of origin and destination for the four types of flows. This is shown in Table 3.3. Hidden flows which remain within the environment are not included in this table.

3.97. The question of the identification of different economic activities is considered first and the elaboration and disaggregation of the different types of flow accounts follows.

Table 3.3 Origin and destination of flows in the physical supply and use tables

Type of flow	Origin	Destination
Natural resources	*Environmental sphere* National environment Rest of the world environment	*Economic sphere* Intermediate consumption Final consumption *Rest of the world economies*
Ecosystem inputs	*Environmental sphere* National environment Rest of the world environment	*Economic sphere* Intermediate consumption Final consumption *Rest of the world economies*
Products	*Economic sphere* Output from Industries *Rest of the world economies* Imports	*Economic sphere* Intermediate consumption Capital formation Final consumption *Rest of the world economies* Exports
Residuals	*Economic sphere* Industries Households *Rest of the world economies* *Environmental sphere* National environment Rest of the world environment	*Economic sphere* Intermediate consumption (scrap and recycling) Capital formation (landfill) *Environmental sphere* National environment Rest of the world environment

1 Identifying economic activities

Products and the environment

3.98. Neither consumer durables nor capital formation are fully consumed in the period in which they are created but remain in the economy as a form of accumulation. Accumulation in physical accounts is measured quite differently than in monetary accounts. In physical accounts, an item remains in the accumulated stock until it is disposed of, all at once, at the point of retirement. This contrasts with the money value of an asset which declines over its lifetime. Also whereas in monetary accounts consumer durables are recorded as being consumed immediately on acquisition, in physical accounts this is not so; again they remain in the stock of accumulated material until disposed of.

3.99. In physical accounts, the disposal of products and capital accumulation has many more ramifications than the simple loss of monetary value. All goods, whether for consumption or accumulation, have ultimately to be disposed of. Treatment plants may be able to extract some of the initial residuals for reprocessing and recycling. The remaining residuals typically go to landfill sites. In the physical accounts, this is accounted for as absorption of residuals by capital formation though it would be difficult to argue that it always constituted land improvement, which this treatment suggests. Landfill sites (strictly speaking licensed and controlled landfill sites) thus become a sort of capital accumulation in themselves and may give rise to the generation of residuals in turn either as methane or as leaching into water sources, for example.

Products and the rest of the word

3.100. In principle, use of products by embassies etc. located in the national economy should be treated as exports and consumption in the country's own embassies abroad should be treated as imports. An allowance for this is made in monetary terms in the balance of payments calculations and in the national accounts but it may not be possible to make a similar adjustment in physical terms. Any error caused by this would normally be well within the margin of error on the whole exercise.

3.101. In a similar way, adjustments for the purchase of products by tourists in the national economy and by nationals abroad are made in monetary terms and should be made in physical terms. In countries where net tourism is significant, it may be important to make an adjustment for this even in physical terms. This is especially important for fuel in the case of countries with land borders where many tourists come using their own cars or in home country buses.

Products within the economy

3.102. The uses of products to satisfy consumer needs and for capital formation has been referred to earlier. The other major use of products within the economy is in the production of other products in the same period. This use is referred to as intermediate consumption. However, the information available on intermediate consumption introduces a complexity to the classification schemes to be used in accounting for products throughout the economy.

3.103. Although any data on the composition of intermediate consumption (use) will show product detail, the production (supply) data is available only for producers. At the most detailed level, the unit involved in production is an establishment. For all but the largest firms, there is only one establishment in an enterprise. Both establishments and enterprises can be aggregated to the level of industries. While the difference between establishment and enterprise is important to national accountants, the term "production unit" is used here to mean either of these (as relevant in context) and the term "industry" to mean a group of either.

3.104. The supply table and that part of the use table relating to intermediate consumption include an industry dimension on one axis and a product dimension on the other. Industries should be classified according to the International Standard Industrial Classification (ISIC) and products according to the Central product Classification (CPC). Information on household consumption should be disaggregated according to the classification of individual consumption by purpose (COICOP). Government consumption is not shown in the examples of the physical flow accounts since it is assumed that government production is articulated along with other industries. However, in the national accounts of some countries the details of government inputs may be recorded as final and not as intermediate consumption. In these cases, the physical accounts should record government consumption by purpose (COFOG) in a similar way to consumption by households (COICOP).

3.105. Not only is production data classified according to industries rather than products, the technical information on residual generation is usually related to industries also. This is because the generation of residuals depends not just on the products consumed but also on the process involved and the processes tend to be industry-specific. This use of different classifications for source and destination is normal in the compilation of supply and use tables, even though for many analyses it is convenient to have so-called "symmetric" tables where supply and use are both shown either of products and by products or of industries and by industries. For products it is possible, however, by the use of a number of assumptions to transform the asymmetric information in supply and use tables into symmetric input-output tables which use the same classification for the same sorts of units for both origin and destination. This transformation of the supply and use tables to symmetric information marks a subsequent step in the analysis of flows and the construction of derived accounts as discussed in Chapter 4.

3.106. Although the tables may show k resources and m products being absorbed by n industries to produce p residuals, not all the technical coefficients linking these factors are known in advance. To a certain degree the economic sphere and environmental sphere of the supply and use tables could be regarded as "black boxes". We know that flows are going in and flows are coming out, but we do not know (or at least cannot *a priori* describe) what is going on inside the black box or what the connection between the in-going and out-going flows are. Such a description is reserved for some of the derived accounts and analysis. In some cases, though, more detailed information for the economic sphere and the environmental sphere exists. For the environmental sphere it is often known into which media (air, water, land) residual flows are discharged. In these cases the destination side can be specified in more detail by the introduction of new row entries.

3.107. The physical supply and use tables shown in the following sections are denominated in physical units of account but not in money terms. The figures presented in the tables are purely illustrative and relate to a fictional country called SEEAland. Tables throughout the handbook showing SEEAland data set as the source are internally consistent to show the interconnections across different subject areas. In the physical accounts, all data are denominated in million metric tonnes though sometimes three decimal places are shown to illustrate the occurrence of small but possibly important entries at the thousand metric tonnes level. Although other units of account may be more appropriate for particular material flows the comprehensibility of the framework is better illustrated by the introduction of a single unit.

3.108. Supply and use tables are developed for each type of flow. Natural resources and ecosystem inputs come from the environment and go to either industries, consumption or (in limited cases) the rest of the world. (Capital formation and exports use only products). Products come from industries or the rest of the world (imports) and are used by industries, capital formation, consumption or exports. Residuals are generated by industry, capital formation and consumption and are either retained within the economy as recycled products or in landfill sites or are "used" by, that is, discharged into the environment. Once these three pairs of tables have been elaborated, they are then assembled into a general matrix presentation as groundwork for further development and analysis.

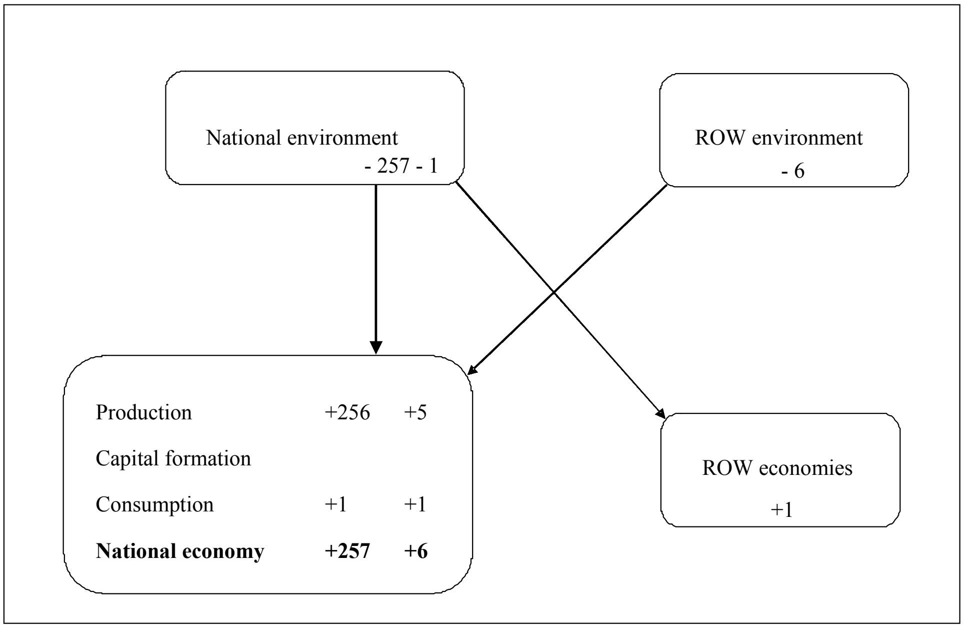
2 Use table for natural resources

3.109. Natural resources are recorded at the moment they are withdrawn from the environment. By definition, the economic sphere does not contribute to the output of natural resources. The description of resource flows focuses purely on the use side.

3.110. Natural resources are used mainly for production and consumption. No uses of natural resources are identified in relation to capital formation. Only in special cases such as fishing is there use by the rest of the world. Once the extraction has taken place, natural resources appear in the accounts as product flows. Therefore, inventory changes and exports of, for example coal, are recorded as exports of products taking place entirely in the economic sphere. These flows are shown schematically in Figure 3.4. Table 3.4 shows example numerical flows in detail.

Figure 3.4 Natural resource flows

Million tonnes



Source: SEEAland data set.

3.111. Resources are classified according to the classification developed in Annex 1[4] and further elaborated in Annex 2. The assets of interest for physical flow accounting are mainly the following:

EA.11 Mineral and energy resources
EA.12 Soil resources
EA.13 Water resources
EA.14 Biological resources (non-cultivated only)

3.112. Land is not included because flows are not relevant. In the example presented in Table 3.4, subsoil assets are shown disaggregated to oil, gas and other; non-cultivated biological assets to wood, fish and other. Non-cultivated biological assets are split into wood, fish and other. The other category shown is water.

3.113. In general it is not difficult to identify the industry concerned with natural resource extraction because there are only a limited number of industries involved. The most obvious industries, classified according to ISIC, are:

01 Agriculture, hunting
02 Forestry
05 Fishing
1 Mining
41 Water supply

[4] The rational and elaboration of this classification appears in Chapter 7.

Table 3.4 Use (destination) table for natural resources

Million tonnes

Destination (use by):	Production				Consumption			ROW	Total
	Agriculture, fishing, and mining	Manufacturing, electricity etc. and construction	Services	Total	Own account transport	Other consumption	Total	Non-residents operating in the national territory	
	I1	I2	I3	I	C1	C2	C	X1	
National resources									
Subsoil assets:									
N1 Oil	38			38			0		38
N2 Gas	27			27			0		27
N3 Other	118	55		173			0		173
Non cultivated biological assets:									
N4 Wood	7	1		8		1	1		9
N5 Fish	1			1			0	1	2
N6 Other		2		2			0		2
N7 Water	1	6		7			0		7
Total national natural resources	**192**	**64**	**0**	**256**	**0**	**1**	**1**	**1**	**258**
ROW resources									
Non cultivated biological assets:									0
N5 Fish	4			4			0		4
N7 Water		1		1		1	1		2
Total ROW natural resources	**4**	**1**	**0**	**5**	**0**	**1**	**1**		**6**
Total natural resources	**196**	**65**	**0**	**261**	**0**	**2**	**2**	**1**	**264**

Source: SEEAland data set.

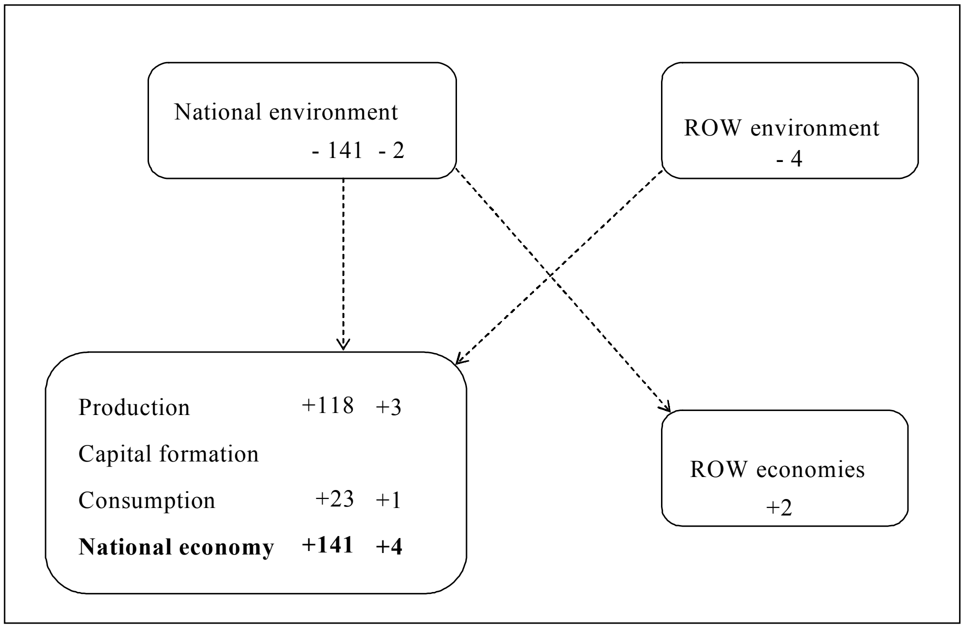
3.114. In the sample tables, industries are aggregated into three groups; agriculture, fishing and mining (which together use most of the subsoil assets and biological resources); manufacturing, electricity and construction (which absorbs the remaining subsoil assets); and services. Consumption is broken down between own account transport and other.

3 Use table for ecosystem inputs

3.115. Only a limited number of ecosystem inputs may be included, such as the water and oxygen required to support combustion and non-product substances required for cultivated biomass growth. These are drawn from the asset classification headings EA.32 - Aquatic ecosystems and EA.33 - Atmospheric systems. The flows are shown schematically in Figure 3.5 and numerically in Table 3.5. All industry groups and both categories of consumption absorb oxygen for combustion. The flows between the national economy and the rest of the world environment, or between the rest of the world economy and the national environment, relate mainly to this use of oxygen for combustion drawn from a foreign environment by national vessels operating outside their own territory.

Figure 3.5 Ecosystem input flows

Million tonnes



Source: SEEAland data set.

Table 3.5 Use (destination) table for ecosystem inputs

Million tonnes

Destination (use by):	Production				Consumption			ROW	Total
	Agriculture, fishing, and mining	Manufacturing, electricity etc. and construction	Services	Total	Own account transport	Other consumption	Total	Non-residents operating in the national territory	
	I1	I2	I3	I	C1	C2	C	X1	
National ecosystem inputs									
E1 Water	2			2		1	1		3
E2 Air, oxygen and nitrogen	13	81	22	116	10	12	22	2	140
Total national ecosystem inputs	**15**	**81**	**22**	**118**	**10**	**13**	**23**	**2**	**143**
ROW ecosystem inputs									
E2 Air, oxygen and nitrogen			3	3	1		1		4
Total ecosystem inputs	**15**	**81**	**25**	**121**	**11**	**13**	**24**	**2**	**147**

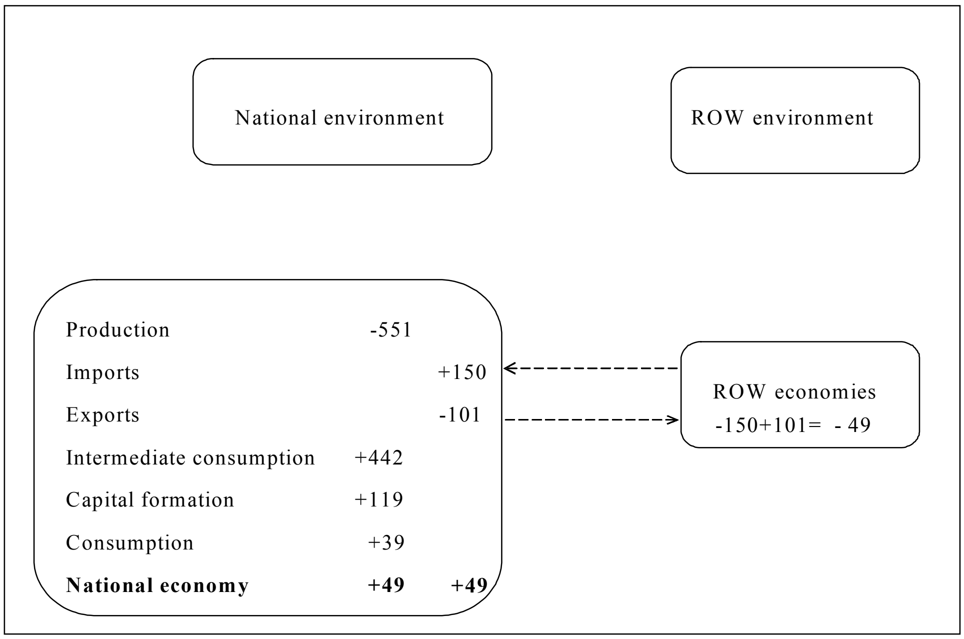
Source: SEEAland data set.

4 Supply and use tables for products

3.116. Figure 3.6 provides a schematic overview of the supply and use tables for products. The only flows coming into and leaving the national economy are those for imports and exports. Flows within the economy mean that the balance from the rest of the world can also be written as the difference between total supply of products (551) and the uses other than exports (intermediate consumption [442], capital formation [119] and consumption [39]). Another way of expressing this is to say that if all the entries for the flows within the economy are aggregated there are no net flows left. This is simply another manifestation of the identity stating that total supply of products (production plus imports) must be equal to the total use (intermediate consumption, final consumption, capital formation and exports).

Figure 3.6 Product flows

Million tonnes



Source: SEEAland data set.

3.117. Table 3.6 and Table 3.7 show the supply and use of all products. Sometimes production and import information is available in quantity terms directly; at other times value figures must be decomposed into average prices and physical units. In general, only the material flows of specific product groups can be estimated directly in full detail. Those product groups for which this is most likely are those representing fairly homogeneous material flows such as fuels, metals, plastics and paper. For other product groups, rougher indirect estimate procedures are likely to be the only ones available.

3.118. When physical quantities have to be determined by dividing the value data by price indices, consideration has to be given to any adjustment which may have been made to the prices to allow for quality changes. In economic statistics in general and national accounts information in particular, the volume figures are not entirely synonymous with physical quantities. If an apparent price increase of five per cent accompanies an increase in quality deemed to be worth two of these five percentage points, then a national accountant will say that the volume has increased by two per cent even though the physical dimensions remain the same. It is a measure of volume of the same quality which is required for national accounts and not just a purely physical measure. For physical flow accounts, however, in principle no such quality adjustment should be made and this may necessitate "removing" or otherwise trying to adjust back to remove any quality effects previously built into the price indices.

Table 3.6 Supply (origin) table for products

Million tonnes

Origin (supply by):	Industries				ROW	Total
	Agriculture, fishing, and mining	Manufacturing, electricity etc. and construction	Services	Total industries	Imports	
	I1	I2	I3	I	M2	
P1 Animal and vegetable products	66	49	1	116	16	132
P2 Stone, gravel and building materials	112	163		275	13	288
P3 Energy	65	59		124	95	219
P4 Metals, machinery, etc.		10		10	10	20
P5 Plastic and plastic products		2		2	2	4
P6 Wood, paper etc.	7	7		14	1	15
P7 Other commodities		9	1	10	13	23
All products	**250**	**299**	**2**	**551**	**150**	**701**

Source: SEEAland data set.

Table 3.7 Use (destination) table for products

Million tonnes

Destination (use by):	Industries				Consumption			Capital	ROW	Total
	Agriculture, fishing, and mining	Manufacturing, electricity etc. and construction	Services	Total industries	Own account transport	Other consumption	Total consumption	Capital formation	Exports	
	I1	I2	I3	I	C1	C2	C	CF	X2	
P1 Animal and vegetable products	23	60	4	87		16	16	3	26	132
P2 Stone, gravel and building materials	12	148	2	162		2	2	114	10	288
P3 Energy	34	101	20	155	7	10	17	0	47	219
P4 Metals, machinery, etc.		11		11	1		1	1	7	20
P5 Plastic and plastic products		2		2					2	4
P6 Wood, paper etc.		7	4	11		1	1		3	15
P7 Other product groups	5	8	1	14		2	2	1	6	23
All products	**74**	**337**	**31**	**442**	**8**	**31**	**39**	**119**	**101**	**701**

Source: SEEAland data set.

3.119. In the examples, data are shown for seven products or groups of products. The industries shown are the same as in the table for natural resource flows.

3.120. Tables such as these can be compiled for specific sets of product groups which are of particular interest. For example it is possible to focus on the supply and use table for specific toxic chemicals or energy products and omit information of the flows of other products. Further, the supply and use table for one or more products can be transformed to supply and use tables for energy (calorific values) or chemical elements (nitrogen, say) by using technical information on the content of the products (for example, percentages of nitrogen in different chemicals, food etc.). Physical supply and use tables for energy products are interesting for the analysis of energy savings/efficiency analysis as well as for the construction of supply tables for energy related residuals, such as CO_2, SO_2, NO_x, etc. The practical aspects of the construction of energy and related residual accounts are further illustrated in Chapter 4.

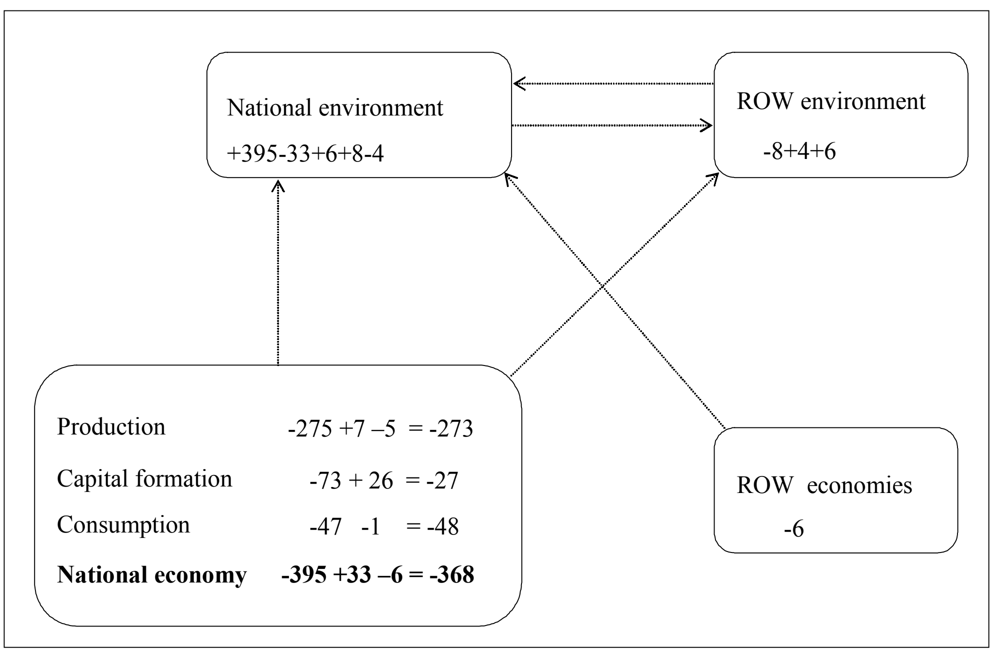
5 *Supply and use tables for residuals*

3.121. Residuals flow into the environmental sphere (air, water, land) from various parts of the economic sphere: production (industries), capital (leakage from landfill sites) and consumption. In addition, some residuals are generated by resident units beyond the national territory and some residuals are generated locally by non-residents. Residuals carried by environmental media between the national and rest of the world environments are also shown. These flows are shown schematically in Figure 3.7.

3.122. The gross output of residuals is equal to the output of residuals generated in the economy including the amount of residuals that may be re-absorbed in a second stage due to recycling or waste (water) treatment.

Figure 3.7 Residual flows

Million tonnes



Source: SEEAland data set.

Generation of residuals

3.123. Table 3.8 shows the generation of gross residuals by the economy. The top part shows the residuals emitted to the national environment. The lower part show emission by national transport companies operating abroad and households on holiday abroad as tourists. This is one table where flows can be read in thousand (kilo) tonnes rather than million tonnes. Although some flows are quite small in absolute terms, they may be significant in terms of their impact on the environment or on human health.

3.124. Residual outputs by industries are classified as before according to the International Standard Industrial Classification (ISIC) and shown in the same three groups in these tables. The direct emission of residuals from households is also shown as before with a distinction between own account transport and other consumption.

Table 3.8 Supply (origin) table for residuals

Million tonnes

Origin (supply by):		Industries				Consumption			Capital	ROW			Total
		Agriculture, fishing, and mining	Manufacturing, electricity etc. and construction	Services	Total Industries	Own account transport	Other consumption	Total consumption	Capital formation	Non-residents on the national territory	Cross-boundary environmental inflows	Total ROW	
		I1	I2	I3	I	C1	C2	C	CF	M1	M3	M	
	To air:												
R1	CO_2	19.020	111.398	29.930	160.348	16.908	25.080	41.988	0.990	4.172		4.172	207.498
R2	N_2O	0.007	0.042	0.012	0.061	0.003	0.004	0.007		0.001		0.001	0.069
R3	CH_4	0.073	0.452	0.125	0.650	0.004	0.020	0.024	0.477	0.001		0.001	1.152
R4	NO_X	0.061	0.275	0.151	0.487	0.084	0.026	0.110		0.025	0.117	0.142	0.739
R5	SO_2	0.023	0.139	0.030	0.192	0.003	0.001	0.004		0.001	0.087	0.088	0.284
R6	NH_3	0.020	0.123	0.038	0.181		0.007	0.007			0.019	0.019	0.207
R7	Other	0.010	0.061	0.015	0.086		0.012	0.012			0.002	0.002	0.100
	To water:												
R8	P	0.070	0.020	0.004	0.094		0.011	0.011	0.003	0.001	0.014	0.015	0.123
R9	N	0.590	0.210	0.098	0.898		0.117	0.117	0.024	0.006	0.323	0.329	1.368
R10	Other	0.030	0.021	0.006	0.057		0.021	0.021	0.001	0.001	0.003	0.004	0.083
	Solid waste:												
R11	Mining waste	7.233	2.320		9.553								9.553
R12	Other	8.103	71.619	22.929	102.651	0.100	5.060	5.160	71.100	1.548	7.656	9.204	188.115
	Total	**35.240**	**186.680**	**53.338**	**275.258**	**17.102**	**30.359**	**47.461**	**72.595**	**5.756**	**8.221**	**13.977**	**409.291**
To ROW territory													
	To air:												
R1	CO_2			4.569	4.569	0.739		0.739					5.308
R4	NO_X			0.010	0.010	0.004		0.004					0.014
R5	SO_2			0.008	0.008	0.002		0.002					0.010
	Total			**4.587**	**4.587**	**0.745**		**0.745**					**5.332**
Total residuals		**35.240**	**186.680**	**57.925**	**279.845**	**17.847**	**30.359**	**48.206**	**72.595**	**5.756**	**8.221**	**13.977**	**414.623**

Source: SEEAland data set.

3.125. Residuals should in all cases be attributed to the economic activity directly responsible for the residual generation. Thus pollution generated from electricity production should be attributed to electricity suppliers and not to the electricity consumers. The attribution of pollution to final users or products should be considered as an analytical continuation of accounting. The direct recording of residual flows is important for accurate and consistent connection of residual flows to material throughputs and economic transactions, and hence linking pollution generation to final use.

Classification and data issues

3.126. Connecting residual flow data to national accounts data will usually result in significant modification of the scope of the original emissions data. One particular point of concern in this respect is the delimitation problem with respect to international transport and tourism (see also: Gravgaard Pedersen, 1998). Regular emission inventories usually cover emissions within the geographic territory of a country and do not correspond exactly to the coverage of the economy of resident units due to the existence of international transport. In order for the environmental consequences of these activities to be taken into account in the SEEA, it is necessary to allow for flows of emissions by non-resident units in the national environment and emissions by resident units outside the national environment. This means that in the SEEA, the output generated by international transport services such as airline and shipping activities is attributed to the country where the operator is resident.

3.127. This is not the case in the IPCC (Intergovernmental Panel on Climate Change) conventions on global warming emissions which specify that pollution from international transport is not attributed to individual countries. A greenhouse gas emission account based on the SEEA will deviate in this respect from the methodology laid down by the IPCC. Equally, emission inventories will usually record emissions that broadly correspond to the (national) geographical territory, including pollution from cars registered in foreign countries.

3.128. It is quite likely that different emission estimates may be compiled for different types of uses in one country. Sometimes emissions will be adjusted for incidental changes such as differences in the average annual temperatures. In other cases, emission figures estimated according to a geographical criterion will be used alongside figures estimated according to the resident criterion. A simple way to avoid misunderstandings is to publish these figures together with straightforward bridge tables which clearly explain these differences. An example is given in Table 4.8 in Chapter 4. Such tables are often published with the national accounts to explain differences in various income measures such as between domestic product and national income.

Destination of residuals

3.129. The disposal of capital equipment and consumer durables forms part of the supply of residuals and is “used” by the economy in landfill sites. The output of residuals in the capital account consists of emissions such as leakage from landfills and infrastructure. The residuals shown in Table 3.8 as being generated in the rest of the world by transport enterprises and tourists are shown as having the rest of the world as their destination in Table 3.9.

Recycling

3.130. There are mainly two types of economic activities that may result in the absorption of residual flows within the economic system, recycling and waste (water) collection and treatment. Economic activities specifically involved in the recycling of material flows are “recycling industries” (ISIC 37) and “wholesale trade in waste and scrap” (ISIC 5149). In principle, Table 3.9 could be subdivided into one table on waste collection and treatment and another table on recycling.

3.131. The main activity of recycling industries consists of the mechanical or chemical transformation of materials in order to make these usable again as industrial inputs. The activity of wholesale trade in waste and scrap is restricted to waste storage, sorting etc. and is one where goods are sold in the same condition in which they are acquired without undergoing any physical transformation other than sorting, and packaging. If any industry, recycling or wholesale, acquires inputs at zero (or near zero) cost, the inputs should be regarded as inputs of residuals. If the inputs for recycling have a positive price, then they should be treated as products and recorded as such.

3.132. Residuals for recycling typically follow one of two paths. Material which can be recycled without further handling, for example paper, often passes through wholesalers to the user. Material which needs processing typically reaches the wholesaler only after it has been converted to “secondary raw material” by the processors.

3.133. In the case where a wholesaler also processes residuals into usable material, special treatment in the accounts may be needed. Under national accounts conventions, wholesalers are not shown as acquiring and disposing of goods but only of adding a trade margin. The goods are shown as going directly from the producer to the user and do not feature as intermediate consumption of the wholesaler. It is desirable to vary this practice in respect of residual handling when the wholesaler acquires residuals and processes some part leaving a smaller quantity remaining as residuals.

3.134. Another example of residuals retained in the economy is the collection and treatment of waste or waste water by environmental services. The main purpose of these services is to reduce the environmental impact of residual flows for example by incineration of solid waste or purification of waste water. Waste (water) treatment in these services will subsequently lead to different and hopefully less harmful types of residual outputs.

3.135. The controlled storage of waste on landfills or public infrastructure is shown as retention of residuals within the economy by capital and thus an accumulation within the economic sphere. Only in the case of clean-up of residuals previously deposited in the environment is there a re-absorption of residuals by the economy. This may be the case for cleaning of contaminated soil, cleaning up oil spills and so on.

Table 3.9 Use (destination) table for residuals

Million tonnes

Destination (use by):	Industries				Capital	ROW environment			National environment	Total
	Agriculture, fishing and mining	Manufacturing, electricity etc. and construction	Services	Total Industries	Capital formation	Residents in ROW	Cross-border environmental outflows	Total		
	I1	I2	I3	I	CF	X1	X3	X	E	
From national territory										
From air:										
R1 CO_2									207.498	207.498
R2 N_2O									0.069	0.069
R3 CH_4									1.152	1.152
R4 NO_X							0.669	0.669	0.070	0.739
R5 SO_2							0.196	0.196	0.088	0.284
R6 NH_3							0.099	0.099	0.108	0.207
R7 Other							0.002	0.002	0.098	0.100
From water:										
R8 P			0.020	0.020			0.010	0.010	0.093	0.123
R9 N			0.115	0.115			0.543	0.543	0.710	1.368
R10 Other			0.010	0.010			0.002	0.002	0.071	0.083
Solid waste:										
R11 Mining waste									9.553	9.553
R12 Other	0.240	2.680	3.780	6.700	25.810		2.398	2.398	153.207	188.115
Total	**0.240**	**2.680**	**3.925**	**6.845**	**25.810**		**3.919**	**3.919**	**372.717**	**409.291**
From ROW territory										
From air:										
R1 CO_2						5.308		5.308		5.308
R4 NO_X						0.014		0.014		0.014
R5 SO_2						0.010		0.010		0.010
Total						5.332		5.332		5.332
Total	**0.240**	**2.680**	**3.925**	**6.845**	**25.810**	**5.332**	**3.919**	**9.251**	**372.717**	**414.623**

Source: SEEAland data set.

Net emissions

3.136. The systematic recording of all residual inputs and outputs of recycling industries and other producers of environmental services requires that the gross residual flows for all other industries is recorded. This gross flow includes residuals remaining within the economic sphere as well as the any which re-enter the economic sphere due to environmental clean-up activities. It also includes emissions generated by the economy in the environment of the rest of the world. In Table 3.10 the figures from the upper and lower part of Table 3.8 have been aggregated under gross emissions.

Table 3.10 Net emissions of selected residuals

Million tonnes

		To national environment									
		Gross emissions				Absorption by economy					
		Industries	Consumption	Capital	Total	Treated and reused by industries	Land fills	Total	**Total net emissions**	Emitted in the rest of the world	Net emissions to the national environment
R1-R7	Air emissions	166.592	42.897	1.467	210.956				210.956	5.332	205.624
R8	P	0.094	0.011	0.003	0.108	0.020		0.020	0.088		0.088
R9	N	0.898	0.117	0.024	1.039	0.115		0.115	0.924		0.924
R10	Other to water	0.057	0.021	0.001	0.079	0.010		0.010	0.069		0.069
R11	Mining waste	9.553			9.553				9.553		9.553
R12	Other solid waste	102.651	5.160	71.100	178.911	6.700	25.810	32.510	146.401		146.401
	All residuals	**279.845**	**48.206**	**72.595**	**400.646**	**6.845**	**25.810**	**32.655**	**367.991**	**5.332**	**362.659**

Source: SEEAland data set.

3.137. It is also helpful to have an accounting for net emissions by deducting that part of emissions which are absorbed into the economy for recycling as well as that part going to landfills. These data are shown in Table 3.9 and are deducted from gross emissions to reach net emissions. Again it is interesting to note how much of the remaining net residuals are absorbed by the national environment and how much flows to the rest of the world environment. Table 3.10 shows net emissions and how these divide between the national and rest of the world environment. These calculations may be performed in aggregate, to show the net effect on the national environment or may be related to individual pollutants.

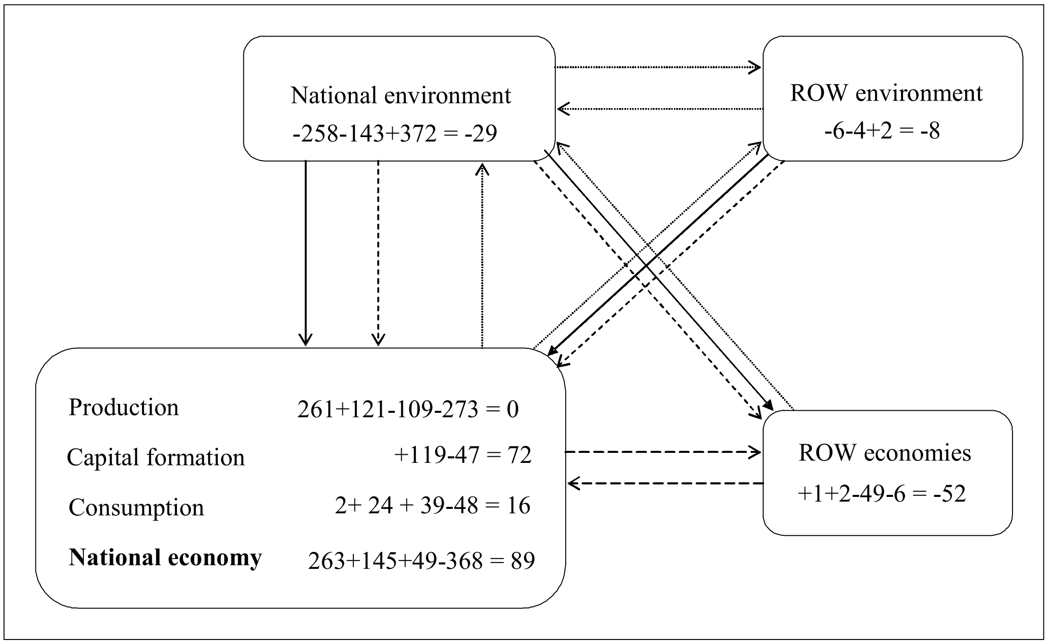
3.138. The treatment of pollution can be taken care of directly at the polluting establishment or can in some cases be handed over to specific waste treatment facilities that usually belong to the environmental services industry. When the direct contribution to residuals is calculated, the accounts show favourable results for those industries which have internal treatment facilities in comparison to those industries who hand over their residual flows to specific waste treatment plants. For this purpose it might be useful to identify for each industry the shares of residual flows that are externally treated. However, in practice, it might be difficult to obtain this information, so often a gross approach will be preferable if transactions between establishments are involved while a net approach is preferable when residuals are processed or eliminated within establishments themselves.

6 The complete system of physical flow accounts

3.139. All the relationships for the different physical flows can be brought together as shown in Figure 3.8. In the entries for the national economy, the counterpart entries for imports and exports have been used (that is, the first column within the national economy box in Figure 3.6 has been used but with production (-551) and intermediate consumption (442) aggregated to a net figure of 109). This shows that the accumulation by production is exactly zero and that the total accumulation in the economic sphere is accounted for entirely by the accumulation of fixed capital or consumer durables.

Figure 3.8 Illustration of total flows described by the supply and use table

Million tonnes



Source: SEEAland data set.

3.140. The system shows a comprehensive overview of the physical economy. Its comprehensiveness can only be guaranteed when all flows are accounted for in similar mass units. Again it must be emphasised that other units may be more relevant in the analysis of specific flows. Nor should the tables be interpreted as the ultimate goal of physical flow accounting but more an illustration of possibilities and an understandable presentation of the overall material balance of a national economy. It is only possible to analyse the overall material balance if all supply and use tables are constructed and combined.

3.141. A comprehensive system of physical accounts including natural resources, products and residuals can also be constructed for specific types of material. One obvious example that has been widely applied in various countries is a comprehensive system of energy accounts. These accounts may include natural resource extraction such as oil and gas mining, transformation of energy into different types of energy products and finally the consumption of these products which usually leads to the output of combustion-related residuals such as emissions of CO_2, SO_2 and so on. The construction of such a system is further illustrated in Chapter 4. Another pertinent example in this respect is the comprehensive system of accounts for timber and forest products described in Section D.

3.142. One way to bring together the tables underlying Figure 3.8 is to use a matrix format. By convention, all the use tables are shown along the rows of the matrix and all the supply tables in the columns. Although there are different classifications used for natural resources, products, industries and residuals, since they are consistent across the tables, it is possible to set up the matrix so that the rows and columns match one by one.

3.143. The information in Table 3.4 to Table 3.9 inclusive is combined in matrix form and portrayed schematically in Table 3.11and in detail in Table 3.12.

3.144. The data in Figure 3.4 to Figure 3.7 can be read off from Table 3.11. The data for natural resources appear in row 6 and 7; those for ecosystem inputs in rows 8 and 9. The entries in rows and columns 1 to 5 correspond to the diagram for products and the identity between total supply and total use of products portrayed in row and column 1. The data in rows and column 10 and 11 relate to residuals.

3.145. Table 3.11 highlights the fact that only in the case of products is total supply equal to total use. For natural resources there is a net inflow from the environment to the economy and for residuals a net flow in the opposite direction. Recalling the starting point of the chapter that total inflows and outflows must balance, it is possible, therefore to use the last column of Table 3.11 to show the net accumulation in either the economy (shown with a positive sign) or in the environment (shown as negative). Note that the flows to the environment take no account of the natural assimilative capacity so that total accumulation in the environment may be less than that apparently shown.

3.146. Table 3.12 shows both the advantages and disadvantages of matrix presentation. It is a very compact and illustrative manner of illustrating the interactions within the economy and between the economy and the environment. Because every element sits at the intersection of a row and a column, it is possible to see immediately its origin (from the row) and destination (column). For expository purposes and to have an overview of the system this is extremely valuable. However, it can be seen that in order to keep the table to a reasonable size some aggregation of the residual rows and columns has been made.

3.147. For practical presentation, therefore, it is common to divide the information into a supply and a use part which eliminate the empty cells in Table 3.12 and where each part has the same row and column identifiers. The supply table in Table 3.13 is formed by taking column 1 for products and columns 10 and 11 for residuals from Table 3.12 and transposing these so that each column appears as a row. In the transposed tables, the (new) columns are dominated by the entries which appear in rows 2, 3, 4 and 5 of Table 3.12. The use table in Table 3.13 is composed of the remaining columns of Table 3.12 (columns 2 to 9) in their original, untransposed, format. This gives the parallel between the two parts of Table 3.13 where the columns in both parts now relate to industries, final consumption, capital and flows with the rest of the world. (Columns 6-9 are often not shown as they are empty by definition since natural resources and ecosystem inputs only flow from the environment to an economy and not from an economy to the environment.) At the end of the supply table, a set of balancing items in a final row shows the net material accumulation in the national economy, calculated as the excess of use over supply for each column/use category. A final column in the use table shows the net withdrawals from the environment, also calculated by deducting supply from use, this time by row/supply categories. Because accumulation can occur in the economy only if there are net withdrawals from the environment, these two balancing items are equal. Together they represent the entries in the material balance column in Table 3.12.

Table 3.11 Matrix representation of physical flows

Million tonnes

		Economy					Residuals		Material balance	Total use
		1. Products	2. Industries	3. Consumption	4. Capital	5. ROW (destination)	10. National destination	11. ROW destination		
Economy	1. Products		Products used by industry 442.000	Products used for consumption 39.000	Products used for capital 119.000	Products used by ROW (exports) 101.000				701.000
	2. Industries	Products supplied by industry 551.000					Residuals generated by industry 275.258	Residuals generated by industry in ROW 4.587		830.845
	3. Consumption						Residuals generated by consumption 47.461	Residuals generated by consumption in ROW 0.745	Net material accumulation by consumption 16.794	65.000
	4. Capital						Residuals generated by capital 72.595		Net material accumulation by capital 72.215	144.810
	5. ROW (origin)	Products supplied by ROW (Imports) 150.000					Residuals generated by non-residents 5.756		Net material accumulation by ROW economy - 51.756	104.000
Natural resources	6. National environment		Natural resources supplied to industry 256.000	Natural resources supplied to consumption 1.000		Natural resources extracted by ROW 1.000			Net accumulation of natural resources in the national environment - 258.000	0
	7. ROW origin		Natural resources supplied to industry 5.000	Natural resources supplied to consumption 1.000					Net accumulation of natural resources in the ROW - 6.000	
Ecosystem inputs	8. National environment		Ecosystem inputs to industry 118.000	Ecosystem inputs to consumption 23.000		Ecosystem inputs to ROW economy 2.000			Net accumulation of ecosystem inputs in the national environment - 143.000	0
	9. ROW origin		Ecosystem inputs to industry 3.000	Ecosystem inputs to consumption 1.000					Net accumulation of ecosystem inputs in the ROW - 4.000	
Residuals	10. National origin		Residuals re-absorbed by production 6.845		Waste to landfill sites 25.810			Cross boundary residual out-flows 3.919	Net accumulation of residuals in the national environment 372.717	409.291
	11. ROW origin						Cross boundary residual in-flows 8.221		Net accumulation of residuals by ROW 1.030	9.251
Total supply		701.000	830.845	65.000	144.810	104.000	409.291	9.251	0.000	2 264.197

Source: SEEAland data set.

Table 3.12 Full matrix presentation of the physical flows between the economy and the environment

Million tonnes

				Economy																
				1. Products								2. Industries				3. Consumption			4. Capital	5. ROW (destination)
				P1	P2	P3	P4	P5	P6	P7	**P**	I1	I2	I3	**I**	C1	C2	**C**	**CF**	**X2**
Economy	1. Products	P1	Animal and vegetable products									23.000	60.000	4.000	**87.000**		16.000	**16.000**	**3.000**	**26.000**
		P2	Stone, gravel and building materials									12.000	148.000	2.000	**162.000**		2.000	**2.000**	**114.000**	**10.000**
		P3	Energy									34.000	101.000	20.000	**155.000**	7.000	10.000	**17.000**	**0.000**	**47.000**
		P4	Metals, machinery, etc.										11.000		**11.000**	1.000		**1.000**	**1.000**	**7.000**
		P5	Plastic and plastic products										2.000		**2.000**					**2.000**
		P6	Wood, paper etc.										7.000	4.000	**11.000**		1.000	**1.000**		**3.000**
		P7	Other product groups									5.000	8.000	1.000	**14.000**		2.000	**2.000**	**1.000**	**6.000**
			All products									**74.000**	**337.000**	**31.000**	**442.000**	**8.000**	**31.000**	**39.000**	**119.000**	**101.000**
	2. Industries	I1	Agriculture, fishing and mining	66.000	112.000	65.000	0.000	0.000	7.000	0.000	250.000									
		I2	Manufacturing, electricity and construction	49.000	163.000	59.000	10.000	2.000	7.000	9.000	299.000									
		I3	Services	1.000	0.000	0.000	0.000	0.000	0.000	1.000	2.000									
		I	**Total industries**	**116.000**	**275.000**	**124.000**	**10.000**	**2.000**	**14.000**	**10.000**	**551.000**									
	3. Consumption	C1	Own account transport																	
		C2	Other consumption																	
		C	**Total consumption**																	
	4. Capital	**CF**	**Capital formation**																	
	5. ROW (origin)	**M2**	**Imports of products**	**16.000**	**13.000**	**95.000**	**10.000**	**2.000**	**1.000**	**13.000**	**150.000**									
Natural resources	6. National environment		Subsoil assets																	
		N1	Oil									38.000			**38.000**					
		N2	Gas									27.000			**27.000**					
		N3	Other									118.000	55.000		**173.000**					
			Non-cultivated biological assets																	
		N4	Wood, etc.									7.000	1.000		**8.000**		1.000	**1.000**		
		N5	Fish									1.000			**1.000**					**1.000**
		N6	Other										2.000		**2.000**					
		N7	Water									1.000	6.000		**7.000**					
		N	**Total national natural resources**									**192.000**	**64.000**		**256.000**		**1.000**	**1.000**		**1.000**
	7. ROW origin		Non cultivated biological assets																	
			Fish									4.000			**4.000**					
			Water										1.000		**1.000**		1.000	**1.000**		
			Total ROW natural resources									**4.000**	**1.000**		**5.000**		**1.000**	**1.000**		
Ecosystem Inputs	8. National environment	**E1,E2**	**National ecosystem inputs**									**15.000**	**81.000**	**22.000**	**118.000**	**10.000**	**13.000**	**23.000**		**2.000**
	9. ROW origin	**E1,E2**	**ROW ecosystem inputs**											**3.000**	**3.000**	**1.000**		**1.000**		
Residuals	10. National origin	R1	CO_2																	
		R2	N_2O																	
		R3	CH_4																	
		R4	NO_X																	
		R5	SO_2																	
		R6	NH_3																	
		R7	Other																	
		R8	P											0.020	**0.020**					
		R9	N											0.115	**0.115**					
		R10	Other											0.010	**0.010**					
		R11	Mining waste																	
		R12	Other solid waste									0.240	2.680	3.780	**6.700**				**25.810**	
			Total national									**0.240**	**2.680**	**3.925**	**6.845**				**25.810**	
	11. ROW origin	R1-R12	Cross-border residual flows from ROW																	
Total				132.000	288.000	219.000	20.000	4.000	15.000	23.000	701.000	285.240	485.680	59.925	**830.845**	19.000	46.000	**65.000**	**144.810**	**104.000**

Source: SEEAland data set.

Table 3.12 Full matrix presentation of the physical flows between the economy and the environment *(continued)*

Million tonnes

				Residuals															
				10. National destination													11. ROW destination	Material balance	**Total**
				R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	**Total**			
Economy	1. Products	P1	Animal and vegetable products																132.000
		P2	Stone, gravel and building materials																288.000
		P3	Energy																219.000
		P4	Metals, machinery, etc.																20.000
		P5	Plastic and plastic products																4.000
		P6	Wood, paper etc.																15.000
		P7	Other product groups																23.000
			All products																**701.000**
	2. Industries	I1	Agriculture, fishing and mining	19.020	0.007	0.073	0.061	0.023	0.020	0.010	0.070	0.590	0.030	7.233	8.103	**35.240**			285.240
		I2	Manufacturing, electricity and construction	111.398	0.042	0.452	0.275	0.139	0.123	0.061	0.020	0.210	0.021	2.320	71.619	**186.680**			485.680
		I3	Services	29.930	0.012	0.125	0.151	0.030	0.038	0.015	0.004	0.098	0.006	0.000	22.929	**53.338**	4.587		59.925
		I	**Total industries**	**160.348**	**0.061**	**0.650**	**0.487**	**0.192**	**0.181**	**0.086**	**0.094**	**0.898**	**0.057**	**9.553**	**102.651**	**275.258**	**4.587**		**830.845**
	3. Consumption	C1	Own account transport	16.908	0.003	0.004	0.084	0.003	0.000	0.000					0.100	**17.102**	0.745	1.153	19.000
		C2	Other consumption	25.080	0.004	0.020	0.026	0.001	0.007	0.012	0.011	0.117	0.021		5.060	**30.359**		15.641	46.000
		C	**Total consumption**	**41.988**	**0.007**	**0.024**	**0.110**	**0.004**	**0.007**	**0.012**	**0.011**	**0.117**	**0.021**		**5.160**	**47.461**	**0.745**	**16.794**	**65.000**
	4. Capital	**CF**	**Capital formation**	**0.990**		**0.477**					**0.003**	**0.024**	**0.001**		**71.100**	**72.595**		**72.215**	**144.810**
	5. ROW (origin)	**R1-R12**	**Generated by non-residents**	**4.172**	**0.001**	**0.001**	**0.025**	**0.001**			**0.001**	**0.006**	**0.001**		**1.548**	**5.756**		**- 51.756**	**104.000**
Natural resources	6. National environment		Subsoil assets																
		N1	Oil															- 38.000	
		N2	Gas															- 27.000	
		N3	Other															- 173.000	
			Non-cultivated biological assets																
		N4	Wood, etc.															- 9.000	
		N5	Fish															- 2.000	
		N6	Other															- 2.000	
		N7	Water															- 7.000	
		N	**Total national natural resources**															**- 258.000**	
	7. ROW origin		Non cultivated biological assets																
			Fish															- 4.000	
			Water															- 2.000	
			Total ROW natural resources															**- 6.000**	
Ecosystem Inputs	8. National environment	**E1, E2**	**National ecosystem inputs**															**- 143.000**	
	9. ROW origin	**E1, E2**	**ROW ecosystem inputs**															**- 4.000**	
Residuals	10. National origin	R1	CO_2															207.498	207.498
		R2	N_2O															0.069	0.069
		R3	CH_4															1.152	1.152
		R4	NO_X														0.669	0.070	0.739
		R5	SO_2														0.196	0.088	0.284
		R6	NH_3														0.099	0.108	0.207
		R7	Other														0.002	0.098	0.100
		R8	P														0.010	0.093	0.123
		R9	N														0.543	0.710	1.368
		R10	Other														0.002	0.071	0.083
		R11	Mining waste															9.553	9.553
		R12	Other solid waste														2.398	153.207	188.115
			Total national														**3.919**	**372.717**	**409.291**
	11. ROW origin	R1-R12	Cross-border residual flows from ROW				0.117	0.087	0.019	0.002	0.014	0.323	0.003		7.656	**8.221**		**1.030**	**9.251**
	Total			207.498	0.069	1.152	0.739	0.284	0.207	0.100	0.123	1.368	0.083	9.553	188.115	409.291	9.251	**0.000**	**2 264.197**

Table 3.13 Physical supply and use table

Physical supply table

Million tonnes

		Industries				Consumption			Capital	Rest of the World				National environment	
		Agriculture, fishing and mining	Manufacturing electricity and construction	Services	**Total industries**	Own account transport	Other consumption	**Total consumption**	**Capital formation, changes in inventories, waste storage**	Imports of products	Natural resources and ecosystem inputs supplied by non-residents in national territory	Residuals by non residents in ROW	Cross boundary in-flows from ROW by environmental media		**Total material supply**
		I1	I2	I3	**I**	C1	C2	**C**	**CF**	M2	M1	M1	M3	E	
Products	P1 Animal and vegetable products	66.000	49.000	1.000	**116.000**					16.000					**132.000**
	P2 Stone, gravel and building materials	112.000	163.000		**275.000**					13.000					**288.000**
	P3 Energy	65.000	59.000		**124.000**					95.000					**219.000**
	P4 Metals, machinery, etc.		10.000		**10.000**					10.000					**20.000**
	P5 Plastic and plastic products		2.000		**2.000**					2.000					**4.000**
	P6 Wood, paper etc.	7.000	7.000		**14.000**					1.000					**15.000**
	P7 Other commodities		9.000	1.000	**10.000**					13.000					**23.000**
	All products	**250.000**	**299.000**	**2.000**	**551.000**					**150.000**					**701.000**
Residuals	To national territory														
	R1 CO_2	19.020	111.398	29.930	**160.348**	16.908	25.080	**41.988**	**0.990**			4.172			**207.498**
	R2 N_2O	0.007	0.042	0.012	**0.061**	0.003	0.004	**0.007**				0.001			**0.069**
	R3 CH_4	0.073	0.452	0.125	**0.650**	0.004	0.020	**0.024**	**0.477**			0.001			**1.152**
	R4 NO_X	0.061	0.275	0.151	**0.487**	0.084	0.026	**0.110**				0.025	0.117		**0.739**
	R5 SO_2	0.023	0.139	0.030	**0.192**	0.003	0.001	**0.004**				0.001	0.087		**0.284**
	R6 NH_3	0.020	0.123	0.038	**0.181**		0.007	**0.007**					0.019		**0.207**
	R7 Other to air	0.010	0.061	0.015	**0.086**		0.012	**0.012**					0.002		**0.100**
	R8 P	0.070	0.020	0.004	**0.094**		0.011	**0.011**	**0.003**			0.001	0.014		**0.123**
	R9 N	0.590	0.210	0.098	**0.898**		0.117	**0.117**	**0.024**			0.006	0.323		**1.368**
	R10 Other to water	0.030	0.021	0.006	**0.057**		0.021	**0.021**	**0.001**			0.001	0.003		**0.083**
	R11 Mining waste	7.233	2.320		**9.553**										**9.553**
	R12 Other solid waste	8.103	71.619	22.929	**102.651**	0.100	5.060	**5.160**	**71.100**			1.548	7.656		**188.115**
	Total to national territory	35.240	186.680	53.338	**275.258**	17.102	30.359	**47.461**	**72.595**			5.756	8.221		**409.291**
	To ROW territory														
	To air														
	R1 CO_2			4.569	**4.569**	0.739		**0.739**							**5.308**
	R4 NO_X			0.010	**0.010**	0.004		**0.004**							**0.014**
	R5 SO_2			0.008	**0.008**	0.002		**0.002**							**0.010**
	Total to ROW territory			4.587	**4.587**	0.745		**0.745**							**5.332**
	Total residuals	**35.240**	**186.680**	**57.925**	**279.845**	**17.847**	**30.359**	**48.206**	**72.595**			**5.756**	**8.221**		**414.623**
Total material supply		285.240	485.680	59.925	**830.845**	17.847	30.359	**48.206**	**72.595**	**150.000**		**5.756**	**8.221**		**1 115.623**
						Net increase by consumption (consumer durables)			Net increase in capital	Net export of products	Net extraction by non residents	Net residuals by residents in ROW	Net cross boundary outflow of residuals by env. media	Net accumulation of residuals in the national environment	**Net balance**
Net accumulation of all materials (use less supply)						1.153	15.641	16.794	72.215	-49.000	3.000	-0.424	-4.302	372.717	411.000

Table 3.13 Physical supply and use table *(continued)*

Physical use table

Million tonnes

			Industries				Consumption			Capital	Rest of the World				National environment	
			Agriculture, fishing and mining	Manufacturing electricity and construction	Services	**Total industries**	Own account transport	Other consumption	**Total consumption**	**Capital formation, changes in inventories, waste storage**	Exports	Resources and ecosystem inputs used by non-residents in national territory	Residuals by residents in ROW	Cross boundary out-flows to ROW by environmental media		**Total material use**
			I1	I2	I3	**I**	C1	C2	**C**	**CF**	X2	X1	X1	X3	E	
Products	P1	Animal and vegetable products	23.000	60.000	4.000	87.000		16.000	16.000	3.000	26.000					**132.000**
	P2	Stone, gravel and building materials	12.000	148.000	2.000	162.000		2.000	2.000	114.000	10.000					**288.000**
	P3	Energy	34.000	101.000	20.000	155.000	7.000	10.000	17.000		47.000					**219.000**
	P4	Metals, machinery, etc.		11.000		11.000	1.000		1.000	1.000	7.000					**20.000**
	P5	Plastic and plastic products		2.000		2.000					2.000					**4.000**
	P6	Wood, paper etc.		7.000	4.000	11.000		1.000	1.000		3.000					**15.000**
	P7	Other commodities	5.000	8.000	1.000	14.000		2.000	2.000	1.000	6.000					**23.000**
		All products	**74.000**	**337.000**	**31.000**	**442.000**	**8.000**	**31.000**	**39.000**	**119.000**	**101.000**					**701.000**
Natural resources		National natural resources														
	N1	Oil	38.000			38.000										**38.000**
	N2	Gas	27.000			27.000										**27.000**
	N3	Other	118.000	55.000		173.000										**173.000**
	N4	Wood	7.000	1.000		8.000		1.000	1.000							**9.000**
	N5	Fish	1.000			1.000						1.000				**2.000**
	N6	Other		2.000		2.000										**2.000**
	N7	Water	1.000	6.000		7.000										**7.000**
		Total national natural resources	192.000	64.000		256.000		1.000	1.000			1.000				**258.000**
		ROW natural resources														
	N5	Fish	4.000			4.000										**4.000**
	N7	Water		1.000		1.000		1.000	1.000							**2.000**
		Total ROW natural resources	4.000	1.000		5.000		1.000	1.000							**6.000**
		Total natural resources	**196.000**	**65.000**		**261.000**		**2.000**	**2.000**			**1.000**				**264.000**
Ecosystem Inputs		National ecosystem inputs	15.000	81.000	22.000	118.000	10.000	13.000	23.000			2.000				**143.000**
		ROW ecosystem inputs			3.000	3.000	1.000		1.000							**4.000**
		Total ecosystem inputs	**15.000**	**81.000**	**25.000**	**121.000**	**11.000**	**13.000**	**24.000**			**2.000**				**147.000**
Residuals		From national territory														
	R1	CO_2													207.498	**207.498**
	R2	N_2O													0.069	**0.069**
	R3	CH_4													1.152	**1.152**
	R4	NO_X												0.669	0.070	**0.739**
	R5	SO_2												0.196	0.088	**0.284**
	R6	NH_3												0.099	0.108	**0.207**
	R7	Other from air												0.002	0.098	**0.100**
	R8	P			0.020	0.020								0.010	0.093	**0.123**
	R9	N			0.115	0.115								0.543	0.710	**1.368**
	R10	Other from water			0.010	0.010								0.002	0.071	**0.083**
	R11	Mining waste													9.553	**9.553**
	R12	Other solid waste	0.240	2.680	3.780	6.700				25.810				2.398	153.207	**188.115**
		Total from national territory	0.240	2.680	3.925	6.845				25.810				3.919	372.717	**409.291**
		From ROW territory														
	R1	CO_2											5.308			**5.308**
	R4	NO_X											0.014			**0.014**
	R5	SO_2											0.010			**0.010**
		Total from ROW territory											5.332			**5.332**
		Total	**0.240**	**2.680**	**3.925**	**6.845**				**25.810**			**5.332**	**3.919**	**372.717**	**414.623**
Total material use			285.240	485.680	59.925	830.845	19.000	46.000	65.000	144.810	101.000	3.000	5.332	3.919	372.717	**1 526.623**

Source: SEEAland data set.

Aggregate tables

3.148. It is possible to have an even more compressed matrix than that in Table 3.11 showing only the flows between the economy and the environment. This was described schematically in Table 3.1 and is shown numerically in Table 3.14.

Table 3.14 Aggregate flows between the economy and the environment

Million tonnes

	National		Rest of the world (ROW)			
	Economy	Environment	Economy	Environment	Net material accumulation	Total
National economy		395 -33	101	6	89	558
National environment	398		3	4	-28	377
ROW economy	150	6				
ROW environment	10	8				
Total	558	377				

Source: SEEAland data set.

3.149. The first step is to derive the first row and column for the national economy by consolidating rows and columns 1 to 4 from Table 3.11. A consequence of the consolidation is that there is no longer an entry at the intersection of row 1 and column 1. Because there are no products left in the top left cell of Table 3.14, the flows of recycled residuals back to production plus the "use" of residuals by landfill sites from row 10 are deducted from the gross output of residuals to give a net figure of emission to the national environment.

3.150. The entries for the national environment are formed by consolidating rows 6 and 8. There are no entries in the columns 6 and 8 of Table 3.11.

3.151. The entries for the row for the rest of the world economy in Table 3.14 show the entries in row and column 5 and that part of row 11 from Table 3.11 which relates to entries to the rest of the world economy. The column for the rest of the world is a consolidation of columns 5, 7 and 9. This reflects the asymmetries that there are inputs of natural resources and ecosystem inputs from the national environment to the rest of the world economy and outputs of residuals from the national economy to the rest of the world environment.

3.152. The entries remaining in the last row and column of Table 3.14 thus relate only to cross-boundary flows of residuals from the national to the rest of the world environment and vice versa appearing in row and column 10 of Table 3.11. As noted in the discussion of Table 3.1, the bottom right hand section of the table is empty because flows between the rest of the world economy and rest of the world environment are not recorded.

3.153. The data in the first row and column of Table 3.14 can also be structured as an account explaining the net material accumulation in the economic sphere. This is shown in Table 3.15.

Table 3.15 Physical flows and material balance for the economic sphere

Million tonnes

Origin		Destination	
Import of products	150	Export of products	101
Natural resource extraction		Gross output of residuals to national environment	395
From the national environment	257	Gross output of residuals to ROW environment	6
From the rest of the world environment	6	*less* recycling and landfill	-33
Ecosystems input			
From the national environment	141		
From the rest of the world environment	4		
		Net material accumulation in the economic sphere	**89**
Total material inputs	558	Total material outputs	558

Source: SEEAland data set.

3.154. A similar account, drawn from the second row and column of Table 3.14 can be constructed to explain the net material accumulation in the environmental sphere, as shown in Table 3.16.

Table 3.16 Physical flows and material balance for the environmental sphere

Million tonnes

Origin		Destination	
Gross output of residuals to the national environment	395	Natural resource extraction	
less recycling and landfill	-33	To the national economy	257
Discharge from ROW economy	6	To the rest of the world economy	1
Cross-border residual flows from ROW environment	8	Ecosystems input	
		To the national economy	141
		To the rest of the world economy	2
		Cross-border residual flow to another country	4
		Net material accumulation in the environmental sphere	**-28**
Total material inputs	377	Total material outputs	377

Source: SEEAland data set.

3.155. The last aggregate table of interest is to know in what form the net material accumulation in the economy takes place. This is shown in Table 3.17 which shows how the total net material accumulation in the economy (89 million tonnes) is brought about by a net inflow of products of 49 million tonnes from the rest of the world, 28 million tonnes from the national environment and 12 million tonnes from the environment of the rest of the world. These figures can be derived from the last column of Table 3.11. The net flows from the environment are calculated as residuals generated less natural resource and ecosystem inputs. The material accumulation in the economy is accounted for as 72 million tonnes of capital and 17 million tonnes of consumer durables.

Table 3.17 Material accumulation in the economic sphere

Million tonnes

Origin		Destination	
Balance of trade	49	Net increase in capital and other stocks	72
Net material absorption		Net increase in consumer durables	
from the national environment	28		17
from the rest of the world	12		
Total	89	Total	89

Source: SEEAland data set.

7 *Input-output identities*

3.156. The five sections above provide an overview of the different flows represented in the system of physical flow accounts and show how these can be brought together to give a measure of the net material accumulation in each of the several sectors of the economy and in the environment.

3.157. The entries for rows and columns 1 to 5 of Table 3.11 all relate to products and separate accounts can be constructed for each type of economic activity (production, capital accumulation and consumption) as well as for transactions with the rest of the world. This is done in Table 3.18.

3.158. As noted before, for production there is a complete balance between inputs and outputs.

3.159. A separate capital account shows on the input side the amount in physical terms of gross fixed capital formation and net changes in inventories. A decline in the inventories of certain product groups may possibly result in negative entries on the input side of the capital account. The using up of capital will usually not produce a continuous flow of residuals over time as residuals are recorded as being generated at the moment when the capital item is discarded. This is shown on the output side of the account as part of the generation of residuals.

3.160. The capital account displays another feature. The controlled storage of waste as landfill is also regarded as material accumulation taking place within the economic sphere. Therefore the input side of the capital account shows the absorption of residuals which corresponds to the gross increase in waste stocks. Leakages from landfill sites appear on the output side of the account as a further source of residuals generated by capital.

3.161. For household consumption, the accounts do not make a division between current and capital flows. The input side shows consumption of households and the extraction of natural resources. The output side shows the residual disposal by households. The difference between inputs and outputs is made up by the net increase in transport equipment and other consumer durables.

3.162. With respect to the rest of the world two separate balancing items are included. One represents the difference between exports and imports (the physical balance of trade). The data show that in the SEEAland economy the mass of imports substantially exceeds exports so there is a net inflow of material into the economy from other economies. The second balancing item shows the net balance of residual transfers where again there is a net inflow into the national environment from the rest of the world.

Table 3.18 Input-output relationships for economic activities

Million tonnes

Inputs			Outputs
Production			
Intermediate consumption	442	Output	551
Extraction of natural resources	261		
Ecosystem inputs	121		
Re-absorption of residuals	7	Generation of residuals	280
Total material inputs	831	Total material outputs	831
Capital formation			
Capital formation and changes in inventories	119	Generation of residuals	73
Waste to landfill sites (absorption of residuals)	26	Net material accumulation in the economy	72
Total material inputs	145	Total material outputs	145
Consumption			
Household consumption	39	Generation of residuals	48
Extraction of natural resources	2	Net material accumulation in the economy (consumer durables)	17
Ecosystem inputs	24		
Total material inputs	65	Total material outputs	65
Rest of the world			
Exports	101	Imports	150
		Net material accumulation of products in the rest of the world	-49
Total material inputs	101	Total material outputs	101
Residuals generated by residents in the rest of the world	5	Residuals generated by non-residents in the national economy	6
Ecosystem inputs to the rest of the world	3	Ecosystem inputs from the rest of the world	10
Cross boundary flows to the rest of the world	4	Cross boundary flows from the rest of the world	8
		Net accumulation of residuals in the rest of the world	-12
Total flows to the environment from the rest of the world economy	12	Total flows to the rest of the world environment from the economy	12

Source: SEEAland data set.

D Physical flow accounts in practice

1 Introduction

3.163. In this section practical examples of physical flow accounts are given. They show how supply and use tables have been presented in practice and how related accounts have been constructed for supply or use of materials.

3.164. The first two examples demonstrate possible alternative presentations of the treatment of residuals. The first of these is an example investigating the flow of residuals and their use (or not) for recycling based on data for (West) Germany for 1990. The second, also based on German data for 1990, concerns the question of ecosystem inputs and the consequences for recording the impact of generation of products and the recording of residuals.

3.165. The third example shows how the various stages in the product cycle of natural resources can be explained. It concerns the supply and use of timber and forest products in Finland. This example shows traditional supply and use tables for products and residuals even though the format of the tables is somewhat different from the general format presented earlier in Section C.

3.166. The last two examples focus on economy wide flow accounts and the various indicators which can be derived from them. The first is a brief description of material flow accounting (MFA) and the second of physical input-output tables (PIOT).

2 Residuals and recycling in physical flow accounts (West Germany, 1990)

3.167. Residuals directly discharged into the environment cross the border between the economy and the environment; other residuals remain within the economy. Residuals for recycling are an input to the recycling industries. Residuals for treatment are mainly an input of wholesale trade in waste and scrap or environmental services. In addition, some other industries may treat their own residuals or those of other industries. Waste for landfills is that part of the waste that is stored in controlled landfills and is considered to be an accumulation of produced assets.

3.168. The numerical example shown in Table 3.19 is taken from German Physical Input Output Table for 1990. It is a very inclusive table of materials used or otherwise affected by economic activity. Although products are measured at only 10 billion tonnes, the total of natural resources and ecosystem inputs is more than four times this weight and residuals more than five times. The main reason for this is the amount of water which is affected in one way or another by the economy.

3.169. The German accounts are characterised by very detailed information on the nature of residuals. These can be subdivided into four different principal destinations:

residuals discharged into the environment;
residuals for recycling;
residuals for treatment; and
residuals (waste) for landfill.

3.170. An examination of the table shows that the inputs and outputs for production and consumption are equal but that there is a transfer of material from the environment (464 million tonnes) and the rest of the world (185) to the economy, specifically as an increase in consumer durables, fixed capital and inventories (531) and to controlled landfills (117).

Table 3.19 Material flow account for West Germany, 1990

Million tonnes

	Production activities				Consumption activities of households	Produced assets		Non produced natural assets	Rest of the world	**Total**
	Recycling	External environmental protection services	Other	Total		Consumer durables, inventories, fixed assets, produced natural assets	Controlled landfills			
					Inputs (uses)					
Raw materials	13	3 510	45 707	49 230	280					49 510
Raw matererials used (including. air, minerals)	12	10	1 858	1 880	221					2 101
Raw materials not used			982	982						982
Water raised	1	3 500	42 868	46 369	59					46 428
Products	9	17	5 684	5 710	3 075	854			206	9 845
Residuals	104	4 427	3	4 535			117	49 046	2	53 700
Waste for recycling	104			104						104
Waste for treatment		31	3	34					2	36
Waste for landfill							117			117
Raw materials not used								982		982
Other material discharged								614		614
Waste water for treatment		4 396		4 396						4 396
Waste water discharged								44 847		44 847
Water evaporated								1 566		1 566
Oxygen								226		226
Carbon dioxide								778		778
Other air emissions								34		34
Total inputs	126	7 954	51 394	59 475	3 355	847	117	49 053	208	113 055
					Outputs (supply)					
Raw materials								49 510		49 510
Raw matererials used (including. air, minerals)								2 101		2 101
Raw mat., not used								982		982
Water raised								46 428		46 428
Products	91	0	9 139	9 231		222			393	9 845
Residuals	35	7 954	42 255	50 244	3 355	100				53 700
Waste for recycling	0	6	77	83	4	17				104
Waste for treatment	1	4	18	23	4	8				36
Waste for landfill	1	2	84	87	11	20				117
Raw material, not used			982	982						982
Other material discharged	13	11	515	539	20	56				614
Waste water for treatment	4	0	1 756	1 760	2 636					4 396
Waste water discharged		7 895	36 952	44 847						44 847
Water vaporised	5	22	1 066	1 094	472					1 566
Oxygen			226	226						226
Carbon dioxide	11	12	560	583	195					778
Other air emissions	0	1	19	21	13					34
Total outputs	126	7 954	51 394	59 475	3 355	323		49 510	393	113 056

Source: Stahmer, Kuhn and Braun, 1996.

3 Biological assets and ecosystems inputs

3.171. For the material flows connected with agricultural and forestry production, in practice the distinction between the economic and the environmental sphere is particularly difficult to make in statistical terms. According to the SNA production boundary, cultivated plants and cultivated animals are the results of production processes and have therefore to be regarded as products. An exception holds only for wild biota. They are considered to be raw materials extracted from the environment. But unlike other purely technical processes of production, which are almost completely under human control, agricultural and forest production is mainly the result of biological metabolism, whereby the cultivated biological organisms interact more or less directly with the environmental sphere by extracting raw materials and by discharging residuals. The biological metabolism is supported by further production activities (other metabolism), like ploughing, harvesting and transport which are also connected with use of materials (such as energy).

3.172. The total metabolism and especially the biological metabolism in agriculture can conceptually be described in terms of the physical input output table (PIOT) which is based on the identity of physical inputs and outputs for each industry. This concept allows a complete picture to be drawn of the material flows necessary for the metabolism of cultivated plants and animals. The inputs of the biological metabolism are raw materials such as water or air (oxygen, carbon dioxide) and products such as animal feeds, seeds, fertilizers and pesticides. The metabolic outputs include the natural growth of plants, animals, animal products and residuals (evaporated water, liquid manure and so on). To arrive at the identity of material inputs and outputs all physical flows of the metabolic processes have to be included. Ecosystem inputs are absorbed by biological assets, both cultivated and non-cultivated. The consequences are of significant importance in their own right for several reasons. One concerns the carbon fixing role of plants and forests, which is independent of the distinction between cultivated and non-cultivated assets. Another concerns the role of residuals, particularly the eutrophication caused by intensive animal husbandry. The third reason is that there are practical issues concerned with data compilation for the physical accounts for produced assets when ecosystem inputs must be taken into account as well as products and residuals.

3.173. The statistical implementation of this concept is rather difficult. As a rule, except for the output and input of products, only rough estimates for the elements of the biological metabolism are possible. For these estimates, physiological information has to be combined with data on the production of cultivated plants and animals by categories. It is also rather difficult to arrive at an estimate of what part of the fertilizers, farm manure and pesticides is incorporated into cultivated plants and what part is dissipated directly into the environment, for example as nitrate pollution of groundwater.

3.174. For practical purposes, especially if it is not the aim to construct a complete PIOT but only a material balance for the whole economy, a simplified version may be sufficient. To see how this can be done, it is useful to look at some illustrative figures for animal husbandry and plants and forests separately.

Animal husbandry

3.175. Even when the cultivation of animals falls clearly within the production boundary, the pattern of inputs may vary substantially. In some countries where cattle ranching is prevalent with low densities of animals per hectare, as in many developing countries, virtually all the fodder and water may be provided from natural ecosystems with comparatively few other inputs. In contrast, in much of Europe, most of the fodder and water will itself be classed as products and other inputs, such as veterinary expenses may be significant. In these circumstances intensive animal husbandry is more like an industrial process than a purely natural one.

3.176. For all animals, whether cultivated or not, however, ecosystem inputs in the form of oxygen and water are essential to life. By volume, most of the oxygen is converted to carbon dioxide and a large proportion of the food and water input is converted to solid, liquid and gaseous residuals; for example, carbon dioxide and methane from the animals' digestive processes. The value of physical output is equal to the value of weight gain by the animals and this is usually a fairly small proportion by volume of the inputs. Table 3.20 gives an impression of the relative orders of magnitude involved. It is drawn from the same physical input output table for West Germany as the data in Table 3.19

Table 3.20 Metabolism account for cultivated livestock

Million tonnes

Inputs (uses)		Output (supply)	
Ecosystem inputs	137.5	**Products**	32.3
Water from nature	115.7	Biomass increase	32.3
Oxygen	21.8		
Products	169.3	**Residuals**	274.5
Water	53.3	Water	7.8
Agricultural products	98.3	Excreta	241.3
Other products	17.7	Carbon dioxide	23.8
		Methane	1.6
Total inputs	306.8	**Total outputs**	306.8
Water	169.0	Water	7.8
Other inputs	137.8	Materials (excluding water)	299.0

Source: Stahmer, Kuhn and Braun, 1996.

Plants and forests

3.177. Although plants and forests (hereafter referred to for convenience as "plants") are grouped with animals as biological resources, their interaction with the environment is entirely different. Plants absorb mainly carbon dioxide and water and convert this into oxygen and an increase in weight (production in the case of cultivated assets). The weight of oxygen released by plants is about two-thirds the weight of carbon dioxide absorbed so the increase in weight of the plants is accounted for by this "fixing" of the carbon and the absorption of water. Not all the water absorbed is retained, most is lost through evapotranspiration, but the net retention is still significant.

3.178. Other inputs into plant cultivation are relatively small by volume and mainly concern fertilisers and pesticides. Not all of these are absorbed by the plants; some reach the soil or water courses (dissipative losses).

3.179. Because of the difficulties of measuring the ecosystem inputs accurately, the following pragmatic approach is often followed. The increase in the biomass of plants is well measured and so is taken, by convention, to be equal to the net value of ecosystem inputs (that is water and carbon dioxide in less oxygen and water vapour out). The value of other inputs is taken, also by convention, to be equal to the value of other residuals. This assumes the take-up by plants of fertilisers is exactly offset by plant residues such as dead leaves. While obviously not strictly correct and not in strict accordance with the measurement of production using SNA conventions, it does rely on direct measurement and the statistical error introduced by this in practice is unlikely to be significant. Table 3.21 gives an example for plants and forests under both detailed accounting and using the simplification suggested here. This simplification is incorporated in the example on material flow accounting discussed in Section 5 below.

3.180. In Germany, all animal husbandry is treated as production because of the intensive nature of the activity. In countries where intensive animal husbandry is not common, a pragmatic approach, similar to that shown above for plants and forests, may be appropriate. This is also the approach which is likely to be useful in measuring the take up of ecosystem inputs and the generation of residuals by non-cultivated biological resources.

Table 3.21 Metabolism account for plants

Million tonnes

	Full biological metabolism			Pragmatic approach		
	Cultivated plants other than forests	Cultivated forests	Plants and forests	Cultivated plants other than forests	Cultivated forests	Plants and forests
	Inputs (uses)			Inputs (uses)		
Ecosystem inputs	385.3	47.5	432.8			
Water from nature	107.6	13.8	121.4			
Minerals	0.7	0.0	0.7			
Carbon dioxide	277.0	33.7	310.7			
Biomass increase				195.1	23.0	218.1
Products	11.2	0.1	11.3	11.2	0.1	11.3
Water	5.7	0.0	5.7	5.7	0.0	5.7
Agricultural products	1.3	0.0	1.3	1.3	0.0	1.3
Fertilizers, pesticides	4.2	0.1	4.3	4.2	0.1	4.3
Total inputs	396.5	47.6	444.1	206.3	23.1	229.4
Water	113.3	13.8	127.1	5.7	0.0	5.7
Other inputs	283.2	33.8	317.0	200.6	23.1	223.7
	Output (supply)			Output (supply)		
Products	195.1	23.0	218.1	195.1	23.0	218.1
Biomass increase	195.1	23.0	218.1	195.1	23.0	218.1
Other products	0.0	0.0	0.0	0.0	0.0	0.0
Residuals	201.4	24.6	226.0	11.2	0.1	11.3
Water vapour etc.	0.0	0.0	0.0	5.7	0.0	5.7
Oxygen	201.4	24.6	226.0	0.0	0.0	0.0
Agricultural products				1.3	0.0	1.3
Fertilizetrs, pesticides				4.2	0.1	4.3
Total outputs	396.5	47.6	444.1	206.3	23.1	229.4
Water	0.0	0.0	0.0	5.7	0.0	5.7
Materials (excluding water)	396.5	47.6	444.1	200.6	23.1	223.7

Source: Stahmer, Kuhn and Braun, 1996.

4 Accounts for timber and wood products

3.181. One application of the principles of accounting for physical flows of materials is to follow the progress of a natural resource through the successive stages of its absorption into various products. Table 3.22 and Table 3.23 give an example for timber and wood products based on Finnish data for 1995.

3.182. Table 3.22 is divided into two vertical sections and three horizontal ones with a final balancing row. The top left sub-matrix of the table shows the supply of three sorts of wood from fellings and from imports. Felled timber is either coniferous softwood or broad-leaved hardwood. The figures here are consistent with those referring to the volume of harvested timber in the asset accounts for standing timber in Chapter 8. Fuel wood from fellings is mainly small-size timber, which is felled and removed from the forest directly for combustion purposes. Some supply of each of these three sorts of timber goes to export and some to inventories (or is supplied from inventories). A balance can thus be made of the total supply available for domestic use. For fuel wood, the "other supply" row indicates logging residues from the forestry and logging industries which are collected for industrial and small-size combustion. Fuel wood is mainly burnt in households and in agriculture though also to a limited extent in the energy sector.

3.183. The middle section of the table relates to forest industries. One line shows in negative figures the inputs to a series of forest industries; sawing and planing, veneer production, particle board and fibre board production. The subsequent line shows in positive figures the production of residues and forest industry products. The total production, as the sum of all positive entries in this second part of the table, also appears in the row "Output of forest industries" in the top right sub-matrix. The total use of the products within the forest industries is shown as the sum of all the negative entries at the bottom of the middle section of the table. For example, the industry for sawing, planing and veneer production uses 23 770 thousand solid cubic metres of saw logs, 790 thousand solid cubic metres of pulp wood plus small amounts of sawn wood and particle board. This is turned into 10 258 thousand solid cubic metres of sawn wood and veneers and 14 471 thousand solid cubic metres of residues. Of these residues, 1 008 thousand cubic metres is used as fuel in sawing, planing and veneer industries.

Table 3.22 Material flows of timber and forest products in Finland, 1995

		Saw logs	Pulp wood	Fuel wood	Residues Fuel	Residues Raw material	Sawn wood and veneers	Particle and fibre board	Mechanical and chemical pulp	Sulphate (black liquors)	Paper and board	Recycled paper
		1000 solid cubic metres					1000 cubic metres		1000 metric tons			
Supply for domestic use												
Fellings as harvested timber		25 680	26 310	4 720								
Import		640	9 920		42	681	216	55	96		204	68
Outputs of forest industries					6 277	10 685	10 258	573	10 088	9 803	10 941	
Other supply				300								512
Export		- 858	- 175		- 1	- 163	-8 089	- 282	-1 302		-9 603	- 35
Inventories		77	-4 353	..	..	- 504	- 51	2			- 50	..
Total		**25 539**	**31 702**	**5 020**	**6 318**	**10 699**	**2 334**	**348**	**8 882**	**9 803**	**1 492**	**545**
Forest industries												
Sawing, planing	Inputs	-23 770	- 790	- 17	-1 008		- 50	- 1				
and veneer production	Outputs				4 858	10 685	10 258					
Particle and fibre	Inputs		- 20		- 282	-1 050	- 6				- 3	
board production	Outputs				5			573				
Mechanical and	Inputs	-1 470	-31 120	- 12	-3 989	-9 210				-9 313		- 70
chemical pulp production	Outputs				2 486				10 088	9 803		
Paper and board	Inputs								-8 750		- 64	- 380
production	Outputs										10 941	
Total	**Inputs**	**-25 240**	**-31 930**	**- 29**	**-5 279**	**-10 260**	**- 56**	**- 1**	**-8 750**	**-9 313**	**- 67**	**- 450**
Other industries												
Wood industries	Inputs	- 406	- 54		- 80	- 31	- 618	- 100				
Paper goods, printing and publishing	Inputs								- 38		-1 370	- 75
Energy sector	Inputs			- 97	- 904							
Building and construction	Inputs	- 101	- 23				-1 706	- 241				
Others and households use	Inputs	- 15		-4 867		- 47	- 53	- 6	- 94	- 5	- 73	
Total	**Inputs**	**- 522**	**- 77**	**-4 964**	**- 984**	**- 78**	**-2 377**	**- 347**	**- 132**	**- 5**	**-1 443**	**- 75**
Losses, statistical error		- 223	- 305	27	55	361	- 99	0	0	485	- 18	20

Source: Statistics Finland.

3.184. The third sub-matrix shows the use of felled timber and forest industry products not accounted for in earlier parts of the table as inputs to non-forest industries and other uses. The heading "Wood industries" includes the manufacture of prefabricated buildings, carpentry and furniture. "Others and household use" includes agriculture, households, the rest of manufacturing industry and other industries. All the entries in this part of the table are negative since they all relate to uses.

3.185. The fourth and fifth columns relate to the production and use of wood residues as raw materials and fuel. Residues (chips, bark, sawdust and particles) originate in the processing of saw logs and pulp wood in saw-milling, veneer and pulp industries. Most residues (chips) are used as raw materials in pulp production and in particle and fibre board production; some in wood industries. Residues as fuel (bark, sawdust and particles) are burnt both in power plants mainly providing energy to forest industries and in power plants for general energy production included in the industrial sector of electricity, gas, steam and hot water supply (the "energy sector").

3.186. Once the lower sub-matrices are completed, the upper part of the table can be completed. Total production of forest products is shown in the right part, exports and changes in inventories are also recorded. The balance for this part of the table shows the supply available domestically for the year in question for each sort of timber and forest products. In principle, this supply must be used either by forest industries or other industries. In practice an arithmetical residual is calculated and ascribed to losses and statistical error.

A picture of the role of forestry in the economy

3.187. Supply and use balances can be presented by individual timber assortments and products, and/or aggregated timber and product categories as in Table 3.22. The table shows that most saw logs are transformed into sawn wood and veneers. Some saw logs are used in wood industries, in construction industries and even in pulp industries. The majority of sawn wood and veneer is exported but a significant proportion goes into construction industry and wood industry. Particle and fibre boards are made mainly from residues, and pulp is made from both pulp wood and residues. Pulp output goes mainly into paper and paperboard production as does an amount of recycled paper. Some pulp is exported. Paper and board in turn goes into paper goods production and printing and publishing, but again the vast majority is exported. Sulphate liquors from processes of chemical pulp production (the wood content of these liquors is 70 per cent) are burnt for energy production in chemical pulp mills.

Mass balances

3.188. In Table 3.22 different units are used depending in what is most appropriate for the product in question. The first three columns relate to felled timber measured in solid cubic meters over bark. The right hand columns in the sub-matrices are shown in cubic metres for sawn wood, veneers and particle and fibre boards, and metric tonnes for mechanical and chemical pulp, sulphate liquors, paper and paper board and recycled paper.

3.189. Wood material balances for inputs and outputs in each branch of forest industries, and also at the level of the national economy, can be calculated by converting timber and products into a common unit. Conversion factors from volume and weight of timber and products to weight of dry wood take into account the water contents of timber and products, as well as such items as glues, chemicals, coating materials and other components in forest industry products. A summary table of Finnish supply and use mass balance for wood material is presented in Table 3.23. The mass balance of wood material can be expanded to a wider material balance by using the "natural" weights of timber and products, adding the inputs of other materials than wood, and by presenting the fuel use as air emissions and other wastes from combustion.

3.190. Tables on material flow and balances presented draw on information from specialist trade associations and research institutes as well as information collected in a statistical office. They are useful in understanding the implications for industrial activity consequent on the existence of significant forest reserves and harvest, especially when linked to employment and regional data. They also form a vital role in providing the basic input-output tables in monetary terms.

Table 3.23 Mass balance of timber and forest products in Finland, 1995

Million dry-matter tonnes of wood

Inputs		Outputs	
Saw logs and pulp wood	-24.4	Exported raw wood	0.5
Forest industry	-24.2	Forest industry products	14.0
Domestic wood	-19.4	Sawn goods and veneers	4.5
Imported wood	-4.8	Particle and fibre boards	0.3
Other use	-0.2	Exported residues	0.1
Fuel wood	-2.1	Exported pulp	1.2
Imported residues and pulp	-0.3	Paper and board	8.0
Recycled paper	-0.4	Fuel	11.2
		Residues	2.6
		Black liquor	6.5
		Fuel wood	2.1
		Other goods	0.2
		Wood waste	1.2
Total	-27.3	**Total**	27.2
		Losses, error	-0.1

Source: Statistics Finland.

5 *Economy-wide Material Flow accounts (MFA)*

Introduction

3.191. The purpose of economy-wide material flow accounting (MFA) is to provide an aggregate overview, in tonnes, of annual material inputs and outputs of an economy including inputs from the national environment and outputs to the environment and the physical amounts of imports and exports. Economy-wide MFA and balances constitute the basis from which a variety of material flow based indicators can be derived (Eurostat, 2001a, p. 15).

3.192. As mentioned in Section A, there is little that conceptually distinguishes MFA from physical supply and use tables. However, some general differences can nevertheless be outlined, as follows:

In general, MFA focuses on the overall flows into an economy and out from the economy. The product flows within the national economy are not described.

MFA requires that all materials are accounted for. Supply and use tables are often set up for a subset of materials.

In MFA, flows of materials are often aggregated in order to produce indicators for total material flows. Supply and use tables are often more detailed.

MFA operates at two levels; one for direct flows and one for indirect flows. The direct flows are those that cross either the border between the national environment and the national economy (national resources) or the border between the rest of world economy and the national economy (imported products). These flows are a subset of flows described in physical supply and use tables. The indirect flows described by MFA happen either within the environment (such as mining overburden) or within the rest of the world (in particular resource extraction in other countries). These flows are not described by physical supply and use tables.

Due to the more aggregated focus in MFA a lot of detail on the domestic origin and destination (breakdown on industries and households) can be avoided. Thus, for the direct flows, MFA is less demanding with respect to data and labour needed for compiling the accounts. On the other hand, MFA is very demanding when it comes to the indirect flows.

3.193. The physical flow accounts can be presented in different levels of aggregation. Probably the most condensed form of presentation is the so-called economy wide material flow accounts in Table 3.24. Accounts of this type have been published (Adriaanse *et al*., 1997) for Germany, Japan, the Netherlands and United States. A highly simplified version of the economy wide material flow account was already represented by the overview scheme of the economic sphere earlier in Section B. In economy wide material flow accounts, the material inputs and total material outputs are balanced by the net material accumulation in the economic sphere. In the construction of these accounts, the transfers within the national economic sphere such as (intermediate) consumption can basically be ignored. Only the underlying mass flows of imported and exported products have to be taken into consideration.

3.194. A major aim of economy-wide material flow accounts is the estimation of the total material requirement of a national economy. This is the sum of the total material input in the economy. Besides the direct material inputs presented in Table 3.24 material flows within the environment are also taken into consideration. These flows consist of:

ancillary flows: material that must be removed from the natural environment, along with the desired natural recourse, to obtain the natural resource.

excavated or disturbed flows: material that is moved or disturbed to obtain the natural resource.

These flows are sometimes described as hidden flows, indirect flows or unused extraction.

3.195. It is important to further narrow down the boundaries of the physical flow accounts in the first section of this chapter in order the know to what extent supplementary estimations are required for the coverage of hidden flows. For example, the ancillary mass flow of ore residuals may have been taken into account by the production or import of ore and subsequently in the residual output of steel manufacturers. Secondly, from a conceptual point of view the excavated material with respect to the construction of infrastructure such as highways or buildings contributes to the total material accumulation in the economic sphere as an increase in capital stock. Therefore this material input and accumulation should be recorded as such in the tables.

3.196. In the WRI publication the estimation of hidden flows connected to imported products is also taken into consideration. The total material requirements related to products consist not only of these hidden flows but may also include other products, such as energy inputs and capital that will never be physically embodied in the final imported product. Input-output analysis can be a very helpful tool to systematically estimate these indirect material requirements of final products.

3.197. The level of “dematerialisation” of the economy can be shown by a comparison of the changes in the volumes of total material requirement to those of gross domestic product. When the balancing item of net material accumulation in the economic sphere is relatively small, most of the total material input is released back into the environment. With respect to residual outputs, it is very important to know some of the elementary characteristics in order to understand the environmental consequences of these residual outputs. Hazardous materials such as heavy metals are often represented by tiny mass flows that are easily hidden in the margins of error of the accounts. However, the account presented in Table 3.24 can also be constructed for particular material flows such as energy (denominated in joules), nutrients, heavy metals etc. Also for these partial material flows the same underlying definition equation applies:

products imported
+ natural resource extraction
= products exported
+ net residual output
+ material accumulation in the economic sphere.

Table 3.24 Economy wide material flow account

Million tonnes

	Inputs	Outputs
Economic sphere		
Products		
Imports	150 000	
Exports		101 000
Environmental sphere		
Natural resources		
Subsoil deposits	238 000	
Non-cultivated biological assets	16 000	
Water	12 000	
Air (O_2, N_2)	142 000	
Residuals		
To air		210 956
To water	145	1 226
Solid waste	32 510	188 464
Total material accumulation in the economic sphere		89 009
Total inputs/outputs	590 655	590 655

Source: SEEAland data set.

3.198. Table 3.24 is a typical presentation of a material flows account consistent with Table 3.15 and, indeed, is essentially just a different way of presenting the same information. Compared to the above mentioned MFA accounts for Germany, Japan, Netherlands and United States and the guidelines published by Eurostat, Table 3.24 deviates with respect to the treatment of cultivated biological products. In the table shown here ecosystem inputs used for the growth of these products are recorded. In "traditional" MFA accounting the total amount of harvest of plants are recorded instead of the ecosystem inputs. In practice this difference is of minor importance and to illustrate the connection with the supply and use tables, the MFA accounting conventions have been interpreted loosely here.

Indicators based on material flows analysis

3.199. MFA based indicators have been suggested to provide an overview on the headline issues of resource use, waste disposal and emissions to air and water. They consist of input indicators, output indicators and consumption indicators.

Input indicators

3.200. ***Direct Material Input*** (DMI) measures the input of materials used in the economy, that is, all materials which are of economic value and are used in production and consumption activities; DMI equals domestic (used) extraction plus imports. Materials which are extracted by economic activities but that do not normally serve as input for production or consumption activities (mining overburden, etc.) have been termed unused extractions. They are not used for further processing and are usually without economic value. DMI plus unused domestic extraction comprises Total (domestic) Material Input.

3.201. ***Total Material Requirement*** (TMR) includes, in addition to DMI, the upstream hidden material flows which are associated with imports and predominantly burden the environment in other countries. It measures the total "material base" of an economy; that is, the total primary resource requirements of the production activities. Adding these upstream flows converts imports into their "primary resource extraction equivalent".

Output indicators

3.202. ***Domestic Processed Output*** (DPO) represents the total mass of materials which have been used in the national economy, before flowing into the environment. These flows occur at the processing, manufacturing, use, and final disposal stages of the economic production-consumption chain. Exported materials are excluded because their wastes occur in other countries. Included in DPO are emissions to air from commercial energy combustion and other industrial processes, industrial and household wastes deposited in landfills, material loads in waste water, materials dispersed into the environment as a result of product use (dissipative flows), and emissions from incineration plants. Material flows recycled in industry are not included in DPO.

3.203. ***Total Domestic Output*** (TDO): The sum of DPO and disposal of unused domestic extraction. This indicator represents the total quantity of material outputs to the environment released on the national territory by economic activity.

3.204. ***Direct Material Output*** (DMO): The sum of DPO and exports. This parameter represents the total quantity of direct material outputs leaving the economy after use either towards the environment or towards the rest of the world.

3.205. ***Total Material Output*** (TMO): The sum of TDO plus exports. It therefore measures the total of material that leaves the economy.

Consumption indicators

3.206. ***Domestic material consumption*** (DMC) measures the total amount of material directly used in an economy, excluding hidden flows. DMC equals DMI minus exports.

3.207. ***Total material consumption*** (TMC) measures the total primary material requirement associated with domestic consumption activities. TMC equals TMR minus exports and their hidden flows.

3.208. ***Net Additions to Stock*** (NAS) measures the physical growth rate of an economy. New materials are added to the economy's stock each year (gross additions) in buildings and other infrastructure, and materials incorporated into new durable goods such as cars, industrial machinery and household appliances, while old materials are removed from stock as buildings are demolished and durable goods disposed of.

3.209. ***Physical Trade Balance*** (PTB) measures the physical trade surplus or deficit of an economy. PTB equals imports minus exports. Physical trade balances may also be defined including hidden flows associated with imports and exports (for example on the basis of TMC accounts).

6 *Physical input-output tables (PIOT)*

Construction of PIOT

3.210. Based on a set of physical supply and use tables for all materials (or a sub-set of these) it is possible to construct a physical input-output table which shows the physical flows (or the sub-set of materials) from the environment or rest of the world to the economy, within the economy and from the economy to the rest of the world or the environment in a condensed way.

3.211. Supply and use tables are asymmetric in the sense that they show industries and other economic entities in one dimension and products or materials in the other. They are industry by products tables. In contrast, input-output tables are symmetric; they are either industry by industry or product by product tables.

3.212. In order to convert the asymmetric physical supply and use tables into symmetric physical input-output tables some assumptions and techniques are needed. These are in fact the same assumptions and techniques that are used when monetary supply and use tables are converted into monetary input-output tables. Monetary input-output tables are described briefly in Chapter 4 and in greater detail in the 1993 SNA (Chapter XV) and in the Handbook of Input-output Tables (United Nations, 1999a).

3.213. Table 3.25 shows an industry by industry physical input-output table corresponding to the physical supply and use tables presented earlier in Section C.

Table 3.25 Physical input-output table

Million tonnes

	Industries				Capital	Households	ROW Exports	Residuals	Accumulation	Total
	I1	I2	I3	I	CF	C	X	R		
I1 Agriculture, fishing and mining	26.258	120.799	10.581	157.638	45.833	14.290	32.239	35.240		285.240
I2 Manufacturing, electricity and construction	26.446	146.144	10.263	182.853	66.526	13.401	36.221	186.680		485.680
I3 Services	0.392	0.802	0.074	1.268	0.066	0.208	0.458	57.925		59.925
I Total industries	53.096	267.746	20.917	341.758	112.425	27.899	68.918	279.845		830.845
CF Capital								72.595	72.215	144.810
C Households								48.206	16.794	65.000
M ROW Imports	20.904	69.254	10.083	100.242	6.575	11.101	32.082	5.756	-51.756	104.000
N Natural resources	196.000	65.000		261.000		2.000	1.000			525.000
E Ecosystem inputs	15.000	81.000	25.000	121.000		24.000	2.000			268.000
Absorption of residuals	0.240	2.680	3.925	6.845	25.810					39.500
Total	285.240	485.680	59.925	830.845	144.810	65.000	104.000	406.402	37.253	

Source: SEEAland data set.

3.214. The columns in the PIOT show the input into the corresponding category and the rows show output from the category. It is seen that agriculture has a total input of 285 240 kilotonnes, of which 26 446 kilotonnes are products received from manufacturing, electricity and construction, 196 000 kilotonnes are natural resources, 15 000 kilotonnes are ecosystem inputs and 240 kilotonnes are residuals received for re-absorption or re-circulation. The total input has been converted to an amount of output equal to input. Thus, the row sum for agriculture is also 285 240 kilotonnes. The cells in the row shows that this amount includes

157 638 kilotonnes received by manufacturing, electricity and construction and 35 240 kilotonnes of residuals.

3.215. In the PIOT inputs (column totals) equal outputs (row totals) for each of the industries, for capital, for households and rest of the world. No balancing items for the environment as such are introduced in the table shown.

3.216. If Table 3.25 is compared to Table 3.12 it is seen that entries in the rows in the supply and use table showing the use of products have been converted in the input-output table to show the source as coming from a particular national industry or the rest of the world as imports. The total inputs for each category within each column remain unaltered, however. It can also be seen that the totals and balancing items for industries, capital, households, and the ROW are the same in the two set of tables. For the rest of the world the balancing item in the PIOT (-51 756 kilotonnes) is the sum of the net material balance for products (trade balance) and residuals coming from non-residents on the national territory less ecosystem inputs to the rest of the world. The table focuses on flows coming from economic activity on the territory. Thus the trans-boundary flows of residuals by environmental media and the flows related to resident units abroad have not been introduced in this table, but by introducing more columns and rows that can be done in the same way as has been done in Table 3.12.

Examples of PIOT

3.217. Compiling a physical input-output table in practice is an extensive task. Although it does not involve any tasks which have not already been covered in principle, in practice many more data entries need to be considered. Generally, it will only be possible to construct a physical table when detailed monetary supply and use tables already exist because for some entries the physical quantities will have to be determined by dividing the monetary figures by appropriate prices. In any case, both tables should exist side by side to ensure that analytical lessons from the two are consistent with the pattern of prices and quantities to be observed in the economy. Descriptions of the compilation of physical input-output tables are available elsewhere, for example for Germany (Stahmer *et al.*, 1996) and Denmark (Gravgaard Pedersen, 1999).

3.218. As well as compiling a complete table in physical terms for all materials, in some cases it is possible to compile supply and use tables or physical input-output tables for some of the materials or chemical substances which are relevant to environmental policy. Two examples are given here, one for packaging materials and one for the nitrogen content of goods.

Packaging

3.219. The example for packaging materials shows how a subgroup of products of particular policy interest can be drawn from a full, detailed supply and use table for all products. Alternatively, particular tables for the specific subgroup can be constructed directly on the basis of production statistics and foreign trade statistics.

3.220. Table 3.26 shows the main supply and use aggregates related to aggregates of 30 different types of packaging, including sheets, foils, bags, sacks, carboys, bottles, drums, pallets, boxes, tubes, barrels, stoppers and caps made of plastic, wood, paper, cardboard, glass or metal.

3.221. The supply consists of imports and materials needed for the production of empty packaging. When materials needed for the production of packaging are included as supply instead of packaging materials as such, a double counting of packaging used as input for the production of other packaging materials is avoided. On the use side exports and use by industries and households are the main components even though some gross fixed capital formation (for example pallets) and changes in inventories are recorded as well. Of course, more detail can be introduced, for example by distinguishing between types of materials used for the packaging (plastic, wood, paper, etc.) or, if a physical input-output table based on the detailed supply and use table is constructed, analysis can be made of the flows of packaging within the economy.

Table 3.26 Supply and use of packaging in Denmark, 1990

Kilotonnes

Supply		Use	
Imports of empty packaging	191	Exports	251
Materials for the production of empty packaging	883	Gross fixed capital formation	14
		Changes in inventories	-18
		Use in industries and households	827
Total	**1 074**	**Total**	**1 074**

Source: Gravgaard Pedersen, 1999.

Nitrogen

3.222. The example for nitrogen illustrates the more complicated cases in which materials or chemical substances are not commodities as such and therefore not explicitly included in the supply and use tables for products. However, in some cases such as nitrogen, it is possible to calculate the content in the various commodities supplied to and used in the economy. The starting point is a detailed supply and use table for all commodities which include nitrogen (food, feeding stuff, fertilisers, other chemical products, wood, textile, plastic etc.). For each accounting entry in the physical supply and use table for the products, the nitrogen content expressed as the proportionate weight of nitrogen per unit of product is multiplied by the weight of the product. In this way a supply and use table for the nitrogen flows embedded in products is obtained. Table 3.27 shows aggregated results of such a calculation based on supply and use information for approximately 800 products and matching nitrogen percentages.

Table 3.27 Supply and use of nitrogen embedded in products in Denmark, 1990

Kilotonnes

Origin/supply		Destination/use	
Imports	784	Exports	296
Danish resources	98	Gross fixed capital formation	2
		Changes in stocks	47
		Losses etc.	536
Total	**882**	**Total**	**882**

Source: Gravgaard Pedersen, 1999.

3.223. Nitrogen flows to the economy consisted of 784 kilotonnes of nitrogen in imported commodities plus 98 kilotonnes included in biomass extracted from the domestic environment. Thus, the total supply of nitrogen was 882 kilotonnes.

3.224. This quantity is broken down on the use side into 296 kilotonnes in exports, 47 kilotonnes in inventory changes, 2 kilotonnes accumulated in connection with gross capital formation (agricultural breeding stock, etc.) and a residual of 536 kilotonnes, which include losses to the Danish environment.

3.225. Based on the detailed physical supply and use table for nitrogen flows a physical input-output table for the flows can be constructed in order to analyse the flows in more detail. Table 3.28 shows an aggregated version including three main groups of industries. This table includes inter-industry flows of nitrogen embedded in products, flows from industries to final uses (private consumption, fixed capital formation, inventory changes and exports), imports and flows from environment with reference to the biological fixation of nitrogen during (produced) biomass growth. A column for the nitrogen losses from industries and households is introduced in the table. This loss corresponds to the difference between the total input for each of the industries and the output for intermediate consumption and final uses. The nitrogen content supplied to private consumption from domestic industries and imports is, as a whole, also recorded in the physical input-output table's residual part on the basis of an assumption that nitrogen is finally returned to the environment in conjunction with waste and sewage.

Table 3.28 Aggregated physical input-output table for nitrogen flows in Denmark, 1990

Kilotonnes

	Intermediate consumption				Final demand					Losses to the environment etc.	Total
	1. Agriculture etc.	2. Manufacturing etc.	3. Services	Total	Private consumption	Capital formation	Changes in stocks	Exports	Total		
1. Agriculture, horticulture, fishing, mining etc.	52	156	1	209	6	1	7	87	101	446	**755**
2. Manufacturing, construction etc.	187	90	10	288	32	1	55	195	283	24	**595**
3. Services	-	-	-	-	8	-	-	-	8	7	**15**
Domestic industries total	239	246	11	496	46	1	62	282	391	477	**1 365**
Imports	419	349	4	771	12	0	- 14	14	12	-	**784**
National resources – biological fixation of nitrogen, etc	98	-	-	98							**98**
Nitrogen from private consumption										59	**59**
Total	**755**	**595**	**15**	**1 365**	**59**	**2**	**47**	**296**	**404**	**536**	**2 305**

Source: Gravgaard Pedersen, 1999.

Chapter 4 Hybrid flow accounts

A Chapter overview

1 Objectives

4.1. Chapter 3 introduced a set of physical flow accounts using classifications and a structure familiar to national accountants. In this chapter the analytical potential of juxtaposing these data with the corresponding monetary flow accounts is explored. In addition the extra robustness in both sets of data which comes from considering them simultaneously is discussed. One strength of this approach is that the integration of physical and monetary accounts in this way does not impact any of the SNA accounting conventions. Those who wish to examine the implications of environmental phenomena within the context of the national accounts as presently defined and understood therefore find this a particularly attractive presentation. The possibilities of integration in which SNA accounting conventions are modified to yield additional macro-aggregates that incorporate information on environmental flows are discussed in chapters 8 and 10.

4.2. This chapter should be viewed together with Chapter 3. Much of the discussion there, including many general accounting rules and definitions, is also relevant to this chapter but is not repeated here.

4.3. Throughout this chapter and in those which follow, reference is made to various national accounts tables as presented in the 1993 SNA. It is the bringing together of environmental accounts and economic accounts which is the motivation of this entire handbook. It is the flexibility to augment the system via satellite accounts which allows the SEEA to be part of the wider set of national accounting formulations consistent with the 1993 SNA. It is not the place here to try to reproduce all the arguments underlying the rationale for the particular format of the economic accounts nor to explain all the strict accounting conventions there. A very brief overview of some of the important concepts of the SNA is given in Chapter 2. Beyond that, it is assumed that those who are interested in this detail are either well-informed on the subject or will seek explanations in material dedicated to the economic accounts alone.

4.4. The term "hybrid flow accounts" is used to denote a single matrix presentation containing both national accounts in monetary terms and physical flow accounts showing the absorption of natural resources and ecosystem inputs and the generation of residuals. The acronym NAMEA has come into widespread use for these types of tables. It stands for a National Accounting Matrix with Environmental Accounts and originated with the work developed throughout the 1990's by Statistics Netherlands. However, the notion of confronting monetary and physical data also lay at the heart of the 1993 SEEA and the use of the term NAMEA should be seen as convenient shorthand for the development of the 1993 SEEA rather than an alternative to it. Indeed, the basic principles of hybrid accounting structures as discussed in this chapter were actually founded in the late 1960's by Leontief (1970) and others (see, for example, Cumberland, 1966; Daly, 1968; Isard, 1969; Ayres and Kneese, 1969; and Victor, 1972). These researchers introduced the analysis of the "physical economy" by way of input-output modelling. They represented residual emissions as a by-product of regular production activities and showed how this could be incorporated in the conventional input-output framework. The underlying data system of their models comprised physical data, described in connection with monetary information on the economic structure. These data systems could be regarded as forerunners of the hybrid account.

4.5. Different forms of hybrid accounts exist. This chapter concentrates on two of them, first hybrid supply and use tables and then hybrid input-output tables. A more extensive hybrid account which includes all the distributive and redistributive monetary accounts of the SNA is discussed in Chapter 6 after other monetary flows have been discussed in Chapter 5. A hybrid account records physical flows in a manner compatible with economic transactions as presented in the national accounts. This linkage guarantees a consistent comparison of environmental burdens to economic benefits, or environmental benefits to economic costs. This linkage can be examined not only at the national level but also at disaggregated levels; for example, relating to regions of the economy, specific industries, or to examine the relations leading from the absorption of a particular natural resource or leading to the emissions of a particular residual. Because it combines physical data which may be of more immediate comprehensibility to scientists with monetary data familiar to economists, it has the potential to form a bridge between these two schools of concern about the environment. An important point to note is that it is quite legitimate to include only a limited set of natural resources, ecosystem inputs and residual outputs, depending on the most urgent environmental concerns to be taken into consideration. It is certainly not necessary to complete an exhaustive natural resource input table, or a residual output table. This is also true for the overall accounting framework that is to be used. National accounting matrices, supply and use tables or input-output tables can each be used as an appropriate framework, depending on the intended analysis and the availability of data.

4.6. A hybrid account thus represents an analytical framework showing which parts of the economy are most relevant to specific indicators and how changes in the economic structure influence the evolution of indicators over time. Further, because the accounts provide consistent environmental and economic indicators, the possible trade-offs in environmental terms between alternative environmental and economic strategies can be analysed. At finer levels of disaggregation, the hybrid accounting framework provides the scientific community with access to a structured database for further research into the role of these indicators in monitoring the overall environmental-economic performance of national economies. In this way, hybrid accounts build a bridge between (aggregate) policy assessment and (underlying) policy research.

2 Products and industries

4.7. The physical flow accounts presented in Chapter 3 are based around the distinction between natural resources, ecosystem inputs, products and residuals. Natural resources and ecosystem inputs enter the economy; residuals eventually leave it. Economic activity itself is concerned with the production and consumption of goods and services (products). All natural resources and ecosystem inputs absorbed by the economy are converted into products by one means or another. All physical products eventually return to the environment as residuals. It is the process in between, when products circulate within the economy which is of interest for economic accounting since this is the point in the cycle when monetary values can be associated with the flows.

Supply and use tables

4.8. There are three basic economic activities recorded in the national accounts: production, consumption and accumulation. Accumulation may relate to physical products as capital formation or to intangible non-financial assets. For the present, it is the physical products which concern us and although some products remain within the economy for a period of time, maybe for a very long period as in the case of buildings, even these eventually return to the environment. Thus we may focus on the processes of production and consumption accepting that the same process which applies to consumption will in the long run apply to physical accumulation also.

4.9. Confronting data on production and consumption is part of the process of matching supply and use of products. The important distinction between these two pairs of concepts is that production is undertaken by enterprises which we classify by industry but what is supplied and used (consumed) is expressed in terms of products. If there were always a simple one to one match between products and industries, statistical life would be simpler with one classification being applicable to both. Some conventions can be adopted to approximate this as closely as possible. For example, we may say that there is an industry producing hydro electricity, one producing nuclear electricity and several producing electricity by means of fossil fuel combustion, but in that case we designate each of these forms of electricity to be separate products instead of treating all electricity as a single product.

4.10. Some products are available only in conjunction with other products, such as cotton and cotton seed, and some are available only as by-products; for example, molasses emerges from cane sugar refining. Some which have quite different purposes and therefore look quite different in a product classification are made by such similar technological processes that it is not practical to refine the industrial classification to the same extent as a product one. One example is that the manufacturer of vehicle chassis may not know (or care) whether they are to be used for railway rolling stock or road vehicles even though rolling stock and road vehicles are made by different industries.

4.11. The data with which to compile a supply table comes from producers (that is, enterprises grouped by industry[1]). The value of production relates to all products made as do the sum of all products used for intermediate consumption and the components of value added. The data for a use table reflect information from producers and households on the products consumed. Imports and exports also are classified by products and not the industry of production. Both supply and use tables show a cross-classification of industry by product. While the product totals and industry totals of the two matrices are identical pair-wise, two tables are necessary to reconcile supply and use when different classifications are used for each.

Input-output tables

4.12. A pair of supply and use tables is closest to the basic data available and is the starting place for any subsequent analysis of the interaction between products and producers. However, in order to look at the consequences of changing patterns of consumption on industrial output or import substitution, to take only two examples, it is necessary to be able to relate consumption and production directly. Input-output tables are the means of doing this. An input-output table takes a pair of supply and use tables and eliminates either the industry or product dimension to produce a single table showing both supply and demand according to a single classification. An input-output table is thus either a product-by-product table or an industry-by-industry table. Lengthy expositions and extensive algebra can be invoked to explain the transformation from supply and use tables to input-output table. More on this, together with a brief explanation of the transformation process involved, is given in Section C.

[1] Strictly speaking, large enterprises may provide information for smaller units, establishments or kind of activity units. The purpose of doing this is to collect data for units which are as homogeneous as possible in terms of the products they make but even the smaller units are grouped together according to an industrial classification.

3 Elaborating and using hybrid flow accounts

4.13. The elaboration and use of purely physical flow accounts was covered in Chapter 3 with emphasis on environmental analysis. The rest of this chapter discusses the two forms of hybrid tables discussed above, supply and use tables and input-output tables. Discussion of the more complete form of a hybrid account where all income flows are also included takes place in Chapter 6.

4.14. Section B is concerned with hybrid supply and use tables. Much experience in this area has been built around air emissions accounts and these are described at some length. It is important to recognise that this emphasis reflects experience to date and should not be read as a limit to the applicability of supply and use tables. Part of the section describes the process of establishing a robust energy account in physical terms, though making use of monetary information in the course of its derivation. Part is devoted to some of the applications to derive indicators combining both physical and monetary aspects of the use of environmental materials.

4.15. Section C describes input-output tables. This concentrates not on the mechanics of producing an input-output table but on the various applications for which an input-output table is the appropriate tool. As in the case of the supply and use tables, the examples given are illustrative only and not meant to indicate that the tables are useful only for studying energy use and emissions accounts.

4 Scope and limitations of hybrid flow accounts

Work in progress

4.16. The full potential of hybrid accounts has not yet been exploited. Much of the experience to date has centred on developing air emission accounts on a supply and use basis. Eurostat has sponsored work in all EU countries so that the international applicability can be tested and some cross-country results are now available (Eurostat, 2001d). Work is also progressing on accounts for water and waste (see, for example, Nordic Council of Ministers, 2000).

4.17. Those countries such as the Netherlands and Denmark, who were the first to exploit the supply and use tables of the hybrid accounts, are so far the countries with the most experience of applying the input-output version of these tables. However, it will not be long before similar results are available for other of the countries developing the supply and use tables.

The time dimension

4.18. Accounts in matrix formats convey a lot of material very succinctly, but each matrix refers only to a single time period. Especially for environmental concerns, the interest is in knowing whether and how fast behaviour is responding to environmental issues, either through the use of more advanced and more environmentally benign technologies or more cautious behaviour based on public perceptions about possible future damages and a desire to abide by precautionary principles. A hybrid account can be used to simulate alternative scenarios with different technological assumptions, but it will only be when the compilation of such tables has become routine and a time series of tables exists that *ex post* investigation of the impacts of changing behaviour can be undertaken.

Quantity and volumes

4.19. A hybrid account, whether supply and use or input-output based, in effect has two overlapping matrices for products, one in monetary terms and one in physical terms. By implication, therefore, vectors if not matrices of prices are also available.

4.20. The national accounts pay attention to the means of distribution as much as the means of production. Since it is virtually impossible to buy a pure good, this means national accounts prices are almost always composite indices which reflect not only the cost of production of the good but also the cost of getting it to market. In fact, two sets of prices are available within the national accounts tables. The first of these, referred to as being at "purchasers' prices" represent the total cost to the purchaser including any taxes on products payable at the point of sale, most importantly valued added tax (VAT). An alternative set of prices, called basic prices, is frequently used. These exclude taxes such as VAT and more nearly represent the value initially retained by the producer. They also exclude the "margin" charged by specialist wholesale and retail distributors to get the products to the market place and any transport costs which are billed separately to the purchaser. This means that the effects of most taxes and most distribution costs are removed from basic prices, but not all. When there is a change in the level of taxes charged at the point of delivery or in the mechanism of retail and wholesale distribution, the movements in purchasers' prices and basic prices will differ reflecting this structural change.

4.21. Increasingly, countries are beginning to implement monetary supply and use tables and input-output tables in both current and constant price forms. The ratio of current to constant prices also gives rise to an implicit price index. These implicit prices may be expressed at either purchasers' or basic prices. However, another important difference arises concerning units. Physical accounts are expressed in physical units, often tonnes, while national account volume figures are expressed in the numeraire of the base year (referred to by national accountants as "constant price currency units"). This distinction is easy to remember when the natural units are cited but less so if quantities or volumes are expressed in index number form and more particularly in the case of price indices.

4.22. In national accounting terms, a main objective of expressing amounts at constant prices is to measure economic growth, for which change in quality is as important as change in quantity. National accounts volumes and national accounts prices are thus always quality-adjusted. Equally deliberately, physical quantities and prices are not quality-adjusted. In the case where there has been no quality change, the prices will coincide, but those wishing to derive physical quantities by dividing current price figures by prices must enquire whether these are or are not quality-adjusted and should not simply assume that there has been no change in quality.

4.23. When new technologies are adopted, it is important for the national accountant to decide whether the product produced with the new technology is simply a more expensive version of the previous product or a higher quality version. For example, is a car with a catalytic converter simply a more expensive car or a package of a car plus some environmental services? Attention is drawn to this point because as increasing use is made of market instruments to invoke environmentally preferable behaviour, the consequences for SNA prices and SEEA prices may become more important and analysis based on the inappropriate set of prices may be increasingly misleading. This issue is discussed further in Section C of Chapter 5.

4.24. It is important to note and to remember at various points in the following expositions, that the prices derived from hybrid accounts are simply prices per physical quantity. They are thus not necessarily the same as the prices used in economic accounting when adjustments to prices to allow for changing qualities of products are incorporated. Where it is important to draw attention to this fact, the term "SEEA price" is used for the unadjusted price. Similarly, the term "volume" is used only in the context of quality-adjusted volumes and the term quantity used when the physical measure is not adjusted for quality differences.

B Hybrid supply and use tables

1 Introduction

4.25. The objective of a hybrid account is to bring together physical and monetary data in comparable terms. Since supply and use tables can be represented in both monetary and physical units, a choice must be made over which parts to show in monetary terms and which parts to show in physical units. In principle, the analyst has a degree of freedom in making this choice.

4.26. A logical starting point is to extend the national accounts by those pieces of information that are not captured in that system, that is to say by the resource inputs and residual outputs. These do not appear in the SNA because there are no direct costs linked to their use or generation. The inclusion of physical flow accounts may be used to illustrate the importance and relative magnitude of these environmental interactions.

4.27. This choice preserves a strict boundary between the economic sphere and the environmental sphere, the former represented by accounts in monetary terms, the latter denominated in the most relevant physical units. In this presentation, the SNA is neither extended nor changed in respect of any of the basic principles concerning the transactions to be recorded, the manner of recording them or the prices applying to them. At the same time, the analytical power of the system is extended by juxtaposing information which can be directly related to the economic processes which consume the environmental inputs and generate the residuals. Production and consumption activities are not only described in terms of their transactions but also in terms of their environmental requirements. In this respect, the economic as well as the environmental performance of the economy and the units in it can be evaluated together. This information is especially relevant in formulating policy strategies that are concerned with decoupling economic growth and environmental degradation.

2 The SEEAland hybrid supply and use tables

4.28. Table 4.1 shows a supply and use table in monetary units which corresponds exactly to the physical tables in Table 3.13. Both the similarities and the differences in format between monetary and physical tables are clear from a comparison of the two tables. The monetary tables concern products only, with no entries for natural resources, ecosystem inputs or residuals either used or generated.

4.29. The most significant difference is that two totals are shown for supply in monetary terms. The first of these shows the value retained by the producer; that is, production valued at basic prices. This is usually more than sufficient to cover all the costs the producer must bear, including some taxes on production such as taxes levied on the labour force or on the premises where production takes place. However, this value is usually lower than what the user pays because two factors intervene in bringing products to market. One of these is the margin levied by, typically, wholesalers and retailers, to get goods from the producers' factories to the market place where customers may have access to them. The other is the amount of tax levied by government at the point of sale. Increasingly, this tax often takes the form of some sort of VAT. Another factor which affects the two totals is that the first relates to production in the national economy only whereas the second relates to all products available in the national market and thus includes imports. In this the monetary tables resemble the physical ones, where total supply includes imports also. In monetary terms, though, both margins and taxes may apply to imports as well as to national production. Thus in the upper part of Table 4.1, two totals are shown, one for production at basic prices and one for supply at market prices.

Table 4.1 Monetary supply and use tables

Billion currency units

Total supply of products

	Agriculture, fishing and mining	Manufacturing, electricity and construction	Services	Total domestic production at basic prices	Imports	Trade margins	Taxes less subsidies on products	Total supply at market prices
P1 Animal and vegetable products	39.4	45.0	0.0	84.4	11.2	9.4	0.6	105.6
P2 Stone, gravel and building materials	18.0	26.6	0.0	44.6	5.2	7.8	2.4	60.0
P3 Energy	132.9	125.1	0.0	258.0	82.9	17.5	13.9	372.3
P4 Metals, machinery, etc.	0.0	67.2	0.0	67.2	70.0	6.0	1.9	145.0
P5 Plastic and plastic products	0.0	2.0	0.0	2.0	2.8	0.6	0.3	5.6
P6 Wood, paper etc.	2.2	16.8	0.0	19.0	1.9	2.1	0.9	24.0
P7 Other product groups	36.9	407.4	367.0	811.3	189.0	- 43.5	50.0	1 006.9
All products	229.4	690.0	367.0	1 286.4	363.0	0.0	70.0	1 719.4

Total use of products

	Intermediate consumption	Final consumption			Capital formation	Exports	Total use at market prices
P1 Animal and vegetable products	72.0	0.0	12.8	12.8	0.0	20.8	105.6
P2 Stone, gravel and building materials	54.5	0.0	1.0	1.0	0.0	4.5	60.0
P3 Energy	210.4	11.9	12.2	24.1	0.0	137.8	372.3
P4 Metals, machinery, etc.	32.0	1.5	0.0	1.5	66.5	45.0	145.0
P5 Plastic and plastic products	4.2	0.0	0.6	0.6	0.0	0.8	5.6
P6 Wood, paper etc.	16.1	0.0	2.0	2.0	0.0	6.0	24.0
P7 Other product groups	274.8	0.5	463.9	464.4	79.5	188.2	1 006.9
All products	664.0	13.9	492.5	506.4	146.0	403.0	1 719.4

Source: SEEAland data set.

4.30. Another prominent difference between disaggregated monetary and physical tables is that entries for services are very large in monetary terms and very small in physical terms. In terms of outputs of products, the cells for services in physical terms may often be shown as zero, although small entries may occur when the service concerned is delivered on a physical medium (for example, software and music discs and in the case of catering establishments). On the other hand, virtually all service producers consume physical goods, if only office supplies, and generate residuals.

4.31. The classifications of products and industries in the monetary supply and use tables are the same as in the physical ones, depending on CPC and ISIC in both cases. Classifications of government and household consumption are also compatible, both systems drawing on COFOG and COICOP. In practice, and dealing with much bigger matrices, it is possible that there would be more detail shown in some areas and less detail in others. However, what is important is that exactly the same classification system is used so that a complete consistency can be achieved by suitable aggregation.

4.32. Because there is a match between the monetary and physical amounts of products supplied, it is possible to calculate implicit prices for each commodity. These prices may be based on either the basic price valuation or the market price valuation of the monetary data. At this point, the discussion above on the difference between the implicit prices coming from such a comparison and the prices used in national accounts should be borne firmly in mind. Nevertheless, comparing these implicit prices with other price information available is one important way to control the quality of the data. Equally, if the quantity figures have been derived by dividing the monetary figures by price indices, there must be a check that the resulting quantities make sense when compared across products.

4.33. The use table shows the same amount of products in both physical and monetary terms as in the supply table. The fact that supply and use must be balanced in two dimensions is also a valuable part of the quality control process of compiling the data.

4.34. As explained in Chapter 3, the information in the supply and use tables can be merged into a single table. The use table stays in the format as above; the supply table is transposed and superimposed on the use table. Examples of the result of merging physical supply and use tables are shown in tables 3.11 and 3.12.

4.35. Just as it is possible to combine supply and use tables in physical terms, so it is possible to do this for the monetary tables. This is a much smaller table since there are no rows or columns for natural resources, ecosystem inputs or residuals. Instead of a column to show the balancing item in physical terms, the material accumulation in the economy, there is a balancing row, value added, which could be viewed as a sort of "monetary accumulation" in the industries. That is, it represents the excess of revenue from selling products over the costs of the products needed to manufacture them. This table is shown as Table 4.2.

Table 4.2 A monetary supply and use table

Billion currency units

			Economy																	Total
			Products								Industries				Consumption			Capital	Exports	
			P1	P2	P3	P4	P5	P6	P7	**P**	I1	I2	I3	**I**	C1	C2	**C**	**CF**	**X2**	
Products	P1	Animal and vegetable products									0.7	68.0	3.2	72.0		12.8	12.8	0.0	20.8	105.6
	P2	Stone, gravel and building materials									3.5	50.0	1.0	54.5		1.0	1.0		4.5	60.0
	P3	Energy									47.0	133.4	30.0	210.4	11.9	12.2	24.1	0.0	137.8	372.3
	P4	Metals, machinery, etc.										32.0		32.0	1.5		1.5	66.5	45.0	145.0
	P5	Plastic and plastic products										4.2		4.2		0.6	0.6		0.8	5.6
	P6	Wood, paper etc.										10.1	6.0	16.1		2.0	2.0	0.0	6.0	24.0
	P7	Other product groups									26.6	213.4	34.8	274.8	0.5	463.9	464.4	79.5	188.2	1006.9
		All products									77.8	511.2	75.0	664.0	13.9	492.5	506.4	146.0	403.0	1719.4
		Trade margins	9.4	7.8	17.5	6.0	0.6	2.1	- 43.5											
		Product taxes	0.6	2.4	13.9	1.9	0.3	0.9	50.0	70.0								1.0		
Industries	I1	Agriculture, fishing and mining	39.4	18.0	132.9			2.2	36.9	229.4										
	I2	Manufacturing, electricity and construction	45.0	26.6	125.1	67.2	2.0	16.8	407.4	690.0										
	I3	Services							367.0	367.0										
	I	**Total industries**	84.4	44.6	258.0	67.2	2.0	19.0	811.3	1 286.4										
ROW	M2	**Imports of products**	11.2	5.2	82.9	70.0	2.8	1.9	189.0	363.0										
		Value added									151.6	178.8	292.0	622.4						
Total			105.6	60.0	372.3	145.0	5.6	24.0	1 006.9	1 719.4	229.4	690.0	367.0	1 286.4						

Source: SEEAland data set.

4.36. This table also shows the overall balancing item for the economy. There are three ways of calculating this. It is the total for production by the national economy (1 286.4) less the total for all products used by industry (664.0), leaving 622.4 which is also total value added. It can also be calculated as the sum of consumption (506.4), capital (146.0) and exports (403.0) less imports (363.0) and taxes on products (70.0). Because GDP is usually measured in market prices, the value of taxes on products is usually added to the value of production and value added, rather than being deducted in the third identity to give a figure for GDP of 692.4.

4.37. It would be possible to put Table 3.13 and Table 4.1 next to one another to arrive at a hybrid supply and use account showing both physical and monetary data according to the same classifications in the same table. A more usual form, and the one most often used in the SEEA, is to use a format similar to Table 4.2. If this is compared with Table 3.12, it can be seen that the rows and columns of Table 4.2 correspond to the first two sets of rows and columns in Table 3.12. In addition, Table 3.12 contains the columns for residuals generated and the natural resources, ecosystem inputs and residuals which are used by industry. The normal hybrid supply and use table consists of exactly the entries of Table 4.2 augmented by these "extra" rows and columns from Table 3.12, still expressed in physical terms. The result is shown in Table 4.3.

4.38. Figure 4.1 gives a schematic representation of the hybrid supply and use table. It includes a provision for the addition of ancillary information which may be useful such as employment or energy use. In Table 4.3 the monetary blocks are shown in italics to distinguish them from the physical blocks, while in Figure 4.1 the monetary cells are shaded. Note that the material balance column shown at the end of Table 4.3 does not include entries for capital formation, consumption or imports. This is because all the physical data on product flows necessary to calculate these balances are not provided in the table. As a result, the material balance column does not sum to zero as would be the case if the balances for capital formation, consumption imports were included. In Figure 4.1, there are no separate rows and columns to show whether natural resources and ecosystem inputs originate in the national or rest of the world environment or whether residuals are expelled nationally or internationally. Instead, these flows are indicated in the row for the rest of the world as origin and column for the rest of the world as destination. This is sufficient in a schematic matrix such as this where the exact origin and destination of the flows is of lesser importance. In practice, it is usual to show at least some of the distinction in detail. In Table 4.3, there are separate rows for the origin of each of natural resources, ecosystem inputs and residuals and a separate column for the destination of residuals. In this way, Table 4.3 can be compared exactly with Table 3.13. Provision of natural resources and ecosystem inputs to the national economy from the rest of the world environment and residuals destined for the rest of the world environment are shown in, respectively, the column containing exports of products and the row showing imported products. In this way, this row and column pair encapsulate the impact of the national economy on both the rest of the world economy and environment and *vice versa*.

Figure 4.1 A schematic diagram of a hybrid supply and use table

	Products	Industries	Consumption	Capital	Exports	Residuals
Products		Products used by industry (intermediate consumption	Products consumed by households	Products converted to capital	Products exported	
Industries	Products made by industry					Residuals generated by industry
Consumption						Residuals generated by households
Capital						Residuals generated by capital
Imports	Products imported					Residuals imported
Margins	Trade and transport margins					
Taxes less subsidies on products	Taxes less subsidies on products					
Value added		*Value added by industry*				
Monetary totals	*Total products supplied*	*Total industry inputs*	*Total household consumption*	*Total capital supplied*	*Total exports*	
Natural resources		Natural resources used by industry	Natural resources consumed by households		Natural resources exported	
Ecosystems inputs		Ecosystem inputs used by industry	Ecosystem inputs consumed by households		Ecosystem inputs exported	
Residuals		Residuals re-absorbed by industry		Residuals going to landfill	Residuals exported	
Other information		Employment Energy use	Energy use			

Table 4.3 A numerical example of a hybrid supply and use table

Monetary items (in italics) in billion currency units; physical items in million tonnes

				Economy																
				1. Products								2. Industries				3. Consumption			4. Capital	5. Exports
				P1	P2	P3	P4	P5	P6	P7	P	I1	I2	I3	I	C1	C2	C	CF	X2
Economy	1. Products	P1	*Animal and vegetable products*									*0.7*	*68.0*	*3.2*	***72.0***		*12.8*	***12.8***	*0.0*	*20.8*
		P2	*Stone, gravel and building materials*									*3.5*	*50.0*	*1.0*	***54.5***		*1.0*	***1.0***		*4.5*
		P3	*Energy*									*47.0*	*133.4*	*30.0*	***210.4***	*11.9*	*12.2*	***24.1***	*0.0*	*137.8*
		P4	*Metals, machinery, etc.*										*32.0*		***32.0***	*1.5*		***1.5***	*66.5*	*45.0*
		P5	*Plastic and plastic products*										*4.2*		***4.2***		*0.6*	***0.6***		*0.8*
		P6	*Wood, paper etc.*										*10.1*	*6.0*	***16.1***		*2.0*	***2.0***	*0.0*	*6.0*
		P7	*Other product groups*									*26.6*	*213.4*	*34.8*	***274.8***	*0.5*	*463.9*	***464.4***	*79.5*	*188.2*
			All products									***77.8***	***511.2***	***75.0***	***664.0***	***13.9***	***492.5***	***506.4***	***146.0***	***403.0***
			Trade margins	*9.4*	*7.8*	*17.5*	*6.0*	*0.6*	*2.1*	*- 43.5*										
			Product taxes	*0.6*	*2.4*	*13.9*	*1.9*	*0.3*	*0.9*	*50.0*	***70.0***								*1.0*	
	2. Industries	I1	*Agriculture, fishing and mining*	*39.4*	*18.0*	*132.9*			*2.2*	*36.9*	***229.4***									
		I2	*Manufacturing, electricity and construction*	*45.0*	*26.6*	*125.1*	*67.2*	*2.0*	*16.8*	*407.4*	***690.0***									
		I3	*Services*							*367.0*	***367.0***									
		I	***Total industries***	***84.4***	***44.6***	***258.0***	***67.2***	***2.0***	***19.0***	***811.3***	***1 286.4***									
	3. Consumption	C1	*Own account transport*																	
		C2	*Other consumption*																	
		C	***Total consumption***																	
	4. Capital	**CF**	***Capital formation***																	
	5. ROW (origin)	**M2**	***Imports of products***	*11.2*	*5.2*	*82.9*	*70.0*	*2.8*	*1.9*	*189.0*	***363.0***									
			Value added									*151.6*	*178.8*	*291.9*	***622.4***					
Natural resources	6. National environment		Subsoil assets																	
		N1	Oil									38.000			**38.000**					
		N2	Gas									27.000			**27.000**					
		N3	Other									118.000	55.000		**173.000**					
			Non-cultivated biological assets																	
		N4	Wood, etc.									7.000	1.000		**8.000**		1.000	1.000		
		N5	Fish									1.000			**1.000**					1.000
		N6	Other										2.000		**2.000**					
		N7	Water									1.000	6.000		**7.000**					
		N	**Total national natural resources**									**192.000**	**64.000**		**256.000**		**1.000**	**1.000**		**1.000**
	7. ROW origin		Non cultivated biological assets																	
			Fish									4.000			**4.000**					
			Water										1.000		**1.000**		1.000	1.000		
			Total ROW natural resources									**4.000**	**1.000**		**5.000**		**1.000**	**1.000**		
Ecosystem Inputs	8. National environment	**E1,E2**	**National ecosystem inputs**									15.000	81.000	22.000	**118.000**	10.000	13.000	23.000		2.000
	9. ROW origin	**E1,E2**	**ROW ecosystem inputs**											3.000	**3.000**	1.000		1.000		
Residuals	10. National origin	R1	CO_2																	
		R2	N_2O																	
		R3	CH_4																	
		R4	NO_X																	
		R5	SO_2																	
		R6	NH_3																	
		R7	Other																	
		R8	P											0.020	**0.020**					
		R9	N											0.115	**0.115**					
		R10	Other											0.010	**0.010**					
		R11	Mining																	
		R12	Other solid waste									0.240	2.680	3.780	**6.700**				25.810	
			Total national									**0.240**	**2.680**	**3.925**	**6.845**				**25.810**	
	11. ROW origin	R1-R12	Cross-border residual flows from ROW																	

Source: SEEAland data set

Table 4.3 A numerical example of a hybrid supply and use table *(continued)*

Monetary items (in italics) in billion currency units; physical items in million tonnes

				Residuals: 10. National destination R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	Total	11. ROW destination
Economy	1. Products	P1	Animal and vegetable products														
		P2	Stone, gravel and building materials														
		P3	Energy														
		P4	Metals, machinery, etc.														
		P5	Plastic and plastic products														
		P6	Wood, paper etc.														
		P7	Other product groups														
			All products														
	2. Industries	I1	Agriculture, fishing and mining	19.020	0.007	0.073	0.061	0.023	0.020	0.010	0.070	0.590	0.030	7.233	8.103	**35.240**	
		I2	Manufacturing, electricity and construction	111.398	0.042	0.452	0.275	0.139	0.123	0.061	0.020	0.210	0.021	2.320	71.619	**186.680**	
		I3	Services	29.930	0.012	0.125	0.151	0.030	0.038	0.015	0.004	0.098	0.006		22.929	**53.338**	4.587
		I	**Total industries**	**160.348**	**0.061**	**0.650**	**0.487**	**0.192**	**0.181**	**0.086**	**0.094**	**0.898**	**0.057**	**9.553**	**102.651**	**275.258**	**4.587**
	4. Consumption	C1	Own account transport	16.908	0.003	0.004	0.084	0.003							0.100	**17.102**	0.745
		C2	Other consumption	25.080	0.004	0.020	0.026	0.001	0.007	0.012	0.011	0.117	0.021		5.060	**30.359**	
		C	**Total consumption**	**41.988**	**0.007**	**0.024**	**0.110**	**0.004**	**0.007**	**0.012**	**0.011**	**0.117**	**0.021**		**5.160**	**47.461**	**0.745**
	3. Capital	**CF**	**Capital formation**	0.990		0.477					0.003	0.024	0.001		71.100	**72.595**	
	5. ROW (origin)	R1-R12	Generated by non-residents	4.172	0.001	0.001	0.025	0.001			0.001	0.006	0.001		1.548	**5.756**	
Natural resources	6. National environment		Subsoil assets														
		N1	Oil														
		N2	Gas														
		N3	Other														
			Non-cultivated biological assets														
		N4	Wood, etc.														
		N5	Fish														
		N6	Other														
		N7	Water														
		N	**Total national natural resources**														
	7. ROW origin		Non cultivated biological assets														
			Fish														
			Water														
			Total ROW natural resources														
Ecosystem Inputs	8. National environment	**E1,E2**	**National ecosystem inputs**														
	9. ROW origin	**E1,E2**	**ROW ecosystem inputs**														
Residuals	10. National origin	R1	CO_2														
		R2	N_2O														
		R3	CH_4														
		R4	NO_X														0.669
		R5	SO_2														0.196
		R6	NH_3														0.099
		R7	Other														0.002
		R8	P														0.010
		R9	N														0.543
		R10	Other														0.002
		R11	Mining														
		R12	Other solid waste														2.398
			Total national														**3.919**
	11. ROW origin	R1-R12	Cross-border residual flows from ROW				0.117	0.087	0.019	0.002	0.014	0.323	0.003		7.656	**8.221**	

3 Emission accounts

4.39. As mentioned above, much of the practical experience to date on compiling hybrid supply and use tables concerns examining the consequences of the combustion of fossil fuels in terms of air emissions. The reasons for this interest are obvious; in terms of implementing UN Agenda 21 it is the impact of carbon dioxide on global warming which has excited the most concern and controversy. It is therefore useful to explain in some detail how such air emissions accounts can be compiled and then used. It should be remembered, though, that this is meant only to be an example of how hybrid accounts can be used and is not an exhaustive description of their use.

4.40. Energy accounts are of considerable interest in their own right especially for countries heavily involved in oil mining and processing. At the same time, every economy in the world depends heavily on the availability of oil and other energy sources. The use of energy is critical to the economic process because almost all economic activity is connected either directly or indirectly to the consumption of energy. Energy accounts provide information on the levels of direct energy consumption of industries regarding their production processes and of private households regarding their consumption. The accounts can also provide information on changes in the energy requirements of particular industries in relation to their output. This shows the macro level impacts of new technologies and of eco-efficiency measures and behavioural changes. They are also an indispensable prerequisite for reliable estimates of air emissions related to energy consumption.

4.41. Combustion processes take place in many production and consumption activities, such as heating of houses and buildings, production of electricity, various industrial processes and transportation. The output of emissions resulting from combustion processes is primarily determined by 1) the type of fuel used, and 2) the combustion process. The measurement of these emissions can come either from direct observations or from estimation. For example, many countries have environmental protection agencies which monitor emissions at sources for regulatory reasons. Also, the emissions from motor vehicles are usually analysed in detail.

4.42. Combustion-related emissions may be estimated by combining the amount of fuel used, as estimated in energy accounts, with emission factors relating to the type of fuel and given residual. One of the main uses to which material and energy balances can be put is the compilation of emissions accounts. While large point sources can contribute significant proportions of a given residual and may be measured directly, the estimation of combustion emissions from other sources can often only be done satisfactorily on the basis of energy balances.

4.43. The Intergovernmental Panel on Climate Change (IPCC) and European harmonised system of air emissions (CORINAIR) provide reference data formulated in terms of emission output per unit of product. Although the IPCC or CORINAIR inventories can be used as a starting point in the compilation of physical flow accounts for residual outputs, the harmonisation of classifications is an important point of concern. Often these kinds of emission inventories are based on technical reports on industrial installations and plants. These functional or process-oriented classifications have to be brought in line with ISIC in order to make emissions data comparable with national accounts data. Also, emissions inventories usually relate to emissions on the national territory without regard to the resident status of the emitter. By contrast, the national accounts are defined on the basis of the resident principle which means that supplementary estimates are often required to adjust data from emission inventories to national accounts definitions. This point is taken up in detail below.

4.44. The complexity of emission estimation varies considerably between different residuals. For example, the emission of carbon dioxide (CO_2) for energy use is influenced to only a small extent by the type of combustion process. This means that information on fuel consumption and fuel specific emission factors are sufficient to make a first rough estimation of CO_2 emissions. For sulphur dioxide (SO_2) this also applies, although knowledge of the sulphur content of fuel is obviously also important. Other emissions such as those of nitrogen oxides (NO_X) can only be reasonably estimated on the basis of the technical characteristics of the combustion process. Usually, this means that the estimation of NO_X is more complex and the estimates less reliable than for CO_2 and SO_2.

4 Energy balances and carbon dioxide emissions for Denmark

4.45. This section gives an overview of the process of compiling CO_2 emissions. It is based on experience in Denmark with some additional generalisation added. It begins by describing in some detail the compilation of energy balances in physical terms.

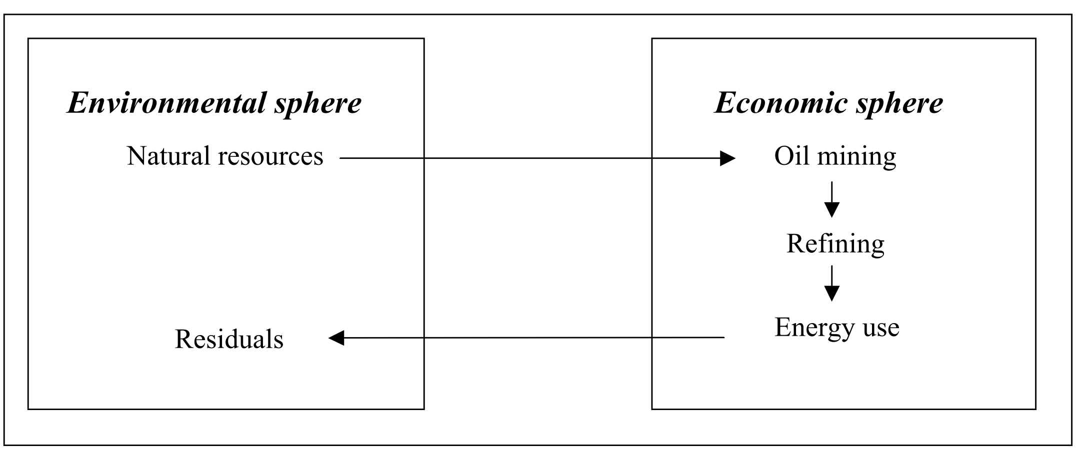
Energy balances - Statistical sources and compilation methods

4.46. Energy and air emission accounts usually embrace all four types of physical flows: natural resource extraction (coal, crude oil and natural gas), ecosystem inputs (oxygen for combustion), products (energy products such as motive fuels and other fuel types) and residuals generated by the use of fossil fuels (emissions to air and other residuals such as ashes). Figure 4.2 summarises the scope of the energy accounts.

4.47. The interest here is mainly on specific accounting techniques. Basic data on both energy supply and demand as well as on air emissions are taken as given and issues related to basic data gathering are discussed only briefly.

4.48. Physical energy accounts should be constructed in extended supply and use tables. Usually the energy supply and use accounts will include both the monetary as well as the physical dimension in, say, tonnes or in their calorific equivalents. Supply of products is defined as domestic production plus import of the various energy commodities while total product use is defined by the intermediate use by industries (classified by ISIC), household consumption (COICOP), inventory changes and exports. The number of energy commodities to be accounted for should be sufficiently large to reflect the different types and levels of emissions from different types of energy. The use table should also be able to show the use of natural resources, for example the use of coal, gas and oil extracted by the mining industries.

Figure 4.2 Scope of energy accounts in the case of oil



4.49. In order to construct energy accounts, we must first consider which data to use to determine both energy supply and energy use and then how to bring these data together in a balanced system. Each of these issues is discussed in turn below.

Data requirements for the supply table

4.50. With respect to data sources for the supply of energy, two main sources are production statistics and foreign trade statistics. It is important that the nomenclatures of these two sources are absolutely compatible. Both the production and the foreign trade statistics will normally provide data on the monetary value as measured in basic prices of the energy commodities both produced domestically and imported as well as the corresponding physical quantities.

4.51. If only monetary values are available, the data can possibly be supplemented with data from the sort of energy balances of the country complied by the International Energy Agency (IEA)[2]. However, some energy types are not commodities in the narrow sense of the word. That goes for many types of renewable energy sources, which are not tradable. Some are provided by the environment, for example wind energy. Some may be related to residual flows, such as biogas, wood or other solid waste. The physical supply of such renewables is thus determined by the total use, while the supply in monetary terms is determined either by the unit value of relevant substitutes (or some other "rule of thumb") or set to zero, depending on the corresponding market prices.

4.52. In order to construct the physical energy accounts, the calorific energy content of the energy commodities must be converted to a common unit of energy. Gigajoules or petajoules are the common energy unit most often the used by statistical agencies. The unit of account adopted by the IEA is the tonne of oil equivalent (toe) which is equivalent to 10^7 kilocalories or 41.868 gigajoules. This quantity of energy is, within a few percent, equal to the net heat content of 1 tonne of crude oil. The difference between "net" and "gross" calorific value for each fuel is the latent heat of vaporisation of the water produced during combustion of the fuel. For coal and oil, the net calorific value is five per cent less than the gross calorific value.

4.53. An important distinction is made between ***primary energy sources***, separated into fossil fuels and renewable energy sources (such as water power and solar energy), and ***secondary energy sources*** such as electricity and refined petroleum products which have been produced from the transformation of a primary energy source.

4.54. The physical quantities of each of these need to be converted to a common energy unit and the conversion factors and conventions for doing so are described further below. Since there are widespread differences between the different types of coal, oil and other fossil fuels in different countries, conversion factors for each major fossil energy source should be based on country-specific and product-specific information (provided by to the IEA) in order to calculate the primary energy associated with these products. For energy sources such as solar, hydro, wind, etc., the IEA recommends that the primary energy form is the electricity generated (assuming 100 per cent efficiency). For nuclear and geothermal energy, the primary energy form is assumed (by convention) to be heat and the primary energy equivalent is the amount of heat generated in the reactor or plant (based on certain assumptions about the efficiency of the technology employed to turn heat into electricity). Thus primary energy equivalents can be calculated, regardless of the sources of energy that are contained in the supply tables. The flow of secondary energy in the supply tables (such as the flow of electricity) can be converted to tonnes of oil equivalent or joules based on readily available conversion factors.

[2] Data from the International Energy Agency is available via their web site www.iea.org

Data requirements for the use table

4.55. The level of disaggregation of the system depends both on the number of energy commodities and the number of industries of the national accounts. Naturally, the usefulness of the system increases with disaggregation as does the complexity of establishing the system. In the end, compiling a comprehensive view of the energy use table typically involves combining all sorts of data together with assumptions and well-defined calculation procedures.

4.56. Often definitive information is available at an aggregate or semi-aggregate level and these data are used as control totals in determining entries at a lower level of aggregation. One example of a control total is the total supply of electricity. The sum of all uses must come to exactly this total in physical as well as monetary terms. Such control totals form one very important source of data.

4.57. When determining the use of the different energy commodities by industries and households, the first group of data consists of information from surveys explicitly concerned with energy consumption. In many countries these are conducted regularly for manufacturing, providing industry specific data on the use of a number of energy products. Surveys on service industries and households are also conducted in some countries. If not conducted yearly, the data must be projected or estimated using various indices and other supporting data.

4.58. In some cases the survey data includes information in both physical quantities and monetary values. If not, accounting data may give more or less detailed information on the amount spent on energy by industry measured in money terms, providing important information on the value dimension of the industry-specific control totals. This, together with information on price statistics may help determine a control total in physical terms also. Filling out the use tables should make best use of both physical and monetary data, typically making use of the one dimension in determining the other in a supplementary way.[3]

4.59. Another group of data consists of data on specific industries, which can be found in publications of such bodies as umbrella organisations, national monopoly companies, national institutes, trade associations or other agencies concerning the industry in question. Such information may of course have to be adjusted for coverage and level of aggregation concerning the different energy commodities.

4.60. There may be other useful registers which provide more or less direct information for the energy accounts system available in a country. For example, some countries have introduced a national CO_2 tax on electricity, which is reimbursed along with the enterprises' VAT payments. Combining such tax data with the business register at the enterprise level thus may contribute to the commodity balance for electricity. In many industries, the use of energy can be formulated as a function of the number of employees within the industry or the total building area as measured in the square metres.

4.61. Foreign trade statistics are used as source of information on imports and exports of the different energy commodities. Both monetary values and physical quantities should normally be available. Changes in inventories take into account official data on changes in inventories as in the IEA balances. Differences between alternative sources of information are usually shown as losses, which may include statistical differences as well as ordinary losses due to distribution.

[3] Refer to the discussion in Part 4 of Section A on the differences between quantities and volumes.

Balancing the system

4.62. Bringing the system into balance means that for any commodity the total supply must equal the total use and for any industry the sum of its uses of each of the energy commodities must equal some given level, which might be one of the control totals. Furthermore, both dimensions must balance in physical as well as monetary terms (at basic prices), before the system can be pronounced “internally consistent”.

4.63. As the whole system tends to be rather large, it often pays to balance smaller blocks of the system separately before putting the whole system together. Some blocks of industries are known to have a more complex composition of energy use than others. Also, parts of the use table referring to some blocks of industries can be filled out with a greater degree of certainty than others. For example, information is normally plentiful and of good quality concerning manufacturing and the energy transformation industries.

4.64. One example of a commodity-specific block relates to the use of gasoline and diesel fuel. A country's fleet of cars may be listed in a car register, attaching each vehicle to either a person or a business. When applying average conditions, such as yearly kilometres driven and use of fuel per kilometre to each vehicle type, it is possible to compute theoretical fuel uses for industries or households. These are subsequently scaled to reach the known total uses of each fuel. The physical dimension of accounts for gasoline and diesel can be established in this way. At least as a first approximation, the monetary dimension can be readily established by applying average basic prices to the physical quantities.

4.65. The balancing of the system thus takes place in stages by first filling out the parts which are known with a fair degree of certainty and then determining the remainder of the system using progressively less hard data and more assumptions such as employment-based distribution rules. In the whole process, the role of control totals is crucial to control the error which inexact assumptions and allocations may introduce.

4.66. In addition to those already mentioned above, consider as another example of control totals the total energy expenditure by, say, hospitals. The value of the use of all energy commodities by hospitals must equal this total, when the whole system is balanced. As yet another example, consider the total output from the district heating industry measured in physical as well as monetary terms, which must exactly equal the sum of the use by households and all other industries in both monetary terms and physical terms.

Energy accounts - the results

4.67. Table 4.4 shows the detailed energy supply and use tables for Denmark. The eight different energy groups shown are an aggregation of 40 energy types in the most detailed supply use tables for Denmark. Each group is expressed in its own specific physical unit. Thus crude oil, coal and lignite, and wood, etc. are measured in kilotonnes, gas is measured in million cubic metres, electricity in TWh (terawatt hours, that is 10^{12} watt hours), and steam and hot water in PJ (petajoules, or 10^{15} joules).

4.68. For each group of energy commodities, the supply table shows domestic production and imports which together make up total supply.

4.69. A distinction is made between primary and secondary energy sources. Primary sources are in the form in which they appear in the environment and thus synonymous with natural resources; secondary sources are in the form in which they are finally consumed in the economy and are thus products. Crude oil, natural gas, coal, wood and straw could be shown as natural resources flowing from the environment to the extraction industries of the economy but for this purpose are shown as products; that is, as outputs of the economy.

Table 4.4 Supply and use table for energy for Denmark, 1998

Supply table

	Crude oil	Natural gas extracted	Coal and lignite	Petroleum products	Gas to users	Electricity	Steam and hot water	Wood, straw and waste	Total energy supply	
	1000 tonnes	*Million m^3*	*1000 tonnes*	*1000 tonnes*	*Million m^3*	*TWh*	*PJ*	*1000 tonnes*	*PJ*	*Billion DKK*
a. Domestic production	11 513	7 314	-	8 007	6 714	42	122	4 557	1 716	53
b. Imports	4 605	-	8 416	6 015	-	3	-	38	654	10
c. Total supply (a+b)	**16 118**	**7 314**	**8 416**	**14 022**	**6 714**	**45**	**122**	**4 595**	**2 370**	**64**

Use table

	Crude oil	Natural gas extracted	Coal and lignite	Petroleum products	Gas to users	Electricity	Steam and hot water	Wood, straw and waste	Total energy use	
	1000 tonnes	*Million m^3*	*1000 tonnes*	*1000 tonnes*	*Million m^3*	*TWh*	*PJ*	*1000 tonnes*	*PJ*	*Billion DKK*
a. Intermediate consumption by industries	**7 819**	**7 138**	**9 283**	**6 463**	**3 283**	**25**	**35**	**3 934**	**1 408**	**33**
Agriculture, fishing and quarrying	-	537	105	814	136	2	2	170	76	2
Manufacturing	7 819	-	446	1 153	940	10	6	358	478	11
Electricity, gas and water supply	-	6 601	8 732	1 569	1 890	3	0	3 405	653	9
Construction	-	-	-	331	5	0	-	-	15	0
Wholesale and retail traders	-	-	-	372	106	4	9	-	43	4
Transport, storage and communication	-	-	-	1 892	14	1	1	-	88	3
Financial intermediation	-	-	-	93	45	1	4	-	13	1
Public and personal services	-	-	-	240	147	4	13	-	41	4
b. Inventory changes	**325**	**-**	**-1 100**	**331**	**-128**	**-**	**-**	**-**	**-8**	**0**
c. Private consumption, total	**-**	**-**	**10**	**2 739**	**768**	**10**	**63**	**599**	**256**	**19**
Own account transportation by cars	-	-	-	1 842	-	-	-	-	81	2
Heating, use of electricity etc.	-	-	10	897	768	10	63	599	176	17
d. Exports	**7 892**	**-**	**140**	**4 392**	**2 785**	**8**	**-**	**5**	**664**	**11**
e. Losses in distribution etc.	**82**	**176**	**83**	**96**	**6**	**2**	**24**	**57**	**49**	**-**
f. Total use (a+b+c+d+e)	**16 118**	**7 314**	**8 416**	**14 022**	**6 714**	**45**	**122**	**4 595**	**2 370**	**64**

Source: Statistics Denmark.

4.70. For petroleum products, gas to users, electricity, and steam and hot water, the domestic production is a result of the conversion of primary energy types. Thus, there is a double counting in the sense that both primary energy (for example coal) and the converted energy (for example electricity produced by coal) are included. This, however, is not different from other monetary or physical supply tables for products in which both raw materials and finished products appear.

4.71. The various units (tonnes, m^3, TWh, PJ) used for the basic measurement of physical flows of energy can be converted into calorific units, for example joules. The result of such a conversion carried out at the most detailed level can be seen in the supply table under the heading total energy supply measured in PJ.

Further, the last column of the supply table shows the monetary value of the total energy supply in basic prices (billion Danish kroner, DKK).

4.72. The use table for energy has exactly the same headings as the supply table. For each group the total use is equal to the total supply as shown in the supply table. However, one additional entry, losses in distribution, etc., is included in the use table in order to take explicit account for the losses that take place when the energy is distributed from supplier to user by pipe, wire, ship, truck or other means of transportation. As an alternative to the explicit accounting, the physical losses in distribution could be allocated to the users of the energy.

4.73. In the table shown, the intermediate consumption is broken down by eight groups of industries. However, this is an aggregation of a 130 industry classification, which is the same as used in the Danish national accounts. Thus, the physical supply and use tables for energy are fully consistent with the monetary supply and use tables for energy included in the national accounts and shown in aggregate in the last column of Table 4.4.

Carbon dioxide emissions

4.74. The detailed use table describing energy use by industry and household activities is the basis of the calculation of CO_2 emissions generated by the combustion of fossil fuel. For each entry in the energy supply table, a coefficient showing kilograms of emission per gigajoule of energy specific to the energy type is multiplied by the energy use. The results of such a calculation are shown in Table 4.5. For each energy commodity group, the CO_2 emissions are shown by industry and private consumption (emissions from households). As in the energy tables, private consumption is divided into two separate consumption purposes, own account transportation and heating, use of electricity, etc. The accounts for CO_2 emissions related to energy use are part of a broader set of emissions accounts covering other sources also. For some residuals, like methane (CH_4) or nitrous oxide (N_2O), the major part of the total emissions are not related to energy use and the energy accounts therefore must be supplemented by other data to give a full picture. At the most detailed level, these estimates are made according to 40 types of energy product groups and 130 industries. The procedure for calculating emissions is described above.

4.75. For crude oil, electricity, steam and hot water no emissions are attached as no combustion is involved in the direct use of these types of energy. Emissions may have been generated during the production of these energy containing commodities, if they were produced by means of fossil fuel combustion. Also, there may be various uses of fossil fuels that will not directly result in emissions of CO_2. Examples are uses related to storage (changes in inventories), exports and losses in distribution. The use of oil products in the production of plastics might be another example though it is not included in the Danish energy balances.

4.76. In other cases it might be difficult to track down the energy consumption underlying certain emissions. For example, natural gas platforms may use some of their gas extractions for own account uses. In addition, emissions of CO_2 may result from other processes than fuel combustion. In fact, CO_2 emissions from own account use and from flaring on natural gas platforms are included in the complete set of Danish emissions accounts.

4.77. The CO_2 emissions from combustion are also included for wood, straw and waste in order to give a full picture of the emissions. This is contrary to IPCC guidelines in which the short term circulation of carbon such as the combustion of wood and biochemical processes is not taken into account because it is supposed that these cycles do not lead to a structural increase in greenhouse gas concentrations in the atmosphere.

Table 4.5 Generation of CO_2 emissions by industry and type of energy use in Denmark, 1998

Kilotonnes

	Crude oil	Natural gas extracted	Coal and lignite	Petroleum products	Gas to users	Electricity	Steam and hot water	Wood, straw and waste	Total
a. Industries	**-**	**1 210**	**22 726**	**19 139**	**7 352**	**-**	**-**	**5 201**	**55 629**
Agriculture, fishing and quarrying	-	1 210	261	2 589	307	-	-	252	4 619
Manufacturing	-	-	1 123	3 541	2 099	-	-	536	7 299
Electricity, gas and water supply	-	-	21 343	3 884	4 236	-	-	4 413	33 876
Construction	-	-	-	1 074	12	-	-	-	1 086
Wholesale and retail traders	-	-	-	1 113	236	-	-	-	1 349
Transport, storage and communication	-	-	-	5 882	31	-	-	-	5 913
Financial intermediation	-	-	-	289	100	-	-	-	389
Public and personal services	-	-	-	767	330	-	-	-	1 096
b. Inventory changes	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
c. Private consumption, total	**-**	**-**	**23**	**8 825**	**1 681**	**-**	**-**	**816**	**11 346**
Own account transportation by cars	-	-	-	5 994	-	-	-	-	5 994
Heating, use of electricity etc.	-	-	23	2 831	1 681	-	-	816	5 352
d. Exports	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
e. Losses in distribution etc.	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**
f. Total emissions (a+b+c+d+e)	**-**	**1 210**	**22 750**	**27 964**	**9 033**	**-**	**-**	**6 018**	**66 974**

Source: Statistics Denmark.

5 Accounts for emissions - the Netherlands

4.78. In the Netherlands, emissions are compiled and recorded in one central database called the Dutch Pollutant Emission Registration. This annual reporting system contains a substantial amount of data on residuals released to air and water and land. Several institutes are jointly responsible for the collection and compilation of these data: the Ministry of the Environment, Statistics Netherlands, the Government Institute for Public Health and the Environment (RIVM) and the Netherlands Organisation for Applied Scientific Research (TNO).

4.79. The Dutch Pollutant Emission Registration combines two estimation procedures. The biggest residual sources in the Netherlands are observed directly. Supplementary estimates are made for the smaller sources including mobile sources such as traffic. The relationships between the different sources are reviewed in Figure 4.3 which refers to the compilation of air emissions.

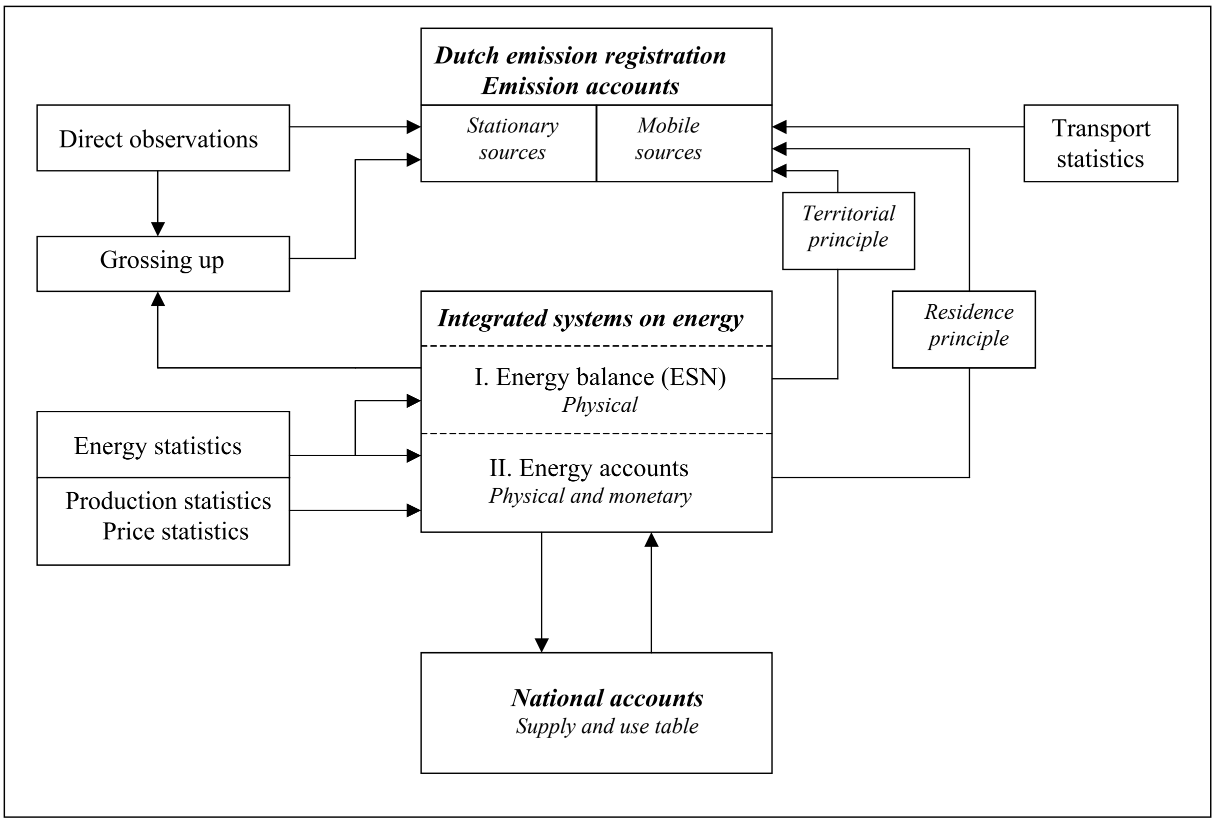
4.80. The Dutch energy balance (Energy Supply in the Netherlands, ESN) is used to estimate emissions for smaller combustion processes by grossing up the air emission data which are originally measured at a sample of emission sources. Air emissions from stationary (point) and mobile sources are recorded separately as different methodologies are followed for each. In the case of stationary sources, Statistics Netherlands is responsible for the estimation of emission totals specified by branch of industry.

4.81. As already noted, emission inventories often make use of process-oriented classifications of emission sources. A reclassification is required in order to connect this information to the national accounts. This reclassification to industries is less complex for processes connected to stationary sources. For mobile sources, much supplementary information is required to allocate the corresponding emissions to industries.

Air emission estimates from mobile sources rely on both energy and transport statistics. In the case of road vehicles the emissions are estimated on the basis of data on:

fuel types (gasoline, diesel, liquid petroleum gas);
annual kilometres driven;
type of driving (on rural roads, inner-city, highways); and
technical data on engines, and so on.

Figure 4.3 The compilation of air emission statistics in the Netherlands



Source: Statistics Netherlands.

4.82. Information on the use and consumption of fuels comes from the energy balances but is not specified by industry. In order to compile the emissions from mobile sources according to economic activities as presented in the hybrid account, supplementary estimates are made by integrating the data on energy consumption from the ESN with the supply and use tables of the national accounts. Monetary data on fuel purchases by industry are converted into physical volumes with the help of price information in such a way that full consistency with the ESN is assured.

4.83. As already mentioned, emission inventories and national accounts usually differ in scope. Emission inventories focus usually on emission sources within the national territory whether by resident or non-resident units. The national accounts measure emissions by resident units whether operating within the national territory or abroad. These differences in scope are largely determined by differences in the compilation of mobile emissions. The difference between emissions on national territory and emissions as compiled in the physical flow accounts is made up by:

additions of emissions by residents in the rest of the world deductions of emissions by non-residents on national territory.

4.84. On the basis of the Dutch Emission Pollutant Registration System, a number of different CO_2 figures are published annually in the Netherlands, each used for different purposes. These different numbers are summarised in Table 4.6 together with their relationship to one another. The differences are due solely to differences in definitions and not to statistical discrepancies.

4.85. Firstly, for the purpose of international climate policies, the IPCC has developed guidelines on the basis of which the emissions of greenhouse gases and so-called indirect greenhouse gases can be calculated and reported for each individual country. According to the IPCC guidelines, international bunkers for civil aviation and marine transport are reported separately from national totals. However, in the agreements on reductions for countries or regions as laid down in the Kyoto protocol, residual emissions from international transport have not been taken into consideration.

4.86. The RIVM publishes the IPCC total corrected for changes in the annual average temperatures. In this way, the data are not influenced by incidental effects such as relatively cold or mild winters thus providing the possibility to monitor structural changes.

4.87. Statistics Netherlands publishes the actual emissions of CO_2. In contrast to the IPCC figure, the temperature corrections are excluded. Then emissions related to the combustion of wood in wood-burning stoves are added. Statistical differences related to the ESN are removed. Lastly the emissions attributed to the future combustion of plastics are subtracted. (The IPCC guidelines consider this part as a non-structural contribution to the greenhouse gas problem.)

4.88. Table 4.6 also shows the estimates made by Statistics Netherlands for emissions in the country by non-residents and by residents abroad (see Verduin, 2000 for further details). This is the definition which is consistent with the national accounts concept of residence and allows for a comparison to aggregates such as GDP.

Emission flows relative to the rest of the world

4.89. The importance of the adjustment for the emissions to and from the rest of the world can be seen from the table; 13 per cent of the emissions by residents in 1998 was generated outside the Netherlands due to international transport.

4.90. Accounting for air transport, water transport, and transport via railways is normally a fairly easy task in that the energy use for these purposes is confined to only a limited number of (ISIC) industries. For example, civil aviation will usually be completely attributed to the activity “air transport” while military aviation carried out by the defence forces is typically part of public administration. The emissions related to road transport, on the other hand, constitutes a more complex issue because the emissions are not restricted to a single industry but rather occur from specific transport service industries as well as from own account transportation in all other industries and by households.

4.91. The emissions related to road transport thus depend on the distribution of the country's fleet of vehicles between different industries and households and their patterns of usage. When designed appropriately, commodity balances for the different fuel types will include use of each fuel type by households and each industry. This information may be estimated from energy balance information. If this is not available, it could be estimated by a simple allocation procedure for example by utilisation of central car registers in combination with assumptions concerning average distances driven (km/year), average usage of fuel (litre/km) for each type of car or vehicle. Additional data sources that can be applied for the allocation of emissions from transport to economic activities are the following:

purchases of motor car fuels and use of vehicle maintenance services;
information on the links between the car register and the business register;
transport statistics; and
fuel taxes.

Most of this information may already have been used in the compilation of the supply and use table. When a supply and use table does not provide sufficient detail, information on fuel tax payments may be used instead, at least to separate transport emissions related to households from those related to production.

Table 4.6 Carbon dioxide emissions in the Netherlands, 1995-1998

Million tonnes

		1995	1996	1997	1998
1.	**Total, IPCC (Kyoto protocol)**	**177**	**185**	**183**	**183**
2.	Temperature correction	3	-5	3	3
3.	**Total – Annual environment report (RIVM)**	**180**	**180**	**186**	**186**
1.	**Total, IPCC (Kyoto protocol)**	**177**	**185**	**183**	**183**
4.	Emissions related to short term carbon cycles (wood burning)	4	5	4	4
5.	Statistical discrepancies in the ESN energy balance	-2	-3	-6	-4
6.	Potential CO_2 from the combustion of plastics	-3	-3	-2	-3
7.	**Total actual emission in the Netherlands (CBS)**	**177**	**184**	**179**	**181**
8.	Residents in the rest of the world	23	23	25	26
9.	Non-residents in the Netherlands	-4	-3	-4	-3
10.	**Total emissions by residents in the Netherlands (CBS)**	**196**	**204**	**201**	**203**

(Note: Figures may not add due to rounding)

Source: Statistics Netherlands.

4.92. There are various possible emission sources other than transportation where the relationship to the ISIC classification is not straightforward; for example, non-methane volatile organic compound (NM-VOC) emissions from spray cans, (fire) extinguishers, cooling systems, etc. Here also supplementary data sources are usually needed to allocate emissions to industry branches.

4.93. Table 4.7 to Table 4.9 illustrate the differences between emissions as they are usually compiled in emissions inventories versus emissions estimates in relation to the national accounts.

Table 4.7 Emissions to air as compiled in the Netherlands' emission inventory (national territory)

Kilotonnes

	CO_2	N_2O	CH_4	NO_X	SO_2
Stationary sources					
Production					
Agriculture and mining	13 420	7	73	56	22
Fishing	-	-	-	-	-
Manufacturing, electricity and construction	106 348	41	452	220	138
Transport, road	-	-	-	-	-
Transport, air	-	-	-	-	-
Transport, water	-	-	-	-	-
Other services	5 052	7	137	3	2
Consumption	25 080	4	20	26	1
Mobile sources					
Road transport	27 084	6	5	202	9
Air transport	70	-	-	21	-
Water transport	5 976	1	1	77	18
Other sources	990	-	477	-	-
Total	184 020	66	1 165	605	190

Source: Statistics Netherlands.

Table 4.8 Emissions to air as compiled in the Netherlands' physical flow accounts (national economy)

Kilotonnes

	CO_2	N_2O	CH_4	NO_X	SO_2
Production					
Agriculture and mining	14 320	7	73	61	23
Fishing	3 700	-	-	25	12
Manufacturing, electricity and construction	111 398	42	452	275	139
Transport services, road	6 644	2	1	60	4
Transport services, air	9 620	-	-	40	2
Transport services, water	10 036	3	1	83	33
Other services	8 102	8	137	33	4
Consumption					
Transport	14 640	3	4	88	3
Other	25 080	4	20	26	1
Other sources	990	-	477	-	-
Total	204 530	69	1 165	691	221

Source: Statistics Netherlands.

Table 4.9 Reconciliation between emissions by residents and emissions on national territory

Kilotonnes

	CO_2	N_2O	CH_4	NO_X	SO_2
Emission by residents	204 530	69	1 165	691	221
Residents in the rest of the world (-)	24 080	3	-	134	45
Road transport	4 830	1	-	52	3
Air transport	9 890	-	-	20	2
Water transport	9 360	2	-	62	40
Non residents on domestic territory (+)	3 570	-	-	48	14
Road transport	1 630	-	-	16	1
Air transport	340	-	-	1	-
Water transport	1 600	-	-	31	13
Emission on national territory	184 020	66	1 165	605	190

Source: Statistics Netherlands.

Environmental themes

4.94. In order to assess the cumulative impact of a number of different flows on the same environmental phenomenon, it is possible to introduce alternative classifications or units of account to represent certain quality aspects of these flows. One example is to use conversion factors to show how much of one substance has the same impact as a single unit of another substance. In this way, these substance-based quantity units can indicate the relative potential stress on the environment caused by individual substances in relation to particular environmental concerns. Subsequently, these equivalents can be used for weighting and aggregating a number of substances into one indicator. Adriaanse (1993) first introduced this systematic compilation of so-called environmental theme indicators. The themes shown in Table 4.10 correspond to the key environmental problem fields identified in the Dutch national environmental policy plans.

Table 4.10 Factors to convert residuals into theme-equivalents

Theme / Residual	Greenhouse effect	Ozone layer depletion	Ground level ozone formation	Acidification	Eutrophication	Toxic dispersion
CO_2	1					
N_2O	310					
CH_4	21		0.014			
HFCs	140 – 11 700					
PFCs	6 500 – 9 200					
SF_6	Specific					
CFC12	8 500	1				
CFC13	5 000	1				
CFC113	9 300	0.8				
CFC114	9 200	1				
CFC115	-	0.6				
Halon 1211	5 600	3				
Halon 1301	5 600	10				
Carbon tetrachloride	Specific	Specific				Specific
1,1,1-trichloroethane	Specific	Specific				Specific
NM-VOCs	Indirect		1			
SO_2	Indirect			$^1/_{32}$ or 0.03125		
NO_X	Indirect		1.22	$^1/_{46}$ or 0.0217	Specific	
NH_3				$^1/_{17}$ or 0.0588	Specific	
CO	Indirect		0.11			
Nutrients						
Phosphorus					Specific	
Nitrogen					Specific	
Metals						
Cadmium						NOEC[2]
Copper						NOEC
Lead						NOEC
Organic compounds						
Benzene						NOEC
Naphthalene						NOEC
PCDF						NOEC
PAH						NOEC

Sources: Global warming potential: Houghton *et al*., 1996.
Ozone layer depletion: World Meteorological Organisation, 1998.
Acidification: Schneider and Bresser, 1988.
Ground level ozone formation: de Leeuw, 2002.
Toxic dispersion: Guinee *et al*., 1996.

Notes: 1. Acidification equivalents derived from molecular weights
2. NOEC: No observable effect concentration.

4.95. Examples of environmental theme-oriented weighting were given in the introduction to Chapter 3. The application of potential impact evaluation of toxic residuals as regularly applied in life cycle analysis can also be applied in environmental accounting. Besides toxicity, the dispersion patterns and degradability of a given residual also influence its expected effects on human health and ecosystems. Dispersion models are used to determine the expected residual concentrations in the various environmental domains (air, water and land/soil). The expected toxic impacts of certain residuals on human health or between terrestrial and aquatic ecosystems may differ considerably so that a number of indicators may be required to cover these various impacts.

4.96. Such theme indicators, compiled on the basis of scientific knowledge, explicitly underline the multiple characters of environmental concerns. They are calculated by taking the volume figures in Table 4.9 and multiplying by the conversion factors in Table 4.10. Some conversion factors are internationally agreed constants; some vary from country to country.

4.97. Two examples of conversions are presented in Table 4.11. One shows the conversion of greenhouse gas emissions into CO_2 equivalent emissions using global warming potentials as the conversion factor. The second example refers to the conversion of the accumulation of acidification residuals in the national environment. The first column in the table shows the amount of residuals generated; the second column shows the conversion factor used and the third the resulting aggregate effect in a common numeraire. The last column, containing percentage shares, indicates the relative contribution of each of the residuals to the theme in question.

Table 4.11 Conversion of residuals by weight into theme-equivalents

Global warming theme				
	Emissions (kg)	GWP factor (CO_2 conversion factor)	CO_2 equivalents (kg)	% shares
CO_2	204 530	1	204 530	81.69
N_2O	69	310	21 390	8.54
CH_4	1 165	21	24 465	9.77
Total			250 385	100.00
Acidification theme				
	Accumulation (kg)	Acidification equivalent	Acid equivalents (moles of H^+ ions)	% shares
NO_X	100	0.0313	3.1300	26.87
SO_2	108	0.0217	2.3436	20.12
NH_3	105	0.0588	6.1740	53.01
Total			11.6476	100.00

Source: Statistics Netherlands.

4.98. It should be emphasised that the theme indicators reflect the potential stress on the environment. Combinations of various stresses as well as spatial and timing considerations together will usually determine the actual environmental consequences of these different stress categories. Thus, environmental theme indicators contribute to a compact representation of environmental pressures without the necessity of oversimplification.

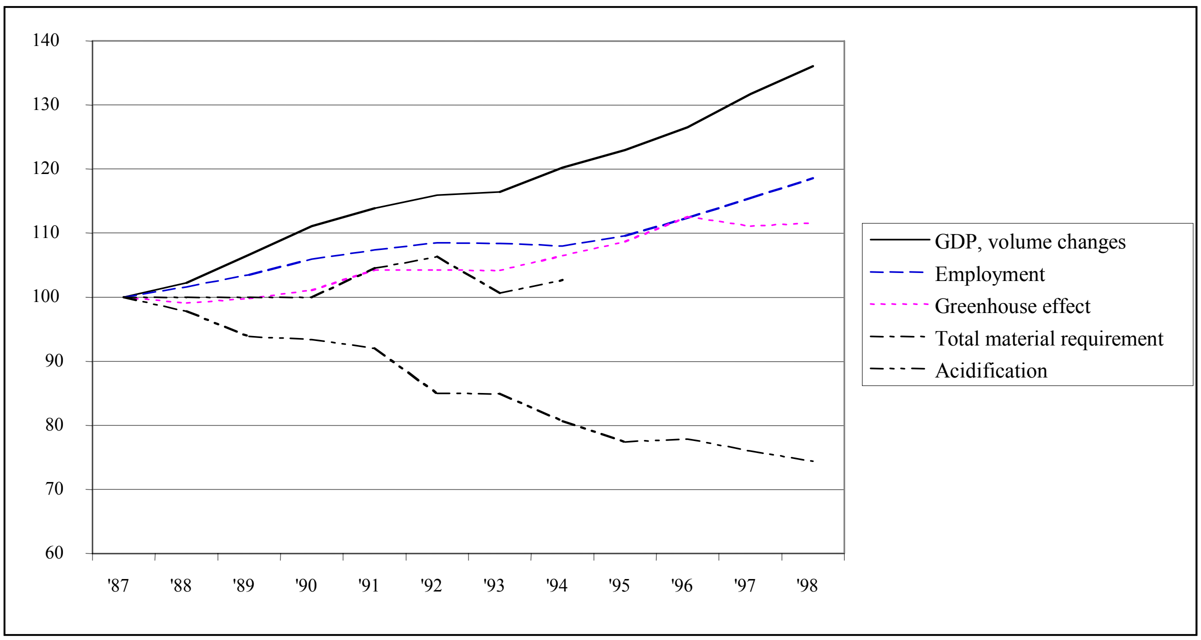
Comparing Economic and Environmental indicators

4.99. Already in some countries, environmental indicators regularly supplement the national accounts aggregates. Aggregate indicators such as GDP, unemployment and environmental theme indicators together provide a compact set of indicators which review the economic performance at the macro level. These indicators can also be presented at a sectoral level and provide the basis for so-called environmental-economic profiles. Besides monitoring the developments of environmental and economic indicators in detail, these profiles also demonstrate the importance of the economic structure. Economies dominated by services industries will show totally different residual emission patterns when compared to economies where agriculture or manufacturing industries predominate.

4.100. Environmental indicators drawn from the hybrid accounts framework supplement the time trends of national accounts figures with comparable time trends of resource use, residual emissions, and environmental degradation, both in total and by industry. The overview of economic and environmental trends helps us assess whether we are achieving national goals, typically set in terms of total figures for residual emissions or resource use. Figure 4.4 provides an example of such an overview of economic development for the Netherlands between 1987 and 1998. GDP and employment grew by about 35 per cent and 20 per cent, respectively, while the emission of most residuals grew more slowly, or even, in the case of residuals contributing to acidification, declined. Similar figures for other important environmental themes can be developed based on the priorities of each country; for example, a different set of residuals, energy and water use might be important in other countries.

Figure 4.4 Macro-indicators for economic and environmental performance of the Netherlands, 1987-1998

Index 1987 =100



Source: Statistics Netherlands, 1999; Adriaanse *et al*., 1997.

Environmental-economic profiles

4.101. While the aggregate figures provide a useful overview of trends in the economy, more detailed information tells us where progress has been made over time and where obstacles still remain, setting the stage for future action. The formulation of policy requires taking into account both the environmental burden imposed by an industry as well as its economic contribution. Environmental-economic profiles, or "eco-efficiency" profiles, have been compiled by a number of countries in order to assist in identifying environmental priorities. The profiles combine economic contribution and environmental burden by industry. The economic contribution is represented, for example, by the percent each industry contributes to GDP or employment. The environmental burden is represented by the percent each industry contributes to the emission of various residuals, or the use of materials and energy.

4.102. In the Netherlands, the profile revealed a very unequal distribution across industries of economic benefits such as employment and value-added on the one hand and environmental burdens in terms of the environmental theme indicators on the other. The striking environmental burden imposed by agriculture compared to its relatively low economic contribution made the headlines in Dutch newspapers and elsewhere. The profiles show that total residuals emissions are determined not only by the size of a national economy but also by its structure.

4.103. Table 4.12 shows the net percentage contributions to the economy and to environmental themes by each economic activity and by final consumers (households and government). The economic contribution for economic activities is represented by value added and for final consumers by total consumption expenditure. The contributions to environmental themes are calculated by using more detailed versions of tables like Table 4.8 and Table 4.10. Reading across the first few rows of the table, it is clear that industrial activity accounts for the majority of all residual emissions (66-97 per cent), although final consumers are responsible for a considerable share of greenhouse gases (19 per cent) and solid waste (31 per cent). Final consumption is further disaggregated into two components, own transport and all other consumption. While own transport accounts for only 8 per cent of household spending, it accounts for a disproportionate share of most household emissions, 38 per cent of greenhouse gas emissions, 88 per cent of the acidification emissions and 21 per cent of eutrophication emissions.

Table 4.12 Net contribution of consumption and production to GDP and to six environmental themes in the Netherlands, 1993

Percentages

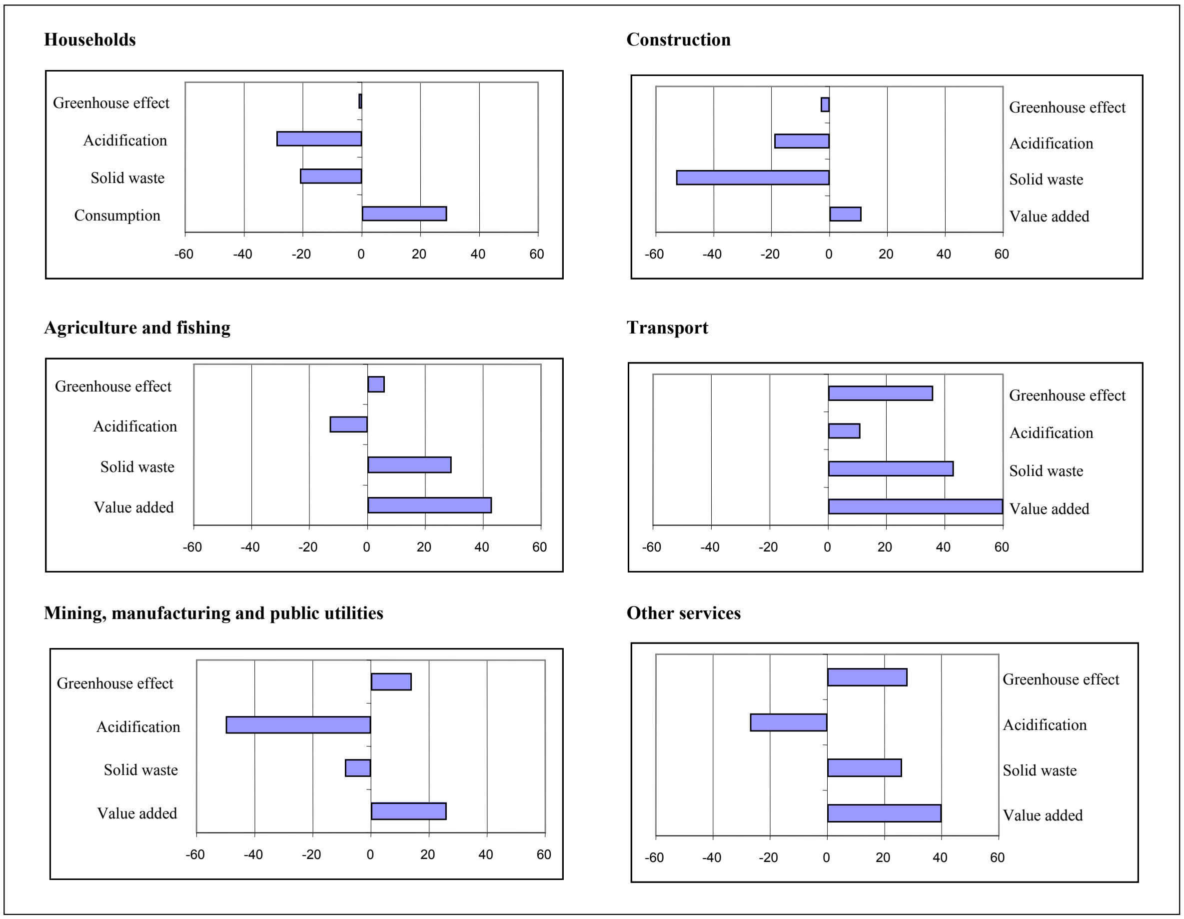
	Economy	Environment				
		Greenhouse effect	Ozone-layer depletion	Acidification	Eutrophication	Solid waste
Total		100	100	100	100	100
Consumption		19	2	15	9	3
Industry		79	97	85	91	66
Capital and other sources		2	1	-	-	31
Consumption	100	100	100	100	100	100
Own transport	8	38	-	88	21	1
Other consumption	92	62	100	12	79	99
Production	100	100	100	100	100	100
Agriculture, hunting, forestry, fishing	3	15	2	47	91	7
Mining and quarrying	3	2	-	1	-	1
Manufacturing						
Petroleum industry	1	7	-	11	-	
Chemical industry	2	14	27	6	2	16
Metal products and machinery industry	3	2	9	1	-	2
Other manufacturing	12	12	20	7	6	25
Public utilities	2	26	-	9	1	2
Transport and storage	6	8	6	12	1	5
Other services	68	14	36	6	-1	42

Source: de Haan, 1997.

4.104. Among industries, the importance of the structure of production is apparent. A large share of residual emissions is produced by a relatively few industries, not at all proportional to their economic contribution as represented by their shares of value added. In terms of greenhouse gas emissions, for example, three industries account for 55 per cent of emissions; agriculture (15 per cent), chemicals (14 per cent), and public utilities (26 per cent), but their combined contribution to GDP is only 7 per cent. Agriculture alone accounts for 47 per cent of acidification and 91 per cent of eutrophication emissions.

4.105. It is also important to track these profiles over time in order to determine whether an industry's performance is improving or not. Figure 4.5 shows changes between 1987 and 1998 for value added and emissions in the Netherlands for selected industries. Although agriculture was identified as a major source of residual emissions in Table 4.12, these figures indicate that the industry has done a great deal to reduce emissions. Value added increased more than 40 per cent over the period, but all emissions grew much less, and acidification emissions actually declined despite the increase in production. The only industry for which all emissions increased is transport services, but even here, emissions did not increase as rapidly as value added.

Figure 4.5 Changes in environmental profiles for households and selected industries in the Netherlands, 1987-1998



Source: de Haan, 1997.

4.106. This simple analysis of descriptive statistics can be done for resource use, such as energy and water inputs, or other environmental impacts. For designing environmental policy, it may also be useful to disaggregate the accounts spatially within a country. Environmental burdens of residuals with a highly localised impact, such as eutrophication, may be very unevenly distributed nationwide. Similarly, the economic impacts of environmental policy may have a very uneven impact. A database which is spatially disaggregated would allow the identification of these dissimilar regional impacts.

4.107. Environmental-economic profiles are being used in Norway for "benchmarking" industry performance, a useful tool both for national environmental policy as well as environmental management at the company level (Hass and Sørenson, 1998). The environmental performance of companies or industries is compared to cleaner, more efficient companies or industries in the same country or in other countries. The performance of an industry over time is also monitored. The first set of benchmark indicators for Norway was developed for air pollutants; this approach is now being expanded to include environmental issues such as solid waste and waste water. Within the EU benchmarking may be quite useful as a means to monitor progress of member countries toward common environmental goals.

C Input-output analysis

4.108. This section reviews some of the non-technical details of environmental input-output analysis. It discusses the research questions that can be solved by way of input-output analysis without presenting the mathematical backgrounds. More extensive and more technical descriptions of the techniques involved can be found in a number of works on input-output, for example the United Nations' (1999a) *Handbook of Input-Output Tables - Compilation and Analysis* or the academic literature (for example, Miller and Blair, 1985 and Konijn, 1994).

1 Supply and use versus input-output

4.109. Section A mentioned the possibility of using either supply and use tables or input-output tables for augmenting the national accounts with physical flow data. The differences between these two formats are briefly explained on the basis of Table 4.13.

4.110. An input-output table is a single table constructed by using the supply table to transform the use table into one where the intermediate consumption sub-matrix is square and consists of either products used to make products or industry output used by industries. Suppose that industry A produces two products, X and Y and that X represents 90 percent of the total production and Y the remaining 10 per cent. The simplest, "industry technology" assumption is to say that exactly 90 per cent of all inputs are required to produce X and 10 per cent are required to produce Y. This assumption is consistent with assuming that for A, Y is a by-product always produced in connection with X and that no extra inputs to process Y are required. If the assumption is valid, it is relatively straightforward to simply re-allocate all by-product production to an industry which has this product as its main product. This process may not be based on very robust technological data but it is bound to result in a matrix which seems more or less plausible. Even if there is no industry which produces Y as a main product, an artificial industry can be created by attributing to it all the by-product production from different industries.

4.111. The alternative simple assumption, a "product technology" is to assume that all Y is produced in the same way that is shown by the inputs for an industry which produces only Y, industry B say. Then from the pattern of B's inputs, the proportion needed to make an amount of Y equal to 10 percent of A's output is calculated. By deduction, the remaining inputs must be those used to produce only X. It is quickly apparent that this assumption, though in many ways more intuitively appealing than the "industry technology" assumption, can run into practical difficulties. If A simply does not use enough of a given input to meet the requirement according to the "product technology" there would be a negative amount left as input for the manufacture of X.

4.112. All means of producing an input-output table amount to reaching a compromise between these two assumptions on a product by product or industry by industry basis subject to plausibility constraints such as the fact that negative inputs are impossible by definition. So, while an input-output table has much greater analytical power because it links use and demand directly, it is further removed from the basic data and involves an amount of manipulation based on partial information and subjective judgements. However, it should be remembered that the basic data for supply and use tables do not fall neatly and automatically into balanced tables and also require applied intelligence on the part of the table compilers. This may encompass implications coming from the exercise of producing an input-output table.

4.113. The result of this transformation of the supply and use tables into a single input-output table is one which has the property that supply and use for each product or industry are equal; that is, the row totals and column totals match pair-wise. For this reason, such tables are called "symmetric" tables. Because supply and use are not only equal but linked by the same classification and equal within the same table, a number of powerful analytical tools drawing on the properties of this type of "symmetric" matrix become available. The power of these techniques for purely economic studies of the linkages between industries has been known and used for a considerable period of time. The possibility of linking economic and environmental issues has been suggested for some time but practical application is somewhat newer.

2 An input output table

4.114. Table 4.13 is the monetary industry by industry input-output equivalent of the monetary supply and use table shown in Table 4.2. Instead of having use expressed in terms of products, it is expressed in terms of demand on the output of industries. In consequence, the first set of columns showing which products are made by which industries also ceases to appear. In effect the upper right and lower left segments of Table 4.2 have been consolidated in the lower right segment of the table. The row and column totals for this new, compact matrix are equal pair-wise and equal to the row and column totals for industries in Table 4.2. The entries for value added are unchanged, since they still relate to industries. The other entries are close to a conversion which assigns products to the industry most likely to produce them but are not exactly so because of the role of imports. In practice, more variation is to be expected because of the role of secondary production (for example some agricultural enterprises making manufactured food from their own products).

Table 4.13 The monetary industry by industry input-output table

Billion currency units

	Industries				Final consumption	Capital formation	ROW Exports	Total use
	I1	I2	I3	**I**	C	CF	X	
I1 Agriculture, fishing and mining	*19.1*	*96.8*	*14.0*	*129.9*	*30.9*	*2.9*	*65.7*	*229.4*
I2 Manufacturing, electricity and construction	*28.4*	*205.7*	*30.2*	*264.3*	*204.2*	*62.9*	*158.6*	*690.0*
I3 Services	*11.3*	*90.1*	*13.5*	*114.9*	*151.9*	*28.3*	*71.9*	*367.0*
I Total industries	*58.8*	*392.5*	*57.7*	*509.0*	*387.0*	*94.2*	*296.2*	*1 286.4*
M ROW Imports	*15.8*	*99.7*	*14.1*	*129.6*	*95.2*	*47.0*	*91.2*	*363.0*
Taxes on products	*3.2*	*19.0*	*3.1*	*25.3*	*24.2*	*4.8*	*15.6*	*70.0*
Total final uses (purchasers value)					*506.4*	*146.0*	*403.0*	*1 719.4*
Value added (basic value)	*151.6*	*178.8*	*292.0*	*622.4*				
Total production (basic value)	*229.4*	*690.0*	*367.0*	*1 286.4*				

Source: SEEAland data set.

4.115. As in the monetary supply and use table, there is a row showing the effect of taxes on products. In this format, though, the trade and transport margins are no longer immediately obvious. Part of the process of collapsing the product dimension to an industry one means that all margins are included in the services entries. The GDP identities can be derived from this table as from the supply and use table. The value is still 692.4 which can be calculated as either the sum of final use (capital formation [146], final consumption [506.4], exports [403]) less imports (363) or as value added (622.4) plus taxes on products (70).

4.116. Just as the monetary supply and use table (Table 4.2) can be combined with the physical supply and use table (Table 3.12) to give a hybrid supply and use table (Table 4.3), so Table 4.13 can be combined with the physical input-output table (Table 3.25) to form a hybrid input-output table. This is shown in Table 4.14. For reasons of space, the non-monetary flows are shown in total only although clearly in practice these would be detailed as in earlier tables. No distinction is made in this table between the national and rest of the world environment as either origin or destination of flows. They are presented in summary form as in Figure 4.1. Clearly this dimension also can be added and cross boundary flows from one environment to the other also shown. As before, the monetary entries are shown in italics.

Table 4.14 The hybrid industry-by-industry input-output table

Billions of currency units (entries in italics) or million tonnes

	Industries				Final consumption	Capital formation	ROW Exports	Total use	Residuals
	I1	I2	I3	**I**	C	CF	X		R
I1 Agriculture, fishing and mining	*19.1*	*96.8*	*14.0*	*129.9*	*30.9*	*2.9*	*65.7*	*229.4*	35.240
I2 Manufacturing, electricity and construction	*28.4*	*205.7*	*30.2*	*264.3*	*204.2*	*62.9*	*158.6*	*690.0*	186.680
I3 Services	*11.3*	*90.1*	*13.5*	*114.9*	*151.9*	*28.3*	*71.9*	*367.0*	57.925
I Total industries	*58.8*	*392.5*	*57.7*	*509.0*	*387.0*	*94.2*	*296.2*	*1 286.4*	279.845
M ROW Imports	*15.8*	*99.7*	*14.1*	*129.6*	*95.2*	*47.0*	*91.2*	*363.0*	5.756
Taxes on products	*3.2*	*19.0*	*3.1*	*25.3*	*24.2*	*4.8*	*15.6*	*70.0*	
Total final uses (purchasers value)					*506.4*	*146.0*	*403.0*	*1 719.4*	
Value added (basic value)	*151.6*	*178.8*	*292.0*	*622.4*					
Total production (basic value)	*229.4*	*690.0*	*367.0*	*1 286.4*					
Capital formation									72.595
Final consumption									48.206
N Natural resources	196.000	65.000		261.000	2.000		1.000		
E Ecosystem inputs	15.000	81.000	25.000	121.000	24.000		2.000		
Absorption of residuals	0.240	2.680	3.925	6.845		25.810	5.332		

Source: SEEAland data set.

4.117. As well as this industry-by-industry version of the input-output table, it is also possible to construct a product-by-product version. This is of less interest in the SEEA context since all inputs of environmental resources and outputs of residuals are available classified by industry and not by product.

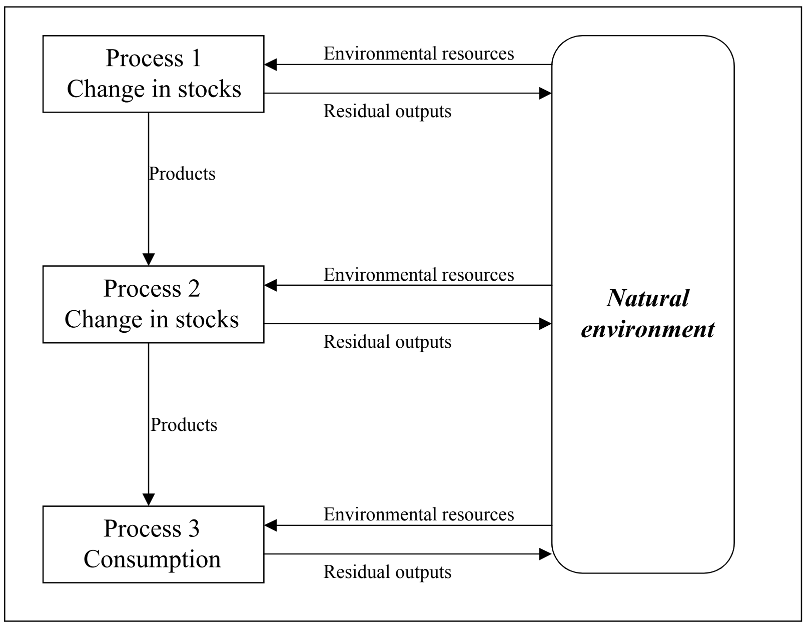
4.118. It is important to remember that both hybrid supply and use tables as well as hybrid input-output tables can in principle be represented by two types of accounting units, in physical terms or in monetary terms. Depending on the scope of the analysis, material flows within establishments (at the level of industrial processes) may also be of concern in order to provide a comprehensive description of transformation processes and their environmental consequences. These internal flows do not appear as product transactions in the monetary supply and use table and the only way to reveal these flows is to deal with "products" at an even more detailed level. Sometimes supplementary units may be required as well in analysing physical flows. An interesting example in this respect is the account on biological metabolism in the physical input-output table for Germany (Stahmer, *et al.*, 1996) in which different biological activities are distinguished such as cultivated plants and animals, forests, pets and human beings.

3 Environmental requirements of products

4.119. Emission accounts show the *direct* residual emissions generated by various production and consumption activities. Obviously, the output of an industry can be compared to the emissions generated in this industry. But this comparison does not show the *indirect* resource inputs or residual outputs that were generated during the production of the required intermediate deliveries. Thus accounting for the direct environmental performance of an economy has certain limitations in that the accounts do not immediately reveal how much material is used or residuals generated during the whole production cycle of a certain product or service. In other words, a complete product chain has to be taken into consideration before the direct and indirect environmental impacts of goods and services can be estimated.

4.120. Figure 4.6 presents such a product chain. Process 1 delivers the raw or supplementary materials required in process 2. Process 2 delivers a final product to a consumption process indicated by process 3. The product flows indicate the direction in which resource inputs or residual outputs in the entire product chain have to be allocated to the final user. In Figure 4.6 this allocation is fairly straightforward. Without changes in stocks, the direct and indirect environmental requirements of process 3, that is consumption, is equal to the summation of all resource inputs or residual outputs across all the processes. Although the consumer is obviously neither the extractor nor emitter of all resource inputs and residual outputs, all the environmental requirements in the product chain have served the provision of a consumer good. Therefore all these requirements can be attributed to the consumption of this good. Obviously, the consumption process itself may also rely on residual emissions or resource extractions.

Figure 4.6 A simple product chain



4.121. A systematic allocation of environmental requirements becomes increasingly complicated when processes are interconnected, for example when products flow in both directions between processes. Simple examples of these interconnections are the following:

steel is required to produce machinery while machinery is needed to produce steel;

the extraction of crude oil may require a substantial amount of energy.

The input-output table typically reveals these interconnections and input-output analysis can subsequently be used to allocate emissions systematically from production processes to final products.

4.122. Table 4.15 shows the results of such an input-output analysis in which the total (direct and indirect) energy requirements are estimated for a number of products. The ten products supplied in the Netherlands with the highest energy requirements are presented in this table (energy commodities such as oil, heating fuel, electricity, etc. are excluded from this ranking). Energy (or material) requirements are not necessarily embodied in products. For example, the high energy requirement of fish is caused by the substantial energy used in cooling and transportation. Besides energy, it is also possible to analyse the total material requirements (water, plastics, steel, etc.) or even the residual requirements (CO_2, NO_X, solid waste, etc.) of final products.

4.123. In analysing the total material or energy requirements of final products, special attention should be paid to the problem of double counting. It is to be expected that energy accounts or balances as presented in this chapter will include a substantial amount of double counting. After all, one particular amount of natural resource extracted may be converted several times in a number of successive production processes. As a result, the supply and use of this particular amount of material may be represented several times in different product groups in the supply and use table. For example, crude oil may be converted into refined petroleum products and some of these may be further used in the production of electricity which is then further supplied to the final energy consumers. This production chain for electricity shows the number of times the energy content is counted in a successive number of energy products. When these energy or material accounts are connected to monetary input-output tables in order to estimate the energy requirements per money unit of final product, as presented in Table 4.15, these estimates will produce an overestimation of the energy requirements of products.

Table 4.15 Energy intensities of products in the Netherlands, 1993

Product	**Energy intensities of products** (Kilojoules per Guilder)
Fertilisers	64.6
Plastics	34.8
Steel	23.2
Fish	23.2
Bricks and tiles	22.7
Zinc	22.2
Aluminum	20.6
Greenhouse vegetables	20.5
Ores	19.8
Pulp	19.6

Source: Konijn *et al*., 1997.

4.124. Physical input-output tables are helpful in eliminating this double counting. Physical input-output tables separate natural resources or ecosystem inputs directly extracted from the natural environment from product flows within the economic sphere. Physical input-output tables and analysis allow for the estimation of the physical amount of natural resource inputs required to produce one physical amount of product. In this way, environmental inputs are allocated to the successive stages of processing. Double counting can thus be avoided since all products are expressed in the amount of raw materials needed for production. The analysis of the energy or material requirements of products as presented in Table 4.15 usually relies on a combination of physical as well as monetary input-output analysis.

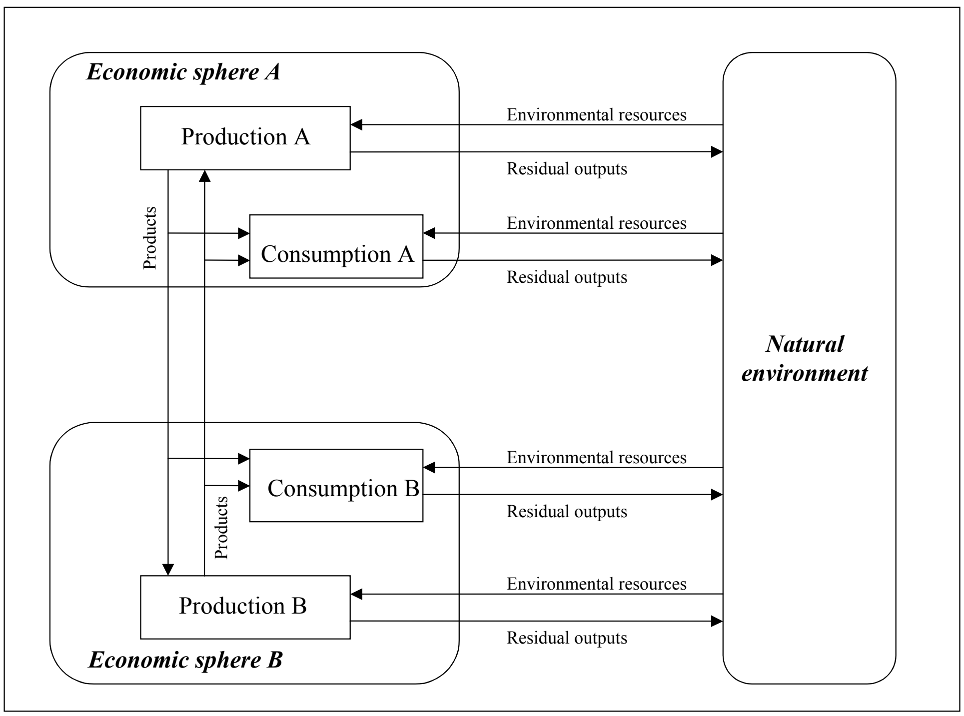
4.125. As already mentioned, the analysis presented in Table 4.15 can also be calculated for the residuals (kilograms of CO_2 for example) required for the production of one monetary unit of final product. However, in such an analysis it seems theoretically sound to use the concept of net residual outputs, that is, gross outputs of residuals minus the re-absorption of residuals within the economic sphere through processes such as incineration, recycling and waste water treatment. If the matrices of gross residual outputs (A) and residual inputs (B) have identical dimensions (residual by industry), a subtraction of B from A will provide the appropriate net emission matrix suitable for the analysis. Some of the entries in this net residual output matrix corresponding to the specialised pollution abatement activities such as waste(water) treatment plants may show negative pollution coefficients.

4 *Environmental requirements of consumption*

4.126. The analysis given in the previous section shows the environmental requirements of production. It is also interesting to know the environmental requirements of consumption. These two will only be exactly the same in a closed economy with neither imports nor exports. International trade exists because different countries have different comparative advantages in terms of economic criteria. They also have different environmental requirements for production and it is interesting to see what the total environmental impact of consumption is, taking into account that part due to imports as well as that due to domestic production. Equally of course, some environmental requirements will be caused by production for exports and this too should be noted for further analysis.

4.127. This impact of international trade flows is illustrated by Figure 4.7 which represents two countries A and B with reciprocal trade relations. Each country includes production and consumption processes and each process interacts directly with the environment via natural resource inputs and residual outputs.

Figure 4.7 Allocation of indirect environmental requirements



4.128. So-called import matrices may be compiled to provide this information. Import matrices combine both dimensions into one table which shows the type of imported product either used as intermediate consumption by industry, or by category of final demand (consumption or capital formation.)

4.129. In the standard supply and use or input-output table, imports appear as one single column in the supply table or as a single row in an input-output table. The column in the supply table contains imports classified by product groups. The specific users of these imports are not identified in the use table. The import row in the input-output table shows the total value of import by industries and households (and government) regardless of the type of product or service that is being imported or used. So, in the input-output table the user is identified while the type of product is not. The type of product and the user of imports have both to be identified in order to be able to analyse the indirect environmental effects of imports in an economy.

4.130. Ideally, information on imports would also be broken down by different importing countries. Then, if the environmental requirements for each product imported were available for the country of origin, an adjustment could be made to the environmental requirements of production to add the requirements of imports and deduct the requirements of exports to reveal the requirements of consumption. Comparisons could also be made to see whether the demand on the global environment made by exports was greater or less than the demand made by imports.

4.131. In practice, however, detail at this level of detail is unlikely to be available. Within the European Union, some information may be available for imports from other EU countries with matching hybrid accounts. In general, however, one of two simplifying assumptions is made.

4.132. The first is to assume that the environmental requirements of imports, product-by-product, correspond to the requirements of domestic production of the same product. This will often be unsatisfactory and, of course, impossible in the case where there is no domestic production of an imported product.

4.133. Table 4.16 provides a macroeconomic overview of all direct and indirect CO_2 emissions of domestic production and consumption activities and imports and exports in the Netherlands. Direct emissions are those associated with a production or consumption process. Indirect emissions are those associated with the production of the products used in a consumption or production process. In this analysis, the direct emissions from national production are supplemented with the foreign direct emissions connected to imports. This total amount of 309 million tonnes CO_2 is subsequently distributed to the final demand categories of consumption, capital formation and exports. In this way, the origin of CO_2 emissions is identified together with the purpose or the kind of use to which the CO_2 generating products can be attributed. In this way, all CO_2 emissions can ultimately be attributed to a final demand category.

Table 4.16 Allocation of CO_2 emissions to final demand in the Netherlands, 1997

Million tonnes

Origin	
Domestic	
Production (direct)	164
Consumption (direct)	36
Rest of the world	
Imports (indirect)	109
Total, origin	309
Causation	
Domestic	
Consumption (direct + indirect)	132
Capital formation (indirect)	27
Rest of the World	
Exports (indirect)	150
Total, destination	309

Source: Statistics Netherlands.

4.134. The direct emissions produced by households are linked to the purpose of their consumption. Direct emissions from imports and production are systematically allocated, or indirectly attributed, to the final users by way of input-output analysis. In this example, the substantial amount of CO_2 attributed to imports and exports reveals the very open economic structure of the Netherlands. A substantial amount of residual emissions attributed to consumption is generated in other countries while a similarly substantial amount of domestic emissions is attributed to exports. This shows that in the Netherlands residual emissions from domestic production are only partially related to domestic consumption. This example underlines the importance of a consistent treatment of environmental emissions related to international trade when looking at the indirect effects of consumption.

4.135. Analysing the indirect environmental effects of imports has another important policy implication. When, from one year to the next, a product whose production process has environmentally hazardous consequences is no longer produced domestically but is imported from abroad, environmental accounting will indicate this substitution as an improvement in the environmental performance of the domestic economy. However, for the environment this substitution may not be optimal since the material use or residual emission is only exported abroad and not necessarily diminished. Analysing the so-called "environmental rucksacks" of imports may reveal this export of polluting industries.

Time series analysis

4.136. The sections above looked at the patterns of residuals coming from different processes and different countries. It is obviously also very important to investigate how these patterns change over time. One technique to be used in time series analysis is that of structural decomposition analysis. This is a means of showing how much of the total change in residual generation is due a number of specified causes. A simple case is to determine the degree to which changes in emissions by vehicles are due to the increase in kilometres driven and how much this increase is abated by improvements in technology that reduce emissions per kilometre. Structural decomposition analysis can be used to analyse the annual changes in residual emissions and material uses for an entire economy. It may identify the key driving forces which influence the development of material consumption and residual emissions over time.

4.137. Obviously, a comparison of environmental and economic data over time must abstract from the pure effect of price changes so that economic changes are captured in terms of volume changes. To this end, input-output tables in constant prices are necessary. Efficiency changes, as measured by the total material input or residual output per money unit of production or consumption, may also affect the emissions of residuals in time. Here, too, a time series of input-output tables is necessary to examine the effect of changing efficiencies and determine whether efficiency gains can compensate for increases in resource consumption or residual emissions triggered by economic growth.

4.138. Examples of effects that can be explicitly presented in decomposition analyses follow.

Input-output analyses can be used to estimate the changes in environmental requirements that have been caused by the volume and type of growth in final expenditure.

With respect to air emissions, a further decomposition could be made between changes in fuel mix on the one hand and changes in emissions per unit of fuel combusted on the other. This can be illustrated by the following equation:

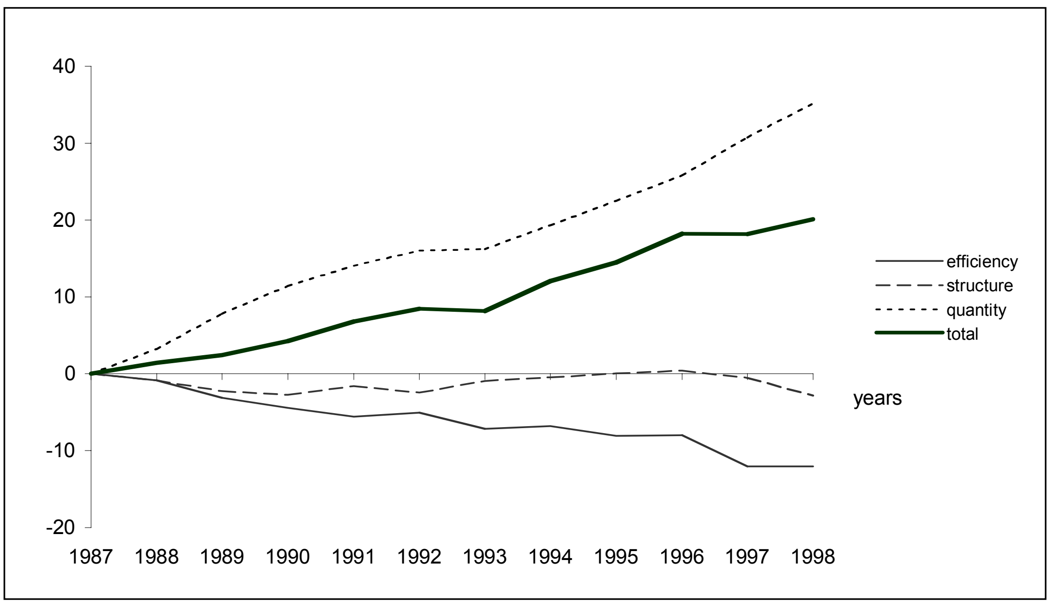
$$\text{residual}_{x} = \text{fuel}_{y} * \text{emission factor}_{x, y, z}$$

4.139. Changes in the structure of the economy may also partly influence changes in emissions. Input-output tables help to trace these structural effects. Many of the world's economies are shifting from manufacturing towards the production of services. The environmental consequences of this structural effect may be substantial since the production of services will have different environmental consequences as compared with manufacturing. Also, when incomes grow, differences in consumer propensities towards various products will lead to a changing economic structure. Another example of structure change, already referred to, is the possibility that highly polluting industries move to other countries (with less strict environmental legislation). A structural decomposition analysis which includes the indirect effects from imports should reveal this relocation of polluting industries.

4.140. Figure 4.8 illustrates a structural decomposition analysis of production-related CO_2 emissions in the Netherlands. The change in the output of CO_2 emissions was less than the increase in production due to the fact that efficiency gains lead to a decrease in emissions per unit. Changes in structure had a small but not continuous effect on keeping the level of emissions down. Structural changes are rather inconclusive. The shift towards a service economy did not lead to a decline in residual emissions. Further, in spite of efficiency gains of more than 12 per cent, emissions increased between 1987 and 1998 by 20 per cent.

4.141. Table 4.17 below compares the results of decomposition analyses for CO_2 emissions for the Netherlands and the United Kingdom, showing some extra detail. The results show that the factors driving emissions changes can differ substantially across countries. For example, the substantial reduction in the emissions from the UK electricity, gas and water supply industry are mainly due to fuel switching (increased use of natural gas) whereas in the Netherlands electricity was generated using mainly natural gas throughout the period covered. The increase in emissions of the Dutch sewage and refuse disposal industry is mainly explained by increased incineration of waste.

Figure 4.8 Decomposition of changes in production-related CO_2 emissions in the Netherlands, 1987-1998



Source: de Haan, 2001.

4.142. Table 4.17 also illustrates that in both economies the structural change component makes a relatively small net contribution to emission reduction at the aggregate level. However, Table 4.17 makes clear that this masks the impact of a substantial structural change within certain sectors such as agriculture, mining, manufacturing and electricity supply which is largely cancelled out by structural changes within the services sectors, in particular the increased residual emissions from transport services.

4.143. Obviously, the identification of these different driving forces provides a good starting point for scanning the possible future developments in the physical economy taking explicitly into consideration expectations regarding economic growth, technical improvements, and structural changes.

Table 4.17 Decomposition of the change in CO_2 emissions by industries in the Netherlands and the United Kingdom

(% of the total change relative to the base years)

	The Netherlands, 1987-1999				The United Kingdom, 1990-1998			
	Efficiency change	Structural change	Economic growth	**Total change**	Efficiency change	Structural change	Economic growth	**Total change**
Agriculture, forestry, fisheries	**-0.2**	**-1.8**	**3.0**	**1.0**	**0.1**	**-0.2**	**0.2**	**0.1**
Crude petroleum and natural gas production	*0.6*	*-0.2*	*0.4*	***0.8***	*-1.1*	*1.3*	*0.8*	***0.9***
Manufacture of petroleum products	*-0.5*	*-1.0*	*2.5*	***1.0***	*-0.4*	*-0.1*	*0.8*	***0.3***
Manufacture of chemical products	*-5.1*	*0.3*	*5.0*	***0.2***	*0.0*	*-0.3*	*0.5*	***0.3***
Manufacture of basic metals	*-0.5*	*-0.2*	*1.7*	***0.9***	*0.2*	*-1.3*	*1.0*	***-0.1***
Other mining and manufacturing	*-1.3*	*-0.6*	*3.0*	*1.1*	*-1.0*	*-2.5*	*1.8*	*-1.7*
Mining and manufacturing	**-6.8**	**-1.7**	**12.6**	**4.1**	**-2.3**	**-3.0**	**5.0**	**-0.3**
Electricity, gas and water supply	**1.2**	**-4.4**	**9.7**	**6.5**	**-14.7**	**-0.8**	**5.3**	**-10.2**
Land transport	*-0.8*	*0.5*	*1.7*	***1.4***	*-0.8*	*0.2*	*0.9*	***0.3***
Water transport	*-0.2*	*0.3*	*1.4*	***1.5***	*0.1*	*0.1*	*0.4*	***0.5***
Air transport	*-3.1*	*3.3*	*2.0*	***2.2***	*-1.0*	*2.4*	*0.8*	***2.2***
Sewage and refuse disposal	*0.7*	*0.9*	*0.8*	***2.4***	*-0.2*	*0.1*	*0.0*	***-0.1***
Other services and construction	*-2.9*	*0.0*	*3.9*	*1.0*	*-1.9*	*0.2*	*1.8*	*0.1*
Total services and construction	**-6.3**	**5.1**	**9.8**	**8.6**	**-3.8**	**2.9**	**3.9**	**3.1**
Total change in CO_2 emissions	**-12.1**	**-2.9**	**35.1**	**20.2**	**-20.7**	**-1.1**	**14.4**	**-7.4**

Source: Adapted from de Haan, 2001 and Harris, 2001.

Chapter 5 Accounting for economic activities and products related to the environment

A Chapter overview

1 Objectives

5.1. The previous two chapters discuss how to augment conventional national accounts by appending information about how the environment provides inputs to and absorbs outputs from the economic process. This chapter and the next show how to identify those transactions within the economy which are directly concerned with using, managing and protecting the environment. The present chapter works mainly within the supply and use framework established in the previous chapters. The next chapter goes beyond product related transactions to consider other economic instruments affecting the environment.

5.2. The SNA encourages the development of satellite accounts in order to study particular parts of the economy in greater depth. This is done by defining the activities and products which are "characteristic" of the field of study. In this case it is activities and products concerned with the environment which are of interest. At present, no new transactions or even re-arrangements of the basic SNA identities and definitions of aggregates are considered. Later chapters do consider variations and additions to the basic SNA structure in the context of an external satellite account.

5.3. The difference between products and industries was introduced in Chapter 3. Products flow from industries to other industries, to consumers and into capital accumulation. All products originating in the national economy come from industries. However, when we wish to identify those industries and products which are characteristic of the environment, the simple industry and product classifications are not sufficient. We need to introduce alternative classifications to discriminate between those products and industries frequently associated with environmental activity. Then we need to identify when these and possibly other products are actually used to achieve environmental goals. This is done by introducing a classification of activity by purpose.

The environmental domain of interest

5.4. The two main purposes designated to be of environmental interest are protection of the environment and the management of natural resources and their exploitation. In addition, there are some activities which, though not primarily aimed at protecting the environment, may have environmentally beneficial effects. Damage avoidance and treatment may also be included in the field of interest though these activities are more concerned with rectifying damage already done than with preventing it in the first place. Lastly, and perhaps less obviously, minimisation of natural hazards may be included although these are activities to protect the economy from the environment where the others are concerned with protecting the environment from the economy. For simplicity, the expression "environmental activity" is used in the rest of the chapter as shorthand for all the environmentally related purposes just described.

5.5. Once the purposes of economic activity of interest are identified, it is possible to construct accounts showing the supply of the relevant products and the nature of the expenditure on them. The accounts can show whether the environmental activities are being undertaken by private enterprises or government and how far the costs fall to industry, to government and to consumers. They also provide the setting within which to explore the potential impact on production patterns and residual generation of new technologies, especially those designed to be more environmentally friendly.

Use of the accounts

5.6. The reason to establish accounts for environmental protection and resource management is to identify and measure society's response to environmental concerns through the supply and demand for environment goods and services, through the adoption of production and consumption behaviour aimed at preventing environmental degradation and by managing environmental resources in a sustainable way. The accounts presented in this chapter systematically identify those parts of the national accounts that are relevant to this objective. This means the analysis is strictly consistent with the national accounts as presently complied but identifies separately the relevant transactions which have actually taken place.

5.7. The accounts can be used to analyse the effects of economic policy measures on environmental activities and issues and to analyse future scenarios. Policy interest is often broader than just environmental protection. For example, water-related policy may include waste water management, water purification and supply, water saving, management of rivers and flood control. The accounts can also be used more simply to derive indicators to highlight change in key areas such as resources spent on pollution prevention and abatement and associated savings, the contribution that the environment protection industry makes to economic growth, and the shift to pollution preventing technologies.

5.8. Another way of using environmental protection and resource management accounts is to model the effects of possible changes in environmental measures, in order to estimate the way such changes will affect (directly and indirectly) environmental pressure, economic activity, growth and employment in the future. A particular use of such models may be to estimate the effect on GDP, employment and trade of a given level of environmental protection measures. This is explored in Chapter 10 as part of the question of how to try to measure the economic costs of preventing the remaining environmental damage.

5.9. A further, immediate, use of environmental protection and resource management accounts is the production of indicators which illustrate how actions to remedy the environmental impact of the economy are changing over time. Chapter 11 explores the question of indicators based on the accounts presented in this chapter as well as other possible uses.

2 Introducing purpose classifications

5.10. So far, in chapters 3 and 4, the classifications used have been those showing what is produced (products) and by whom (industries). The first step in identifying environmental activity is to subdivide products and industries into those which are typical, or characteristic, of environmental activity and those which are not. This can be done by subdividing the rows and columns for products and industries in the supply and use table. However, this does not completely solve the problem because products typical of environmental activity may in fact be used for other purposes and some non-typical products may be used by environmental activities. For example, a unit undertaking street cleaning and refuse collection may buy overalls for its workers, even though overalls are not considered to be typically environmental products. Equally, the vehicles used to collect refuse will typically be manufactured by a producer who also makes non-environmental vehicles.

5.11. In order to include the overalls bought for refuse collection and exclude the non-environmental vehicles, we introduce a further classification into the matrix, one where the purpose of the expenditure undertaken is identified. This too is subdivided to show the purposes which are environmental in nature, and thus of interest here, and other purposes. In this case the purposes of interest are those listed above: protection of the environment, management and exploitation of natural resources, environmentally beneficial activities and the minimisation of natural hazards.

5.12. Table 5.1 shows a supply and use table with both these extra classifications added. (For simplicity at this stage we assume a closed economy with no imports and exports.) The first pair of rows shows the same information on consumption and accumulation classified by products as appears in chapters 3 and 4, but now with a distinction between environmental and other products and categories of expenditure. The refuse collection vehicles appear as environmental capital formation of environmental products. The overalls purchased by the refuse collection industry fall in the column for environmental intermediate consumption but the row for non-environmental products. To take a slightly far-fetched example, if some machinery incorporating the latest environment-friendly technology is bought for display in a museum rather than put to use protecting the environment, it would appear in the row for environmental products and the column for non-environmental capital formation.

Table 5.1 Products, purposes and industries

			Production						Consumption			Accumulation	
			Products		Purposes		Industries		Industries		Consumers	Industries	
			Environmental	Other	Environmental	Other	Environmental	Other	Environmental	Other		Environmental	Other
Production	Products	Environ-mental							Intermediate consumption of products classified by industry		Final use by product	Capital formation of products classified by industry	
		Other											
	Purposes	Environ-mental					Output of industries by purpose						
		Other											
	Industries	Environ-mental	Output of products by industries										
		Other											
Consumption	Industries	Environ-mental			Intermediate consumption by industries classified by purpose								
		Other											
	Consumers				Final use by purpose								
Accumulation	Industries	Environ-mental			Capital formation by industries classified by purpose								
		Other											

5.13. Just as the entries for consumption and accumulation classified by products are disaggregated between those which are environmentally relevant and those which are not, so the entries in the first pair of columns where output is shown by industry in the way described and utilised in chapters 3 and 4 are similarly disaggregated between environmental and other industries. As in all such matrix presentations, the sum of the row for environmental products must equal the sum of the column for the output of environmental products. In this presentation, though, we can see which of these products is made by environmental industries and which by other industries. An important instance of environmental products coming from non-environmental industries is the fact that many industries undertake environmental protection activities on their own account, for example clean-up activities. In addition, some environmental industries may have significant production of non-environmental products. These are called ancillary activities and secondary production respectively.

The further discussion of how to delineate environmental activity and the appropriate treatment of ancillary activity and secondary production is the subject of Section B. Section B discusses classifications of activities according to environmental purpose and elaborates the measurement of activities and products concerned with one of these purposes, environmental protection.

5.14. At this point, we introduce the second extension of the matrix, the pair of rows and columns showing the purpose of supply and use. As before, the row and column sums for these new rows and columns must be equal pairwise, but by introducing this further classification we have moved the overalls into the environmental purpose classification and excluded the environmental vehicles going to the museums. Ideally what we want to measure are the expenditures connected with the designated environmental purposes. For practical reasons concerning available data sources, though, we may be constrained to look at environmental industries or environmental products. This matrix presentation is intended to show that while there is a large overlap between environmental industries, environmental products and environmental purposes, there are examples of activities and products which may fall in only one or two of these groups. Much of the work of determining environmental protection expenditure is concerned with identifying where the boundaries of interest lie.

5.15. Strictly speaking, the match between supply and use by purpose will be achieved only in a closed economy or one where imports and exports are exactly balanced. In practice, it is difficult if not impossible to know whether imported products originated in environmental industries and it is not possible to know the purpose intended for exports. For this reason, purpose classifications are used as subsidiary classifications and there is usually some ambiguity concerning imports and exports.

3 Environmental protection expenditure accounts (EPEA)

5.16. Although the desired scope of accounts concerned with environmental activity covers resource management and exploitation, damage avoidance and treatment and minimisation of natural hazards in addition to environmental protection, in many countries accounts have only been developed for environmental protection expenditure. For this reason, much of the present chapter, and in particular Section C, concentrates on this single aspect of environmental activity. It is hoped and assumed that the techniques developed here will provide useful examples for work in other areas of environmental activity. Some prototype work suggests this may be so but this has yet to be confirmed in more general implementation.

5.17. Section C discusses not only how to measure the supply and use of environmental products but also the expenditure on them. Identifying expenditure on environmental protection in the same framework as expenditure on education and health, say, is a necessary precondition to making an assessment of the balance of relative costs and benefits and the trade-off between areas of different aspects of economic and social life. Section C elaborates a concept of national expenditure on environmental protection as the sum of all uses of environmental protection products plus gross capital formation undertaken by those producing these goods and services adjusted for payments from government and the rest of the world and elaborates how the costs of this expenditure are financed.

5.18. Section C also discusses some of the data issues which arise when compiling the accounts.

5.19. Section D presents two examples of the compilation of accounts in this area. The first concerns the compilation of an environmental input-output table for Germany concentrating on environmental protection expenditure. The second discusses compiling an account for research and development expenditure on environmental protection in Canada. In addition, two extensions of the accounts are briefly discussed, one establishing a link to physical data and the other establishing time series for environmental protection in constant prices.

4 Scope and limitations of the accounts

5.20. The need in a particular country for the accounts described here will vary, reflecting differences in national characteristics and political priorities (for example some countries will have a special interest in water supply, others in forestry management, many will have an interest in energy savings, waste minimisation and recycling), and so each country may wish to define the scope of environment-related activities in its own way. For developing countries which have a high tourist income from people visiting game parks, protection of wildlife will have a greater priority than in many other countries.

5.21. Several countries have put some of the accounts presented in this chapter into practice. Data collection and reporting at the international level is in place for some of the aspects mentioned, for example the joint OECD/Eurostat survey on Environmental Protection Expenditure and Revenues (EPER) and other environmental protection activities. Many countries have already implemented the Environmental Protection Expenditure Account which the chapter describes. Data collection activity is also being undertaken on the "Environment Industry" so as to gain a complete picture of environmental protection activities as well as the role of environmental taxes. So far there is less practical experience with the other accounts, in particular with resource management accounts.

5.22. As well as drawing attention to the uses of the accounts, it is necessary to point out some of their limitations. These result mainly from classification, definitional and data collection issues. As with other satellite accounts there are problems with defining the scope of different environment-related protection activities precisely. The scope of the coverage is important when carrying out subsequent analyses by environmental protection domain, by resource categories, or when analysing the effect of environmental taxes.

5.23. One of the most difficult distinctions to make is whether the primary purpose of the spending is environmental protection, or whether environmental protection is simply a result of decisions taken for some other purpose. A good example is spending on equipment which may reduce pollutant emissions but which may also be more energy efficient. There are also practical data collection problems such as trying to estimate the cost of the additional "clean" part of new capital equipment, particularly where the clean element becomes a standard part of the equipment and there is no "dirty" alternative.

5.24. There are difficulties in linking environmental spending directly with physical reductions in residual emissions. It may be possible for solid waste but difficult where a number of environmental benefits may result affecting different media. But such linkages substantially enhance the value of the information by enabling average or marginal pollution abatement costs to be calculated.

B Environmental activities and products

1 Environmental activities and purpose classifications

5.25. Environmental activities are those which reduce or eliminate pressures on the environment and which aim at making more efficient use of natural resources. Examples are investing in technologies designed to prevent or reduce pollution[1], restoring the environment after it has been polluted, protecting the economy from a deteriorated environment, recycling, conservation and resource management and the production of

[1] Such technologies, and the corresponding products, are sometimes more colloquially referred to as "environment-friendly", "clean" or "cleaner". These latter terms are sometimes used in the tables in this chapter simply to keep the headings of manageable length.

environmental goods and services. Environmental protection and resource management activities include not only those where the primary purpose is environmental protection but also activities which are not necessarily carried out for environmental protection reasons but which nevertheless produce clear, measurable environmental benefits. An example is spending on energy-saving equipment.

5.26. The statistical coverage of all environmental activities is still evolving. For the present, the following groups of purposes are considered:

environmental protection activities;
natural resource management and exploitation activities;
environmentally beneficial activities; and
minimisation of natural hazards.

5.27. Each of these is considered in turn below.

5.28. In addition there are activities aimed at avoiding and treating damage from a polluted environment. Examples include expenditure associated with moving house or place of work to avoid local noise or air pollution; expenditure on cleaning and restoring dirty or damaged buildings resulting from air pollution; and hospital treatment for people adversely affected by poor environments. In practice, however, the identification and estimation of damage avoidance and treatment presents substantial difficulties and for this reason is not discussed further until Chapter 9.

Environmental protection activities

5.29. Environmental protection activities are those where the primary purpose is the protection of the environment; that is, the avoidance of the negative effects on the environment caused by economic activities. Examples include spending by companies on end-of-pipe equipment to reduce or eliminate emissions or make them less hazardous and spending on environmentally protective technology to minimise emissions and pollutant discharges during the production process. By convention, this heading also includes spending on those technologies where only part of the new equipment has an environmentally beneficial component. For example, equipment may need replacing at the end of its life, which is the reason for the investment, but the primary purpose of the "clean" element is to protect the environment. The activities are generally classified by the environmental "domains" which are protected for example air, water, soil and groundwater, biodiversity and landscape. The full classification of environmental protection activities (CEPA) is given in Annex 5.

5.30. Relevant activities and expenditures are identified by the criterion of the primary purpose. Within this "primary purpose" definition, several variants or sub-sets have been used either in combination or separately. The criteria below may also be adapted to identify other environment-related activities and expenditure.

A) ***The pure purpose criterion.*** Activities and expenditure where the main objective is protecting the environment are included in full. This criterion works best where the main objective of protecting the environment is clear and unambiguous, for example end-of-pipe capital expenditure.

B) ***The extra-cost criterion*** is used to identify the portion of the cost of more environmentally friendly technologies and changes in processes and products to be attributed to environmental protection. The investment and operating expenditure are compared to those of a "standard" or less environmentally beneficial alternative, if there is one, or the estimated additional cost of incorporating the environmentally beneficial feature. Only the extra expenditure is included.

C) ***The net-cost criterion***. Only expenditure undertaken for environmental protection purposes which leads to a net increase in cost (that is where spending exceeds any savings or income arising before the net cost was actually incurred) is included. When expenditure is recorded, this criterion only applies to operating expenditure.

D) ***The compliance criterion***. Expenditure undertaken with the main objective of protecting the environment but specifically in order to comply with environmental protection legislation, conventions and voluntary agreements. This can be further sub-divided to show those activities and transactions undertaken in order to comply with legislation only.

5.31. These guidelines do not form an exhaustive, mutually exclusive set. They are simply a practical set of working definitions which have been adopted for particular applications. For example, when analysing public budgets, it will often be impossible to identify the environmental share or the net cost when classifying transactions, so criterion A might be used. When conducting surveys of environmental expenditure of corporations, criterion A alone is less useful and a combination with other criteria might be used. This explains the introduction of criteria C and D as variants of criterion A.

5.32. Expenditures, activities and actions which are intended to improve environmental protection as well as serving another purpose cover investment in new technologies which incorporate environmental improvements and integrated investment programmes by public bodies. In such cases separate information on the environmental component is generally not available or easily estimated. The extra-cost criterion (criterion B) is most useful for such actions. It cannot be used alone but only in combination with other variants.

5.33. Both the extra-cost criterion and the net cost criterion (criterion C) exclude from environmental protection those measures undertaken for environmental protection reasons but which result in net savings. Examples are energy saving or increases in productivity which are higher than direct gross costs. A particular case concerns in-house (ancillary) activities that are used instead of the purchase of marketed environmental protection services. For example, net savings could occur because of reduced waste treatment bills resulting from starting an own account waste treatment activity but the costs of ancillary activity would have to be counted in place of the previously purchased services.

5.34. Criterion C also excludes sales of by-products of environmental protection activities. Valuable information might therefore be lost using this criterion. Use of the net cost criterion is best restricted to identifying expenditure associated with environmentally protective technologies, processes and products.

5.35. The classification suggested for organising environmental protection activities is the Classification of Environmental Protection Activities (CEPA). The classification also applies to expenditure and products. Within the CEPA, environmental protection activities are first classified by environmental domain (air, waste, nature protection, etc.) and then by type of measure (prevention, reduction, etc). The main one-digit headings of CEPA are listed in Table 5.2; the detailed classification is given in Annex 5.

5.36. Experience has shown that basic data do not allow a full classification of activities and transactions below the detail suggested above due to identification and separation problems. The CEPA may be adapted for national purposes (for example concentrating on soil erosion and salinity prevention activities).

Natural resource management and exploitation activities

5.37. Natural resource management and exploitation activities cover the natural resources in the SEEA classification of assets (mineral and energy resources including sub-soil deposits, soil, biological resources such as wild flora and fauna, water resources both marine and fresh water) as well as land and ecosystems. Waste water management, the protection of flora, fauna and ecosystems are covered under environmental protection. As yet, there is no international classification of such activities. Work to identify relevant activities is ongoing.

5.38. Work on accounts for natural resource management may often depend on issues specific to a given country, for example water shortage or forest management. Sometimes the concern may be specifically directed at knowing whether the resource in question is being managed sustainably or not or may even be confined to those activities which do result in sustainable management.

Table 5.2 Classification of Environmental Protection Activity (CEPA)

1.	Protection of ambient air and climate
2.	Waste water management
3.	Waste management
4.	Protection and remediation of soil, groundwater and surface water
5.	Noise and vibration abatement
6.	Protection of biodiversity and landscape
7.	Protection against radiation
8.	Research and development
9.	Other environmental protection activities
9.1	General environmental administration and management
9.2	Education, training and information
9.3	Activities leading to indivisible expenditure
9.4	Activities not elsewhere specified

Source: Annex 5.

5.39. ***Management activities*** include research into management of natural resources, monitoring, control and surveillance, data collection and statistics, costs of the natural resource management authorities at various levels as well as temporary costs for facilitating structural adjustments of sectors concerned. Activities and transactions specifically for environmental protection, for example management of protected forests, are not included. (They are included under environmental protection expenditure activities where the primary purpose is the protection of the environment as mentioned above.) Similarly, qualitative protection activities of natural resources, for example activities for biodiversity and landscape protection or activities aimed at preserving certain functions or the quality of the natural environment (air, water, soil and groundwater), are also included under environmental protection.

5.40. Management activities may also result in associated, secondary, environmental benefits such as protection and restoration of wildlife and natural habitats.

5.41. ***Exploitation activities*** include abstraction, harvesting and extraction of natural assets including exploration and development. These accounts typically correspond to the standard economic accounts for various natural resource-related industries such as fisheries, forestry, mining and water supply. They complement the asset accounts described in chapters 7 and 8.

5.42. Natural resources can be depleted where they are turned into products, for example oil and petrol, and they can also deteriorate in quality where the asset is used in production processes or services, as may happen for example in the case of water. However, activities concerned with the transformation of natural resources into other products, including upstream and downstream activities, are not covered in this chapter.

5.43. Table 5.3 gives a more detailed description of what is included in the natural resource management and exploitation account for each resource and for each of the two main categories, management and exploitation of resources. Illustrative examples of the sorts of activities included follow. As noted above, it may be helpful to make a distinction between sustainable and non-sustainable management activities.

Table 5.3 Natural resource management and exploitation activities

Resources	**Management**	**Exploitation**
Sub-soil assets	Administration of permits, planning supervision, research, regulation	Exploration and extraction
Inland waters	Administration of water ways and water bodies, supervision, research, elaboration of plans and legislation, water police	Exploration, extraction, treatment, distribution
Forest resources	National forest inventories, research for pest control, regulation	Silvicultural activities including harvesting and reforestation
Wild flora and fauna	Supervision and control of fishing fleets, assessment of stocks, administration of quotas and licenses, research, regulation	Harvesting, fishing, hunting

Inland water mobilisation

5.44. Mobilisation covers all activities aimed at abstraction, treatment and distribution of water resources for their various uses. The following may be usefully distinguished.

Drinking water supply: Capital outlays for water abstraction (protection of abstraction perimeters, pumping stations, etc.), processing of drinking water, pressure build-up, storage and distribution, expenditure for major maintenance. Operating expenses such as operating cost of production facilities, energy, purchase of treatment and distribution products, metering, billing, and so on.

Irrigation: All mobilisation activities corresponding to agricultural and animal breeding uses; ground water abstraction, construction of dams, catchments for surface flows, etc., including the operation of irrigation systems.

Industrial water mobilisation: All mobilisation activities corresponding to industrial uses of water; uses for cooling of power plants and industrial installations are included.

5.45. It would also be useful to distinguish between services provided by the water industry and services provided for businesses' own use.

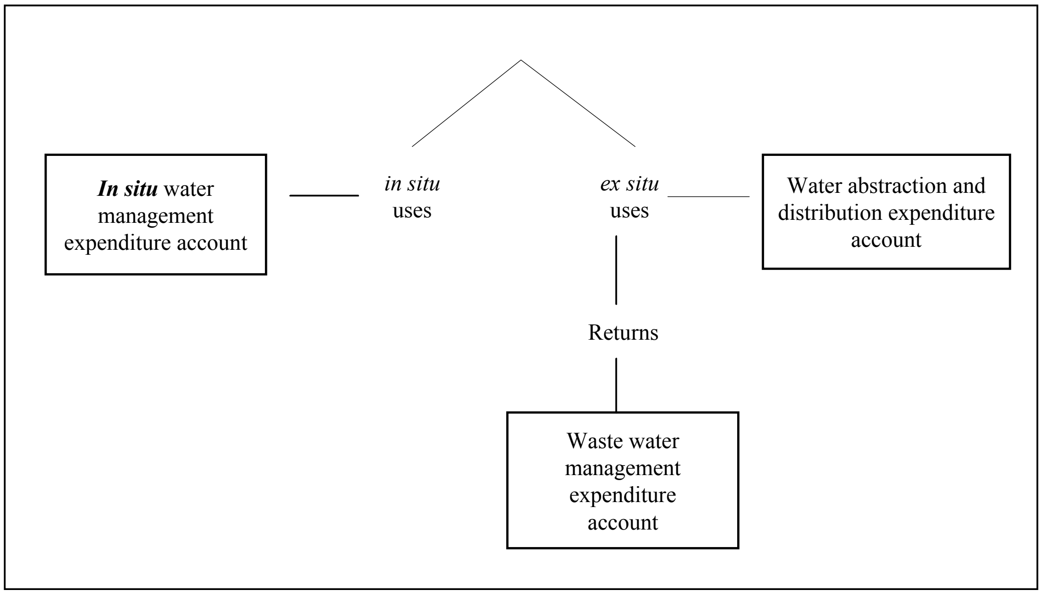
Management of water bodies

5.46. Management of water bodies may include activities involved in the transit of water from its "natural" status to that of "controlled" water status, reinforcing river banks, construction and maintenance of waterways, water engineering and dams. Dams for the production of electricity are not included. Recharging activities may consist of land improvement, development of vegetal cover in order to increase water infiltration and recharge groundwater bodies. In so far as they are not accounted for in protection of soil against erosion, corresponding transactions have to be recorded in the inland water management account.

Accounts for water – French experience

5.47. As a part of a complete system of water accounts, which include physical accounts for water quantity and quality, the French Environment Institute (IFEN) has developed a set of monetary accounts for water. There are three main monetary accounts for water as shown in Figure 5.1.

Figure 5.1 Schematic diagram of the French water accounts



5.48. The waste water management expenditure account is a typical environmental protection expenditure account which describes the national expenditure for waste water collection and treatment according to the methodology of the *System for the Collection of Economic Information on the Environment* (better known by its French acronym SERIEE) using the appropriate CEPA group.

5.49. The abstraction and distribution of water expenditure account, covers expenditure for *ex situ* uses of water, drinkable water, industrial uses, including cooling, and irrigation. Conceptually it covers expenditure for recycling and water saving, although data are rather scarce. This account shows the use of the water resource.

5.50. Finally an account, still under development, concentrates on the management of water *in situ*. It covers all expenditure the purpose of which is to maintain the *in situ* functions of the hydrological system (maintenance of minimal flows, restoration of rivers, increase of infiltration, etc.).

5.51. IFEN has also developed a "prevention of natural hazards" expenditure account which includes flood prevention measures and a "protection of landscape and biodiversity" expenditure account. This last pays particular attention to identifying overlap between the various accounts and so includes, for example, actions for the protection of freshwater fish.

5.52. Paying attention to overlapping areas is particularly important in the context of the establishment of a consolidated monetary water account, which will also cover all water-related expenditure that cannot be distributed to the sub-accounts for general administration, coastal waters, and so on. Such a set of inter-related accounts can be useful to respond to a variety of environmental protection and resource management questions. For example, the increased cost of water supply may be related to water pollution and land use changes as described, separately, in chapters 3 and 8.

Forest management

5.53. Management of forests includes expansion (afforestation) of wooded areas including net acquisitions of land for afforestation, their development for recreational use, inventories and assessment of forest resources, forest-related research, education, training and information activities, forest-related administration and surveillance. Increasing use of wood for construction and furniture, or use of woody biomass as fuel, etc. may be considered as being beneficial for the environment, as it substitutes products based on non-renewable resources (plastics, concrete, fossil fuels, etc.) by renewable resources and increases the net fixation of carbon.

5.54. Public financing may consist of transfers to producers for afforestation or maintenance of wooded areas, or expenditure by general government units engaged in other non-market activities (management, control, regulation of forest and forestry). Because of its importance, it may be desirable to establish a Forest Resource Management Account to record separately the transfers intended to pay for forest resource management expenditure as well as collective consumption of general government. The development and maintenance of wooded areas may benefit from other incentives in addition to subsidies, investment grants and other transfers. For example, specific reductions in taxes on forest assets, reductions in interest rates, etc. may be intended to promote forest development objectives.

Fisheries management

5.55. Management of fisheries includes expenditures for fisheries management purposes, monitoring, control and surveillance, data collection, expenditure of the local, regional and national fisheries management authorities (such as fisheries management bodies), temporary costs for facilitating structural adjustments of the fisheries sector (for example vessel buy-back programmes, re-training) and research.

Environmentally beneficial activities

5.56. Environmentally beneficial activities may be primarily undertaken for economic reasons but yield substantial environmental benefits even though the primary purpose is not the protection of the environment. Examples are investment in energy or material saving equipment such as insulation and heat recovery, activities aimed at saving water such as investments in irrigation systems, industrial or household facilities to reduce water consumption, or recycle water, and the use of products adapted for lower water consumption (such as specially adapted washing machines).

5.57. As noted above, this is one of the newer areas for statistical examination but the importance of including it can be seen from a consideration of waste processing.

5.58. In the ISIC Rev. 3, recycling (division 37) is defined as "processing of waste and scrap into a form which is readily transformed into new raw materials". In-house waste minimisation and in-house recycling and re-processing are naturally included under environmental protection (waste management), often on the basis of the "net-cost criterion". However, the production of recycled goods, while not in itself an action to protect the environment, does have beneficial effects as it generates "secondary raw materials". Table 5.4 gives an interesting example of the amount of material input into recycling and the amount of recycled material coming out of the industry.

5.59. In practice, a clear separation of environmentally motivated and financially motivated measures is not always easy and much will depend on the primary data collected in specific surveys (see criteria B and C above).

Table 5.4 Recycling industries (ISIC 37), 1997: Dutch Example

Input of waste and scrap and output of secondary raw materials, in million Dutch Guilders

Input (waste and residuals)	Paid to disposer	Received from disposer	**Output (secondary raw materials)**	Sales
Photographic waste	34	19	Crushed glass	60
Glass	38	12	Granulate, mix from plastics	200
Cable waste	18	4	Granulate, mix of stone, concrete	100
Plastics	75	13	Ferrous metals	223
Metals	195	5	Non-ferrous and precious metals	134
Construction & demolition waste [1]	8	169	Other [3]	15
Other [2]	25	83	Final products	27
Total	**393**	**305**		**759**

Source: Production statistics, Statistics Netherlands.

Notes: 1. Including grit from drilling activities, slag and fly ash, asphalt.

2. Including waste rubber, waste from dismantling computers and other electronics, waste paper.

3. Including granulate mix from rubber, metal mix from electronics waste.

Minimisation of natural hazards

5.60. Expenditures and activities aiming at the minimisation of natural hazards and of their impacts can be tabulated in the same way as environmental protection expenditure although little country experience is available so far (except the French water example described above). Such accounts may provide useful indicators of the effects of alterations of landscapes and water systems or global warming. It may however be difficult to determine to what extent natural hazards are caused by such human intervention. Countries will have different priorities and the accounts may include the following natural hazards:

forest fires;
floods;
avalanches;
landslides;
storms;
droughts;
earthquakes; and
volcanic eruptions.

5.61. The nature of activities will differ according to the phenomenon covered and may include research, observation and measurement networks, surveillance, administration of hazard warning systems, provisions for fighting the effects of floods or forest fires (equipment, etc.), provisions for the evacuation of the population, structures to prevent hazards (for example, fire barriers in forests, avalanche prevention barriers, dams to slow down water flows, re-naturalisation of river banks and other landscapes).

5.62. Initially only government expenditure may be covered. Government transfers or tax allowance records may also provide an indication of expenditure undertaken by corporations or households. Private entities could be surveyed.

5.63. The account could conceivably be extended to cover the costs of clean-up and remediation after the events so as to arrive at estimates of the economic damages caused by natural hazards and their evolution over time. Data from insurance companies and from government budgets could be a useful starting point.

2 Environmental protection activities

5.64. So far most practical experience has been in the area of environmental protection. This section and the next are therefore confined to this (large) sub-set of environmental activities. The objective in this section is to determine which units are actively involved in the production of environmental protection activities and what the products are. The next section considers which units purchase the products and which units finance the purchases.

5.65. Referring back to Table 5.1 again, we can see that for any class of environmental purpose, there are environmental industries involved in production for that purpose but also that there may be some activities which the industries undertake that are non-environmental in character and there are also some environmental activities undertaken by non-environmental industries.

5.66. For any producer there must be a principal activity. For a market producer, this is the activity which produces most of the revenue (strictly speaking, most of the value added) for the enterprise. For non-market producers, the principal activity is the one which accounts for most of the costs of production. The identification of the principal activity is the basis on which the producer is allocated to one of the headings in an industrial classification. In addition to a principal activity, a producer, whether market or non-market, may produce smaller quantities of other products. If these are destined for use by other units, they are referred to as secondary production. Even when such subsidiary activity is retained by the enterprise and is recorded as capital formation, it is also recorded as secondary production.

5.67. Products other than capital formation which are retained for use within the same unit are referred to as ancillary production. Ancillary activities are not identified in terms of output in the SNA. This chapter discusses why it is desirable to do so in the context of a satellite account for environmental protection.

5.68. Table 5.5 shows the nature of principal, secondary and ancillary activities within the cell of Table 5.1 which shows output by industries classified by purpose. To this we add another categorisation. Principal and secondary activities are referred to as external; ancillary activity is internal.

Table 5.5 Principal, secondary and ancillary activities

		Industries	
		Environmental	Other
Purposes	Environmental	Principal production for environmental puposes Secondary production for environmental purposes Ancillary production for environmental puposes	Secondary production for environmental puposes Ancillary production ofpr environmental puposes
	Other	Secondary production for non-environmental purposes Ancillary production ofr non-environmental purposes	Principal production for non-environmental puposes Secondary production for non-environmental purposes Ancillary production for non-environmental puposes

External activities

5.69. In principle, external environmental protection activities are easy to identify since they result in an output which is separately identified in standard national accounts. This is true not only for products intended for sale to another unit but also for own-account capital formation since it is recorded in the same way as any other capital formation in the SNA. The relevant activities can be determined by reference to the ISIC classification (see Annex 7 for descriptions of the categories and the codes). The main external environmental protection activity is ISIC 90 “sewage, and refuse disposal, sanitation and similar activities”. Other environmental protection activities may be found in ISIC 37 (recycling), 45 (construction), 51 (for example wholesaling of waste materials and scrap including sorting), 73 (research and development), 75 (general administration), etc. These may be carried out as secondary as well as principal activities.

Separating out secondary activities

5.70. Ideally when an enterprise or operating unit producing goods and services has a principal activity and secondary activities, for reporting purposes it should be subdivided and separate establishments created for each of the secondary products. The objective is to align reporting units as far as possible with a single product. In this way the inputs of the unit relate to a single production process and aggregation of units matches the activity classification as closely as possible. This is a standard SNA recommendation but is especially important in the present case since many environmental protection activities are carried out as secondary activities.

5.71. However, the information system of the operating unit must be capable of calculating the value of production, intermediate consumption, compensation of employees, operating surplus, employment and gross fixed capital formation for each resulting establishment and this is often not possible. For example public bodies which often carry out environmental protection activities as part (but not a major part) of their responsibilities are usually unable to separately identify this sort of information. This may be the case for waste water management and waste management and is very likely to be the case for other activities such as biodiversity and landscape protection. Under these circumstances the corresponding output is often difficult to identify. Expenditure classified according to the classification of the functions of the government (COFOG) might be used to make estimates. If information is not readily available, either through the standard national accounts or through COFOG, direct analyses of public budgets might provide the primary data needed to describe environmental activities and their output.

5.72. Estimates should be attempted on a case by case basis, concentrating on the activities which are likely to be most significant, using whatever information happens to be available. For example, if purchases of environmental clean-up services such as soil decontamination by government or property developers can be identified, the corresponding output can be estimated. If information is available for the production account of a unit carrying out a similar activity, it may be possible to make an approximate separation of the costs of the secondary activity on this basis.

5.73. Specialist production of environmental protection is taken to be that produced either as principal activity or as a secondary activity which can be separated out into a separate account as if it were a distinct establishment.

Identifying ancillary activities

5.74. All enterprises and establishments undertake some ancillary activities carried out by enterprises' own employees. These may cover only the simple overhead activities of keeping the accounts or may be more extensive and cover staff training, in-house repairs and maintenance for buildings or vehicles, or may be activities coming within the definition of environmental protection. Examples are in-house waste or waste water collection and treatment, air scrubbers in power plants and environmental management units within enterprises.

5.75. Although the SNA recommends that the costs associated with secondary activities should as far as possible be separated from those for the principal activity, ancillary activities are not separately recorded and identified. The costs associated with these activities are merged without discrimination with other internal costs. In a satellite account, such as the one for environmental protection being considered here, it is important to identify and account for ancillary activities in a manner similar to the identification of secondary activities. The objective is to set up a production account for the activity in question by identifying all the costs, including labour input and the consumption of fixed capital related to the activity. The value of the ancillary output is then set equal to the costs incurred and is treated as intermediate consumption in much the same way as an external purchase of services by the establishment. Box 5.1 gives a simple example of how this is done.

5.76. Changing the recording of ancillary activities does not change any of the macro-economic aggregates in the national accounts. The level of output increases but that of intermediate consumption rises by an equivalent amount so the balancing item, value added, is unaffected. However, the composition of both output and intermediate composition changes and all environmental protection activity is treated in the same manner whether it is internal or external.

Box 5.1 Example of "externalising" ancillary activity

Suppose a firm purchases goods and services to the value of 1000 to manufacture its output which it sells for 1800. The cost of the compensation of employees is 500, consumption of fixed capital is 100 and operating surplus is 200. The standard production and generation of income account entries then appear as follows.

Uses		Resources	
Intermediate consumption	1000	Output	1800
Value added	*800*		
Compensation of employees	500		
Consumption of fixed capital	100		
Net operating surplus	200		

Now suppose that out of the 1000 spent on intermediate consumption, 100 is for cleaning materials, 40 of the compensation of employees covers cleaners, and 5 of the consumption of fixed capital relates to cleaning equipment. By subdividing the output to show cleaning and other output separately, the accounts could be restructured as follows.

Uses	Excluding cleaning	Cleaning	Total	Resources	
Intermediate consumption				Output	
excluding cleaning	900	100		- cleaning	145
Cleaning	145			- other	1800
Total	1045	100	1145	- Total	1945
Value added	*755*	*45*	*800*		
Compensation of employees	460	40	500		
Consumption of fixed capital	95	5	100		
Net operating surplus	200	0	200		

The total cost of the cleaning services is 145 (by convention, no ancillary service generates net operating surplus.) Both the value of output and the total intermediate consumption of the establishment increase by 145 but the value added and all the entries of the generation of income account are unchanged in total. At the economy-wide level, GDP and other macro-aggregates are unaltered. However, it is now possible to treat the cleaning activity in exactly the same way as if a separate company had been formed with these costs. This process of identifying and separating the costs of ancillary services is what is called "externalising" the activity.

5.77. Although straightforward in concept, there are practical difficulties in measuring ancillary output. Standard statistical surveys for enterprises or establishments generally do not separately identify internal (or own account) expenditure on environmental protection. Special environmental expenditure surveys must be conducted in order to get this information. Expenditure on clean technologies such as capital equipment to reduce emissions or waste discharges in the course of production is difficult to identify. Consumption of fixed capital cannot be identified easily in surveys and must be calculated, usually by using the perpetual inventory method which requires long time series of capital formation.

5.78. Even when ancillary activity can be separately identified, it continues to be treated as secondary activity within the unit where it takes place and is not treated as a separate establishment. Non-specialist production of environmental goods and services thus consists of ancillary activity plus any (true) secondary activity which cannot be separated into a separate establishment.

3 Environmental products

5.79. The previous section described the activities which are considered as being characteristic of the environmental activity we wish to measure in the satellite account. In this section we consider the products which are characteristic of the same activities. Products cover both goods and services and it is the environmental services such as those directly contributing to environmental protection which are the most obvious characteristic products. However, there are a number of goods which must be considered also. Some of these are sometimes described as "connected" products. These are products which are not made by the industries characteristic of environmental protection activity but which are (virtually) always used in connection with the implementation of the activity. A classic example is the brooms that road sweepers use. It is the road sweeping which is the activity characteristic of environmental protection but the broom is an indispensable tool for the road sweeper and so the brooms are treated as environmentally "connected" products. In terms of Table 5.1, connected products fall in the column for environmental products and the row for other industries.

5.80. Also in the same location we may find "adapted" products. These are products which have been specially modified to be more environmentally friendly and whose use, therefore, is beneficial for environmental protection.

5.81. The full set of products characteristic for the environment therefore comprises those environmental services which correspond exactly with the characteristic activity and those goods and services which are environmentally connected or adapted. They fall in the first row and column of Table 5.1.

Environmental protection services

5.82. Environmental protection services are the products of environmental protection activities. These were discussed above and the products, like the activities, can be classified according to the CEPA. A distinction is made between those which are treated as market and those which are treated as non-market. Market services are those which are sold either by government or private enterprises at a price which covers all or most of the costs of production. Non-market services are those which are produced by government[2] and provided free or at insignificant prices to the public at large or to individual households. Ancillary services fall between these two categories.

Other environmental products

5.83. There are two broad categories of other environmental products. The first category corresponds to products which are used directly and solely for environmental protection (for example septic tanks, filters, waste bags); these are referred to as connected products. The second category, referred to as adapted products corresponds to products which are cleaner (and therefore more environmentally friendly) when used or disposed of. These products are sometimes also called (environmentally) cleaner products. The inclusion of these products is needed to provide a complete picture of environmental protection and to ensure international comparability. If spending on clean products is ignored then, for example, countries which are densely populated and which have comprehensive sewage collection networks will wrongly appear to have more environmental spending compared to more sparsely populated countries where septic tanks predominate.

5.84. The environmental cost of connected products is simply the cost of the product. Estimates of the cost of adapted products are made in a manner similar to the method of costing integrated technologies; that is, the extra-cost criterion is used to identify the relevant expenditure. The methodological difficulties are thus similar and involve comparison to the corresponding "dirty" product. For example, unleaded gasoline or

[2] In theory, such non-market services could also be provided by non-profit institutions serving households (NPISHs) but this is ignored in the discussion and tables which follow.

desulphurised fuels may be more expensive to produce and these extra costs of production are recorded here as environmental protection expenditure.

5.85. A great number of environmental products may exist. However, experience in EU countries suggests that only very few are quantitatively important and involve significant extra expenditure. (A significant amount of expenditure on connected and adapted products is incurred by households.) For many such products it is found that no extra costs exist. For practical purposes a short list of environmental products has been developed for use by EU countries which may form a basis for use by other countries, adjusted as necessary to the specific needs and circumstances of those countries. This list is shown in Box 5.2.

Box 5.2 EU list of connected and adapted environmental protection products

Mandatory inclusion

- septic tanks
- maintenance services and other products for septic tanks
- catalytic converters for vehicles
- desulphurised fuels (extra costs only)

Recommended for inclusion

- A more complete set of measures related to transport vehicles, based on the cost of compliance with environmental regulations. This includes measurement services of exhaust gases of vehicles, measures to adapt private cars (other than using catalytic converters) and measures to adapt trucks, buses and aeroplanes.
- Trash bags, bins, rubbish containers, compost containers. This item is dependent on the organisation of waste collection in a country; for example, whether wheeled rubbish containers are provided by the local authorities or not or whether rubbish containers are owned by local authorities or must be purchased by households. Publicly accessible containers for collecting material for recycling are typically owned by specialist waste collectors and therefore already covered via these producers' investments and capital stocks.

Possible inclusion

- services for the measurement and supervision of exhaust gases of heating systems
- exhaust pipes of vehicles
- sound-proofed windows (extra costs only)

Source: Eurostat, 2002.

4 The "Environment Industry"

5.86. The manufacturers of all these environmental products are collectively referred to (not quite exactly and initially confusingly) as an "industry" cutting across conventional industrial classifications.

5.87. ***The environmental goods and services industry*** (often referred to as the ***"environment industry"*** for short) consists of activities which produce goods and services to measure, prevent, limit, minimise or correct environmental damage to water, air and soil, as well as problems related to waste, noise and ecosystems. This includes cleaner technologies, products and services that reduce environmental risk and minimise pollution and resource use as well as activities related to resource management, resource exploitation and natural hazards. The environment industry supplies the products for environmentally related expenditures.

5.88. Because the environment industry cuts across standard industrial classifications, its identification requires specific surveys and analysis. The OECD and Eurostat (1999) have jointly published a manual entitled *The Environmental Goods and Services Industry* which discusses the definition and classification of the goods and services of interest and suggests procedures for data collection and analysis.

5.89. The main policy interest is in the impact on economic activity, trade and employment due to environmental protection measures. The principles of satellite accounting can be invoked to address such issues, including the impact on employment.

Definition and classification of the environment industry

5.90. The activities covered by the "environment industry" are grouped together according to three main groups of activities; pollution management, cleaner technologies and products, and resource management.

> A) The ***pollution management group*** comprises goods and services which are clearly supplied for an environmental purpose, which have a significant impact in reducing polluting emissions and which are easily identifiable statistically. In practice this covers environmental protection services and those clean products used specifically for environmental purposes; for example, as fixed capital formation for producers of environmental protection services.
>
> B) The ***cleaner technologies and products group*** comprises goods and services which reduce or eliminate negative environmental impacts, but which are often supplied for other than environmental purposes and for which statistical assessment remains disputed, difficult or expensive.
>
> C) The ***resource management group*** comprises goods and services which are particular for natural resource management. Although environmental protection is excluded from the coverage of resource management, inevitably some products may be included which are associated with environmental protection although their prime purpose is not environmental protection (for example, those used for energy saving and management, renewable energy, etc.). The collection of data for this group is still in the developmental stage.

5.91. Annex 8 gives the full classification of the environment industry. In it, details are given for the production of equipment and specific materials, the provision of services, and construction and installation related to each of the three main activity groups of the environment industry.

Relation between environmental purpose and environment industry categories

5.92. With respect to the environmental purposes identified in Section B, the environment industry activity groups A (pollution management) and B (cleaner technologies and products) have a direct correspondence to activities with an environmental protection purpose; the resource management activity group (C) corresponds to activities with a resource management and exploitation purpose. Note, however, that this correspondence is not exact. Activities related to nature protection come under environmental protection activities in CEPA and under the resource management group in the environment industry account. This reflects differences in the underlying data sets for the different classifications.

5.93. Environmentally beneficial activities and the minimisation of natural hazards are not as well developed as the other environmental protection activities noted in Section B. It is useful, however, to note the relevance of these activities for a comprehensive coverage of environmental activities even if the data do not permit implementation at this stage.

5.94. Within the activity groups of the environment industry, there is a further breakdown of equipment and materials, services and construction and installation. Within each of these types of product there is a distinction made by purpose using a breakdown which follows that of CEPA as closely as possible given the constraints of the data sources.

C Environmental protection expenditure accounts (EPEA)

1 Supply and use tables for environmental protection

5.95. Having determined the coverage of environmental protection activities and products, the next stage is to compile production and generation of income accounts for these activities and supply and use tables for these products. This section considers how the production of those goods and services is organised and marketed. To do this it is necessary to consider activities, products and expenditure categories separately. This section concentrates on steps taken to deal with residuals and does not consider explicitly protection of the environment through means of water and energy conservation or the effects of recycling. An overview of the categories to be described is given in Box 5.3.

Box 5.3 Environmental protection activities, products and expenditures

Categories of environmental protection activities

External activities; activities whose products are for use by other units
- Principal activities; identified based on specific ISIC/NAICS codes (specialised producers)
- Secondary activities; activities not separately identified with reference to ISIC/NAICS codes

Internal or ancillary activities; activities undertaken for own use

Categories of environmental protection products

Environmental protection services
- Market (e.g. waste collection services sold)
- Ancillary services (e.g. ancillary air or noise protection)
- Non market (e.g. government administration or surveillance)

Other environmental protection products
- Solely used for environmental protection (e.g. septic tanks, trash bins)
- Principally used for other reasons but cleaner when used (e.g. desulphurised fuels)

Categories of expenditure on environmental protection:

Current expenditure (e.g. operating expenditure, purchase of environmental protection products)
Capital expenditure (e.g. investment expenditure for end of pipe equipment)

Categories of expenditure on environmental protection

5.96. Separating on-going or current costs from one-time or capital costs is necessary for the supply and use tables. It is also of intrinsic interest to show how far the burden of environmental protection is on-going rather than one-time and to what extent there may be a trade-off between the two types of expenditure. Different classifications can be applied to both types of expenditure. Here it is assumed the greatest interest lies in the type of environmental activity involved in current expenditure and the type of technology used for capital expenditure. If the data sources were sufficiently detailed, further classifications and cross-classifications would also be possible.

Current expenditure

5.97. Current expenditure by enterprises includes internal operational spending on environmental protection activities including, for example, wages and salaries of people involved with the operation of pollution control equipment and environmental management, leasing payments for environmental equipment, and materials such as air filters and scrubbers. External expenditure such as waste disposal by specialists contractors, waste water treatment, regulatory charges to environmental agencies and so on are also treated as current expenditure whether made by enterprises, government or households.

Capital expenditure

5.98. Two types of capital expenditure can be distinguished.

Expenditure on "end-of-pipe" technologies used to treat, handle or dispose of emissions and wastes from production. This type of spending is normally easily identified even within the context of ancillary activity because it is usually directed toward an "add on" facility which removes, transforms or reduces emissions and discharges at the end of the production process.

Expenditure on "integrated investments", also called cleaner technologies. These are new or modified production facilities designed so that environmental protection is an integral part of the production process, reducing or eliminating emissions and discharges and thus the need for end-of-pipe equipment.

5.99. Integrated investments may result from the modification of existing equipment for the explicit purpose of reducing the output of pollutants, or from the purchase of new equipment whose purpose is both industrial and for pollution control. In the first case, expenditure can be estimated from the cost of the modification of existing equipment. In the second, the extra cost due to pollution control has to be estimated; that is, the cost of "non-polluting or less-polluting" equipment is compared to that of "polluting or more-polluting" reference equipment.

5.100. Such estimates are difficult to make when reference equipment no longer exists or new equipment presents other advantages in addition to its beneficial effects on the environment. These may include savings or substitution of raw materials, higher productivity and so on which cannot be isolated in terms of cost. The difficulty arises because the steady integration of environmental standards in equipment and processes means that eventually it becomes impossible to identify a part of the expenditure as environmental. Given the different speed at which new environmental standards are incorporated into different types of equipment and in different countries, comparison of long time series across industries and countries is difficult. However, a misleading picture is obtained if the cost of significant capital equipment is ignored.

The supply table

5.101. The first step in compiling a supply table is to establish which industries make which products. Such a table will show the extent of secondary production by the environment industry and also the extent to which environmental goods and services appear as secondary products of other industries.

5.102. Environmental protection services are usually supplied by domestic units. However, imports and exports of some environment industry products such as environmental protection equipment may be significant.

5.103. Output of market services is valued at basic prices; that is, it records the amount received by the producer excluding any taxes on products. Non-market output is valued at the cost of production (because non-market producers do not make any net operating surplus) and also excludes taxes on products.

5.104. In order to compile total supply, it is necessary to add imports to domestic output and also to include taxes on products and imports as well as trade margins and any transport costs which the purchaser must pay to take delivery of the products. The total of these items gives a value of total supply at purchasers' prices. For some clean products, however, this basis of valuation may be too high, since only the difference between the cost of a clean product and a "dirty" equivalent should be recorded as environmental protection expenditure. In making an estimate of the difference between the cost of a clean and corresponding "dirty" product, attention should be paid to the impact, if any, of different levels of tax or subsidy applying to the different types of product.

The use table

5.105. For each type of product shown in the supply table, it is necessary to determine what sort of use it satisfies. Use of environmental protection services may be classified as "intermediate consumption" in standard national accounts terms (for example production units which purchase waste treatment services), as "fixed capital" by enterprises or general government or as "final consumption" by households or general government.

5.106. The non-market services provided by government may be classified as either collective or individual consumption. Individual consumption relates to those services which benefit individual households to the exclusion of others and in principle an allocation of benefit to the households concerned can be made. Collective consumption benefits the whole community and the extent to which one household avails itself of the service does not affect the amount available to others. Typical individual consumption services are collection of household refuse and waste water collection and treatment. Road-sweeping is typical collective expenditure. However, it may often be that for some individual expenditures the sums involved are very small or there is no satisfactory basis for allocation to individual households. In these cases such services remain under the general "protection of the environment" heading and are treated with other non-market environmental protection services as collective consumption.

5.107. Typically, the method used to estimate the expenditure associated with the use of clean products is based on physical information about market sizes (amount of desulphurised fuels used, number of newly registered cars equipped with a catalytic converter, number of newly constructed houses equipped with septic tanks, etc.). These estimates are then valued by either the market price or by the extra cost due to environmental protection features in the case of environmentally friendly products. Extra costs will normally be difficult to survey so that expert assessment and technical knowledge may be used to estimate extra costs (for example the extra costs of producing desulphurised fuels or of environmental adaptations of vehicles).

5.108. Expenditure for pollution management may be separated into equipment and specific materials on the one hand and construction and installation on the other. Equipment and materials are classified either as intermediate consumption or gross fixed capital formation of specialist and ancillary producers just as clean products are. Expenditure on construction and installation is treated as investment for environmental protection.

5.109. As indicated earlier, ancillary output should be separately identified and treated as both output in the supply table and as intermediate consumption in the use table. It is recorded in the supply and use tables by adding supplementary columns and rows corresponding to the ancillary activities and output. Alternative presentations are also possible. One option is to add columns showing the current outlays corresponding to the ancillary activities for each industry, which would facilitate comparisons with standard supply and use tables; another option is to create a specific column aggregating together the current outlays for the ancillary activities of all industries.

Supplementary data

Value added

5.110. The value added of environmental protection activities represents the contribution made by these activities towards the income measure of GDP. It is the difference between the value of the output and the sum of all intermediate costs. The value added for all industries can be equated with the total final demand but this is not true on an industry-by-industry basis.

Generation of income account entries

5.111. One reason to consider value added is to show how much covers compensation of employees (remuneration of labour), taxes on production (other than taxes on products), any subsidies on production and gross operating surplus. It is also useful to show numbers of employees (in terms of person-hours if at all possible, or full-time equivalents) as well as compensation of employees to demonstrate the role of environmental protection activities in the labour market.

Environmental protection capital stock accounts

5.112. Gross operating surplus should be separated into the element which shows how much capital formation has been used up in the period (consumption of fixed capital) and the net operating surplus. The calculation of consumption of fixed capital also involves estimates of the capital stock available to environmental protection activities and this is another sort of supplementary data which it is helpful to present with the combined supply and use table.

5.113. In order to calculate the consumption of fixed capital (sometimes referred to as depreciation) and to link expenditure data to physical flow accounts, capital stock accounts should be set up based on long time series of investment. These will often be made using the perpetual inventory method. Experience suggests that, if long time series are not available, an initial estimate of the capital stock in place (and its age structure) can be based on a variety of primary data such as the following:

physical environmental data related to capital stock; for example, population served by sewerage networks, number, capacity and category of treatment of waste water treatment plants, number and capacity of waste incineration plants, power plants equipped with flue gas scrubbers, etc.;

physical environmental data related to pollutant releases; for example, using the amount of waste for treatment as the basis to estimate the cost of treatment and the capital stock needed for treatment and collection, or using time series of air emissions together with data on energy use and output to asses the environmental protection measures undertaken;

legal and administrative information; for example, information arising from the coming into force of major environmental laws which may give an indication of past patterns of investment, or permit and supervision data;

environmental investment supported by government via investment grants or preferential loans, especially if long time series are available;

engineering estimates and expert assessment; and

data on operating expenditure as a basis of estimates of the capital stock in place.

5.114. The initial capital stock must be determined or estimated by categories of capital goods (vehicles, structures, and machinery) and by age class. The normal national accounts assumption of the lifetime for these categories may then be applied (unless more specific information is available) to calculate the consumption of fixed capital.

5.115. Capital stock accounts also allow the operating expenditure related to the gross stock of capital in place to be estimated. For this, case studies and expert assessment may be used to estimate average ratios of operating expenditure to the stock of environmental capital, ideally by age of the equipment. For such estimates to be reliable, detailed breakdowns of the capital stock by environmental domain and by type of capital goods as well as detailed categories of operating expenditure (wages and salaries, energy, maintenance, etc.) are recommended. Detailed breakdowns also permit detailed price indices to be applied to each category.

The combined supply and use table

5.116. An illustrative example of a simplified supply and use framework for environmental protection services is given in Table 5.6. This follows the same scheme as used in Chapter 4 and shows the supply and use matrices together with the supplementary data. It allows all the data derived from the primary data sources to be fitted into the framework. Gaps may well remain between supply and use which can be filled by estimation. For example, the split of the use of marketed services between households and businesses can be estimated based on physical data and average prices.

Table 5.6 Combined supply and use table for environmental protection goods and services

Million currency units

	Government services	Specialist services	Ancillary services	Cleaner/connected products	Non-environmental protection goods and services	**Total**	Government producers of environment services	Specialist producers of environment services	Ancillary production of environment services	Producers of cleaner/connected products	Other producers	**Total intermediate consumption**	Government consumption	Household consumption	Capital formation	Exports	**Total**
Government services												**0**	1 800	1 320			**3 120**
Specialist services								1 500			3 400	**4 900**		1 650	100		**6 650**
Ancillary services											4 000	**4 000**					**4 000**
Cleaner/connected products								400			200	**600**		600			**1 200**
Non-environmental protection goods and services							2 000	1 100	1 000	300	*	*					*
Total							**2 000**	**3 000**	**1 000**	**300**	*	*	**1 800**	**3 570**			*
Government producers	3 000				0	**3 000**											
Specialist producers		6 500		0	0	**6 500**											
Ancillary production			4 000			**4 000**											
Producers of cleaner/connected products				1 000	0	**1 000**											
Other producers	0	0	0	0	*	*											
Total output																	
Compensation of employees							600	2 000	2 000	500	*	*					
Consumption of fixed capital							400	1 000	1 000	200	*	*					
Taxes on production less subsidies on production							0	0	0		*	*					
Net operating surplus							0	500	0		*	*					
Output at basic prices	**3 000**	**6 500**	**4 000**	**1 000**	*	*	**3 000**	**6 500**	**4 000**	**1 000**	*	*					
Imports				50	*	*											
Taxes and margins	120	150		150	*	*											
Output at purchasers' prices	**3 120**	**6 650**	**4 000**	**1 200**	*	*											
Gross fixed capital formation							1 100	1 000	2 500	1 500	*	*					
Capital stock							7 000	15 000	12 000	10 000	*	*					
Labour input							4 000	10 000	8 500	5 000	*	*					

Source: SEEAland data set.

5.117. While Table 5.6 gives a good overall view of the interaction between the elements of supply and use, it can be cumbersome to use when a reasonable degree of detail is introduced. For that reason, EPEA are usually presented in a more compact manner as exemplified in Table 5.7.

5.118. All producers of environmental protection goods and services are shown under one of three headings: government providers of environmental services, specialist providers and other non-specialist providers. Activities which are not related to environmental protection goods and services are not included. However, similar tables can be produced for cleaner and connected products as shown in the last column of Table 5.7.

5.119. The difference in layout between the two tables is comparable to that between tables 3.12 and 3.13. In Table 5.7, the supply table which can be read from the middle set of columns of Table 5.6 is presented in the same way. The use table which appears across the first set of rows in Table 5.6 is transposed and appears below the supply table in Table 5.7. In addition, supplementary information can be included below the use part of the table.

5.120. The layout of Table 5.7 can be used to provide a disaggregation of environmental protection activity, for example by CEPA categories or for specific cleaner and connected products.

Table 5.7 Augmented supply and use table for environmental protection services

Million currency units

	Government producers	Specialist producers	Non-specialist producers	Total	Cleaner and connected products
Supply table					
Intermediate consumption	2 000	3 000	1 000	6 000	
Compensation of employees	600	2 000	2 000	4 600	
Consumption of fixed capital	400	1 000	1 000	2 400	
Taxes less subsidies on production				0	
Net operating surplus		500		500	
Output at basic prices	3 000	6 500	4 000	13 500	1 000
Imports				0	50
Total supply at basic prices	3 000	6 500	4 000	13 500	1 050
Taxes on products	120	150		270	100
Trade and transport margins				0	50
Total supply at purchasers' prices	3 120	6 650	4 000	13 770	1 200
Use table					
Intermediate consumption					
Government producers					
Specialists producers		1 500		1 500	400
Non-specialist producers - ancillary			4 000	4 000	
Non-specialist producers - other		3 400		3 400	200
Government consumption	1 800			1 800	
Household consumption	1 320	1 650		2 970	600
Capital formation		100		100	
Total use	3 120	6 650	4 000	13 770	1 200
Supplementary information					
Gross fixed capital formation	1 100	1 000	2 500	4 600	1 500
Stock of fixed capital	7 000	15 000	12 000	34 000	10 000
Labour input ('000 hours worked)	4 000	10 000	8 500	22 500	5 000

Source: SEEAland data set.

2 National expenditure on environmental protection

Objective

5.121. The supply and use table shows the extent of environmental protection activity undertaken in the country and which units consume it. This is not necessarily the same as the total amount of national resources devoted to environmental protection. Later in the SNA sequence of accounts, beyond the supply and use tables, transfers are recorded and some of these may affect the level of spending on environmental protection. For example, if government subsidises some environmental protection, then the extent of this subsidy will not be caught in a supply and use tables measured, as assumed above, in market (purchasers') prices. Further, in some cases there may be funding received from abroad which reduces the need to finance the whole of environmental protection expenditure from national resources. This is so within the EU where central funds may be made available for environmental protection expenditure and also within developing countries where international aid may be specifically targeted at environmental protection. It may also happen when it is more beneficial for a country to provide funding to a neighbouring country to prevent pollution than to face the cost of domestic remediation.

5.122. The various elements that enter this national expenditure aggregate can be compared with the corresponding aggregate from national accounts. Final consumption on environmental protection may be compared with total final consumption; gross capital formation for environmental protection may be compared with the gross capital formation of the total economy.

5.123. However, national expenditure on environmental protection is not strictly comparable with GDP as intermediate consumption is included in the first but not the second of these aggregates. Such a comparison can be made based only on a number of usually quite realistic hypotheses. One is that the amount of environmental protection embodied in imports and in exports is approximately equal so that the pattern of imports and exports does not distort the comparison. Another is that all intermediate environmental protection expenditures are passed on to the customers by the enterprises making the expenditure. That is to say, if industries increase their intermediate consumption of environmental protection products, then they pass the whole of this cost on to their customers in the form of increased prices.

5.124. Some countries may record environmental protection flows in a way which introduces deviations from a strict comparability to central aggregates. Experience so far suggests that these deviations are negligible so that national expenditure can in fact be fairly compared with GDP. It should be noted however, that a calculation in constant prices poses much greater difficulties.

Measuring national expenditure on environmental protection

5.125. Table 5.8 shows how an aggregate for national expenditure on environmental protection can be derived.

5.126. For most economies, the largest part of environmental protection expenditure will be accounted for by the use of environmental protection services and cleaner and connected products. These correspond to the information in the supply and use table (Table 5.7) and are shown as items 1 and 2 in Table 5.8. These items are subdivided to show intermediate consumption (both ancillary and non-ancillary), final consumption and capital formation separately. Although exports of environmental protection products are possible they are not recorded here since they are not funded from within the national economy.

5.127. In order to avoid double counting, the intermediate consumption of environmental protection services by the producers of environmental protection services is not recorded in the tables. (The entries are thus shown as NR.) It is assumed the costs of specialist producers are covered by the purchases made by the consumers of the products. The ancillary costs are covered in the inclusion of this item in intermediate consumption.

Table 5.8 National expenditure on environmental protection

Million currency units

	Specialist producers	Other producers	Consumers: House-holds	Consumers: General govern-ment	Rest of the world	Total
1. Use of environmental protection services						
a. Intermediate consumption (non-ancillary production)	NR	3 400				3 400
b. Intermediate consumption (ancillary production)		4 000				4 000
c. Final consumption			2 970	1 800		4 770
d. Capital formation	NR	100				100
2. Use of cleaner and connected products						
a. Intermediate consumption	NR	200				200
b. Final consumption			600			600
c. Capital formation	NR					
3. Capital formation for environmental protection	2 100	2 500				4 600
4. Specific transfers not included in items 1 to 3						
a. Current	NR				300	300
b. Capital						
5. Total uses	2 100	10 200	3 570	1 800	300	17 970
6. Of which financed by the rest of the world				100		100
7. National expenditure for environmental protection	2 100	10 200	3 570	1 700	300	17 870

Source: SEEAland data set.

5.128. Items 1d and 2c show the expenditure on environmental protection services and cleaner and connected products which are undertaken as capital formation by non-specialist producers. Capital formation in environmental protection services (item 1d) is environmental clean-up services which lead to improvement of land. Households and government undertake capital formation only in their capacity as producers so it is assumed this one entry captures all capital formation by non-environmental producers. Capital expenditure on these items by specialist producers is not recorded separately because these items are already included in item 3 – capital formation for environmental protection.

5.129. In addition to capital expenditure on environmental protection services and cleaner and connected products, the table shows (item 3) capital expenditures by specialist and other producers on other items required for the production processes of environmental protection activities. These may not be, and generally will not be, environmental protection products themselves. For example it may include buildings and transport equipment. Nevertheless it is expenditure necessary to maintain the national effort on environmental protection activity.

5.130. Item 4 is described as specific transfers not captured in items 1 to 3. The objective of this term is to capture any unrequited payments made by government or other units which represent expenditure on environmental protection but which are not captured in items 1 to 3. They may cover consumer subsidies which are not captured in government final consumption, subsidies on production or investment grants; the first two of these are classified as current specific transfers and the third as a capital specific transfer. The characteristic that defines specific transfers to be included under item 4 is that they either alter the price at which environmental protection products are acquired or have no counterpart in the items 1 to 3 at all (e.g.

transfers to other countries as part of international co-operation). Not all transfers relating to environmental protection will be registered here. Only those transfers which affect the total level of expenditure are considered at this point. For example a transfer from central to local government affects which of the two units bears the cost of the expenditure (a point which is investigated below) but not the level of the expenditure. Investment grants are not to be included in item 4 when the corresponding capital formation is already included in item 3.

5.131. One effect of this may be purely practical rather than theoretical. Suppose government gives a transfer to a non-governmental organisation for environmental protection. In principle the expenditure of this non-governmental organisation should be included and the transfer would not then need to be included in national expenditure. In practice, though, measuring all such units is difficult and if there is no record of the unit receiving the transfer in the basic data, the transfer without a recorded counterpart may be included to make good this omission.

5.132. The sum of items 1 to 4 shows the total uses, item 5. To this adjustments must be made for inflows from and outflows to the rest of the world which affect the overall national effort on environmental protection expenditure, shown as item 6. These flows also can be subdivided into current and capital elements.

5.133. National expenditure on environmental protection (item 7 of Table 5.8) can thus be defined as the sum of:

final and intermediate consumption of environmental protection products by resident units, other than those of the environmental protection producers themselves

plus capital formation on environmental protection products

plus gross capital formation on other products required for environmental protection activities

plus (current and capital) specific transfers by residents units not captured in the items above

plus (current and capital) financing provided by transfers to the rest of the world.

less financing by transfers received from the rest of the world.

5.134. It is also useful to show the total expenditure within the economy divided into current and capital expenditure. Capital expenditure comprises items 1d, 2c, 3 and 4b; that is, capital formation on environmental protection products, plus capital formation by specialist and other producers for environmental protection activities plus specific transfers which are classed as capital. The remaining components of item 5 are treated as current expenditure. Based on the SEEAland data given in Table 5.8, current expenditure is 13 270 million currency units and capital expenditure is 4 700 million currency units. Financing provided to and received from the rest of the world can also be divided into current and capital elements to reach a division of national expenditure into current and capital elements.

3 Financing environmental protection

5.135. Table 5.9 shows the expenditure as undertaken by different units. Again this may not show who directly bears the cost because of the role of transfers in the system. In the compilation of Table 5.8, specific transfers where both counterpart entries were recorded in the basic data were ignored in order to avoid double counting. This information, though, provides a valuable insight into which unit is driving the decision to make the expenditure. For example, if an investment grant is not available, an enterprise may be much less likely to undertake the capital formation in environmental protection the grant would cover. The enterprise has to be concerned neither about earning sufficient operating surplus to pay for the investment nor about borrowing to finance it.

5.136. It is therefore useful to amend the entries in Table 5.8 to show which units are directly responsible for the expenditures and which directly bear the costs of financing them. For both current and capital specific transfers related to environmental protection, the unit making the transfer has an increase in expenditure and the unit receiving the transfers has a reduction.

5.137. Many of the specific transfers will be of the nature of subsidies and investment grants where government is the payer of the transfers and it is industries or households which benefit. An example of a transfer benefiting households may be a grant to improve house insulation. If the grant is large and results in appreciation of the property value, then the transfer will be recorded as a capital transfer. If the grant is more modest and closer to funding an immediate remedial problem, then it is more likely to be recorded as a current transfer.

5.138. Some specific transfers may flow in the other direction, from households and industries to government. Examples are ear-marked environmental taxes such as landfill charges. In such a case the payments are more akin to a fee for a service than a tax and the effects can be shown in the satellite account as funding of government expenditure on environmental protection by those paying the earmarked taxes. (Note this is counter to SNA recording where all taxes, whether earmarked or not, simply go into government revenue from which all government expenditure is financed).

5.139. Not all specific transfers will necessarily involve government as either payer or recipient. Both households and industries may make transfers to non-governmental organisations or charities concerned with environmental protection, for example, and it is possible to envisage transfers from industries to their employees to encourage certain forms of environmental protection, possibly on a one-time basis.

5.140. Making adjustments for these forms of transfers does not completely determine who ultimately bears the cost of environmental protection. Costs which initially fall to enterprises are eventually passed on to their customers. This applies to both intermediate consumption and the costs of new capital formation. All government expenditure is funded (at least in large part) by taxes and thus is ultimately borne by those paying the taxes.

5.141. It is possible to estimate an intermediate level of financing with discretion over how far the indirect financing effects are traced. The treatment of earmarked taxes described above is one example. This could be extended to other "green" taxes designed to encourage more environmentally friendly behaviour.

5.142. Table 5.9 gives an example of how Table 5.8 may be amended to show the initial direct financing of environmental protection expenditure. National expenditure is derived as the sum of expenditure by government, corporations and households.

5.143. The entries in the column for the rest of the world correspond to the transfers paid for international co-operation in the field of environmental protection. These transfers can be financed either by the government or by households through non-governmental organisations.

5.144. In Table 5.9 financing by local units is increased by financing from abroad to reach total uses of resident units where earlier the financing was deducted from total uses to derive local financing needs.

Table 5.9 Financing of national expenditure for environmental protection

Million currency units

Financing units	Users/beneficiaries: Producers: Specialist producers	Producers: Non-specialist producers	Consumers: Households	Consumers: Government	Rest of the World	Total	of which: current expenditure
Government	1 300	1 100	0	1 700	300	4 400	2 000
Corporations						0	
specialist producers	800	0	0	0	0	800	0
other producers	0	9 100	0	0	0	9 100	7 600
Households	0	0	3 570	0	0	3 570	3 570
National Expenditure	2 100	10 200	3 570	1 700	300	17 870	13 170
Rest of the world	0	0	0	100	0	100	100
Uses of resident units	2 100	10 200	3 570	1 800	300	17 970	13 270

Source: SEEAland data set.

4 *Net cost of environmental protection*

5.145. Table 5.9 shows how total environmental protection by sector is directly funded. The fact that environmental activities are undertaken can be a source of revenue and Table 5.10 is a first attempt to take the financing requirement of Table 5.9 one stage further and to examine the net cost of self-financed expenditure when all the implicit revenue coming from undertaking the activity is taken into account. For industries, the objective of this complementary analysis is to obtain the supplementary costs linked to the environment. These production costs are not, on the whole, finally borne by producers; rather, they are part of the price they pass on to the purchasers of their products. For households, the objective is to know how much they pay that is actually related to environmental protection. This form of analysis needs further elaboration and is presented here in this form as an indication of a possible supplementary analysis. At present it is applied only to the current element of environmental protection expenditure.

5.146. For each sector, the starting point is the current element only of the total shown in Table 5.9 as the amount financed by each group of units.

5.147. For government, receipts of taxes on production from all environmental protection goods and services producers are deducted as well as any non-deductible VAT payable by these producers.

5.148. Some activities undertaken for environmental protection may lead to side-benefits (savings on energy or raw material consumption, etc.). Any such revenues or actual cost savings, when identifiable, should be deducted from the environmental protection gross costs. Together these items are shown as "any other profits".

5.149. Lastly, for all producers using environmental products an estimate is made of the full cost of operating fixed capital by including the imputed or actual interest on fixed capital. For specialist market producers, this cost is offset by their net operating surplus which represents the actual return to their capital. Because this is already taken into account in the previous calculations, it is deducted here to prevent double counting.

5.150. Table 5.10 illustrates the net cost account resulting from the above operations. This table could be extended to include all environmental taxes and not just those earmarked for environmental protection. The result would then be the total "financial burden" or cost, by sector and for society as a whole, of environmental protection.

Table 5.10 Environment-related net cost burden

Million currency units

Elements of environment-related financial burden	Corporations		Consumers		Total
	Specialist producers	Other producers	Households	Government	
Financing of current national expenditure	0	7 600	3 570	2 000	13 170
Non-deductible VAT on current expenditure	0	0	0	- 270	- 270
Taxes on production	0	0	0	0	0
Any other profits	0	- 75	0	0	- 75
Interest on fixed capital less net operating surplus	1 000	1 200	0	700	2 900
Net cost of environmental protection	1 000	8 725	3 570	2 430	15 725
Environmental taxes	0	3 200	3 800	-7 000	0
Total environment-related burden	1 000	11 925	7 370	-4 570	15 725

Source: SEEAland data set.

5 Description of main data sources

Classifications and links to other systems

SERIEE and the OECD EPER system

5.151. So far, only two systems exist at an international level for the recording of environmental protection expenditure: OECD's Environmental Protection Expenditure and Revenues (EPER) system of collection and Eurostat's SERIEE system. The OECD collection system is used by both OECD and Eurostat to collect data on environmental protection expenditure which is in line with SERIEE but, at present, does not exploit all the features of SERIEE. SERIEE is well documented, more extensive and subject to regular review and enhancement. Those interested in entering into greater detail in the area of environmental protection activities, should consult the SERIEE documentation.

Classifications

5.152. Annex 5 contains details of the classification of environmental protection activities and expenditure (CEPA).

5.153. Functional classifications are used to group transactions according to the purpose for which the transaction is undertaken rather than by its type or by the unit undertaking the transaction. Analysis by functional classification can be a good starting place for satellite account work but some problems may arise. For example there may be transactions that serve several purposes and so cannot be sub-divided by purpose. In such cases the transaction may have to be classified according to the principal purpose. Hence, the data according to the SNA functional classifications alone may not provide a complete picture and additional analyses of some items may be necessary.

5.154. A clear distinction must be made between purpose and effect. For example, in the case of environmental protection, actions undertaken for other than environmental purposes can have positive environmental effects (for example new technologies may lead to reductions in energy use, material consumption and discharges to the environment), whereas it is conceivable that actions undertaken with an environmental protection purpose may not actually have a beneficial environmental effect.

5.155. Classifications by purpose and functional classifications are presented in Chapter XVIII of the 1993 SNA (COICOP, COPNI, COFOG and COPP). A revised version of these was published by the United Nations (2000) as *Classifications of Expenditure According to Purpose*. Annex 6 lists those categories of SNA functional classifications which are most relevant for the purposes of this chapter. As can be seen, the CEPA has been used as the basis of relevant parts of some of the functional classifications also.

Finding data sources

5.156. Identification of data sources begins with a description of environmental protection activities and their organisation and institutional arrangement. Based on this, the organisations and statistical units (or classes of units) involved in environmental protection are identified. Box 5.4 gives an overview of the possible sources of primary data.

5.157. For ***government***, this kind of information is often available in published form and can be refined based on government organisation charts and budgets. The names of departments or budget lines or articles give a first idea of the administrative bodies involved in environmental protection. It may happen that some institutions are involved in environmental protection activities even though environmental protection is not their primary function (for example the Ministry of Agriculture may subsidise environmentally friendly agricultural practices, or the Ministry of Transport may finance the construction of anti-noise walls).

5.158. In a second step, reports of activity, budgetary documents or financial statistics for these departments or institutions are collected. Some information may be readily available (for example, environmental research and development expenditure). The government accounts section of the national accounts department may have useful source data as well. It may be necessary, for example, for local governments to organise specific surveys about their expenditure for environmental protection for their domains of competence.

5.159. For ***enterprises*** specialised in producing environmental protection services such as waste or waste water management services, the main data sources are industrial production surveys. Compilers have to approach the departments in charge of these surveys in order to know which regular data are available, their timeliness and periodicity. Most producers of environmental protection services are classified in division 90 of ISIC. It is important to check with the people in charge of industrial surveys to determine whether producers classified in other divisions (such as division 41, water supply) contribute substantially to the provision of environmental services.

5.160. The third main data source is specific environmental expenditure surveys of industries. These provide the primary data for in-house (own account) environmental protection activities by producers. Specific surveys often cover the current and capital expenditure for environmental protection of the mining, manufacturing and electricity supply industries. As far as possible these surveys should be complemented with information and estimates for other industries (such as agriculture, construction, transport).

Box 5.4 An overview of possible sources of primary data

Government activities
- Government finance statistics and national accounts (COFOG, etc.)
- Detailed analysis of budgets (in particular central and regional governments, large cities)
- Specific surveys to, for example, municipalities or associations of municipalities
- Annual reports of, for example, government agencies or funds

Specialist corporations (for environmental protection services essentially ISIC 90)
- Service statistics
- National accounts
- Input-output tables
- Turnover or tax statistics

Ancillary activities
- Specific surveys
- Data from business associations
- Engineering estimates

Households
- Data on final consumption expenditure (for example, from household surveys)

Non-profit institutions serving households
- Annual reports of environmental organisations, etc.
- Government transfers to NPISHs

Clean products
- Market data and expert assessment

Specific sources
- Research and development statistics
- Data on sewage networks or waste disposal facilities (to estimate capital stocks)
- Environment industry market estimates

Arranging data into EPEA accounts

5.161. In general, the raw statistical data have to be treated and re-arranged into the EPEA accounts except when data from national accounts departments are available at a sufficiently detailed level.

5.162. In the case of specific industrial surveys, treatment may consist in grossing-up or expanding results to cover the whole field the compiler is interested in. As an example, for waste or waste water management it may occur that some (groups of) producers are not covered by the surveys. In this case a specific assessment of these producers is necessary, for example based on the share of the population served or other information.

5.163. An essential step in data treatment is to estimate the value of environmental services produced (the output) in a way consistent with the treatment in the national accounts. Industry production statistics and national accounts data will provide the value of the output directly. For government and in-house activities by producers, the main sources of data may provide only estimates of current and capital outlays. These data are converted into the components of a national accounts production account, specifically outlays for materials, energy or rentals into intermediate consumption, wages and salaries into compensation of employees. In order to calculate the total value of output, the consumption of fixed capital has to be estimated as well, generally by using the national accounts procedures and assumptions.

5.164. In order to assure consistency of the estimates, data have to be organised according to national accounts practices; systematic comparison of supply and uses, elimination of double counting when subcontracting is important. Subsidies paid by government for environmental protection also have to be identified, as they may modify the value of the recorded output.

5.165. As for the compilation of any account, EPEA compilers will have to make their own estimates based on all available information. This includes for example the use of physical data or of expert knowledge.

5.166. The transition process from raw data to accounts should be clearly documented, including the sources, methods and assumptions used for grossing up of raw data, data conversion or correction coefficients and the procedures for estimating missing data.

5.167. For environmental protection expenditure, typical data sources and their relation to the supply and use framework are given in Table 5.11.

Table 5.11 Typical data sources and their relation to the supply and use framework

Data source	Characterisation of the statistical unit	Supply	Use
Specific surveys of environmental protection expenditure by businesses	Non-specialist producer with ancillary environmental protection activity	Ancillary output can be calculated based on own account current and capital expenditure (transformed into cost of production)	Equals supply for the ancillary activities If surveys separately identify operating expenditure and the purchases of (external) environmental protection services within current expenditure, then use of marketed services can be identified as well
Government finance statistics, COFOG analyses, budget data, annual reports of environmental agencies or funds, etc.	Often specialist producer	Market or non-market output can be calculated based on expenditure and revenues	Non-market part: collective consumption Market part: unknown; often households and small businesses
Data on ISIC/NACE 90 and other data sources on private and public producers specialising in environmental protection	Specialist producers	Market output	Unknown; often businesses, sometimes households supply and use tables may be useful to determine users
Household surveys, actual final consumption expenditure of households	Households	No	Can help to identify the purchases of marketed environmental protection services by households

Main data sources and methods for assessing the environment industry

5.168. The main data sources are very similar to those for environmental expenditure and include standard statistics (for example some ISIC categories) and specific surveys. The main approaches to measuring the environment industry are:

supply side approach (specific surveys of environment industry producers, etc.);

use side approach (environmental protection and resource management expenditure);

integrated supply and use approach (not an independent method in itself but a combination of the supply and use side data within an accounting framework).

5.169. On the production side of the account, a distinction should be made between market output and non-market output. The outputs of non-market producers in government and ancillary producers are to be calculated based on costs of production. Estimation will be better if supply and use tables are disaggregated by environmental domain.

5.170. On the use side of the account, information on the uses of market output is generally incomplete so that estimates must be made based on informed judgement. Monetary (as well as physical) supply and use tables may be of some help in this estimation process, as well as physical data and price information (for example the proportion of household waste collected relative to industrial waste).

National accounts

5.171. Where the national accounts are sufficiently detailed, most data necessary for the compilation of expenditure accounts is directly available. The national accounts usually include tables at a very detailed level and comprehensive databases on the various sectors of the economy. It is important for the compilation of the EPEA to have access to these databases and tables.

Production statistics

5.172. Specialised environmental protection producers are subject to regular surveys in the general statistical process (production statistics). These producers are mainly found in class 90.00 of the ISIC. Through these surveys several variables are collected: sales (by product according to the CPC or specific national classification of products), intermediate consumption, compensation of employees, taxes paid on production, subsidies received for production, investments, employment, etc.

5.173. Surveys of producers of other classes of the ISIC should also be considered. Although the principal activity of these producers is not environmental protection, they may produce environmental protection services as secondary output (recycling, construction, water distribution, etc.). Specific Environment Industry surveys can provide useful data on secondary output of environmental protection services as well as data on producers of equipment and facilities specific to environmental protection (producers of pipes for sewage systems, incineration plants, etc.) which constitute a source of data for the assessment of gross fixed capital formation for environmental protection.

Analysis of accounts of government and finance statistics

5.174. Several data sources exist for the activities of government units. The most widely used is based on the detailed analysis of budgets (in particular for central and regional governments and large cities) or government finance statistics. This analysis is part of the process of compilation of national accounts for the institutional sector for general government; however, the results are generally rather aggregated and a specific analysis has to be made for assessing environmental protection outlays of government. Starting from the list of the government units involved in environmental protection, the objective of this analysis is to derive the outlays for the production of environmental protection services as well as other outlays and receipts (transfers given and received, receipts from fees and charges, etc.).

5.175. If government finance statistics do not provide enough detail, in some countries municipalities or associations of municipalities are surveyed in order to collect data on waste and waste water collection and treatment activities. These data may cover various variables, from the physical quantities to the prices and the inputs used, including installations and facilities, investment, etc.

5.176. Annual reports of government agencies or funds for environmental protection also provide data on the activities and outlays of these agencies, as well as their receipts (either from central or local government budgets or from specific environment-related taxes, charges or fees) and the flows of funds to other units (subsidies, capital grants and other transfers).

Industry expenditure surveys

5.177. Specific surveys are the main source for the assessment of the corresponding expenditure for ancillary activities. These surveys provide data on investments made for environmental protection (end of pipe equipment or installations, extra cost of integrated technologies) and often also on current environmental protection expenditure by industries (intermediate consumption, compensation of employees, etc.). Data from business associations and engineering estimates also constitute a source for the assessment of expenditure by businesses.

Other sources

5.178. Household surveys may constitute a source for assessing the consumption expenditure of households for waste and waste water collection and treatment services. Expenditure on cleaner goods and services (anti-noise windows, refuse bins, septic tank emptying services, car exhaust regulation, etc.) will rarely be surveyed and may be estimated based on production statistics, market analysis or studies. Analysis of the annual reports of the main environmental non-profit institutions provides information on their activities, expenditure and receipts. Data on financing by government may also be available.

5.179. Various other sources may complement the previous data: construction statistics (investments in sewerage systems, waste water treatment or incineration plants, anti-noise walls, etc.); business associations (supply or market of connected and adapted products, level of environmental protection in the main industries); environmental reports of big firms (in the noise domain, transportation firms, airport management entities; in the air domain, refineries, power plants, etc.); non-profit institutions; either public or private research and development statistics, when they are sufficiently disaggregated; physical data on sewage networks; waste disposal facilities to estimate capital stocks; environment industry market estimates; price or employment statistics.

5.180. Some of the data needed will have to be based largely on estimates and calculations. For example, expert knowledge and specialised literature may offer coefficients for the costs of adapting vehicles to meet environmental requirements. The total expenditure can then be calculated based on the total number of new vehicles.

5.181. In order to ensure an efficient search for primary data, a first step is an analysis of the country's organisation of environmental protection. Table 5.12 illustrates how environmental protection might be organised. A large X in a cell indicates that this is typically an important component of activities and expenditure in the domain concerned; a small x indicates a small component.

Table 5.12 Illustration of environmental protection competencies/production activities

Domain Sub-sector/Entity	General administration	Waste	Waste water	Nature protection	Air	Etc.
Central government	X	-	-	x	x	
Regional governments	x	x	x	X	-	
Specific government agencies	X	-	x	X	-	
Associations of municipalities	-	X	X	-	-	
Municipalities	-	X	X	-	-	
Publicly owned disposal enterprises	-	X	X	-	-	
Private disposal enterprises	-	X	x	-	-	
Non-profit institutions	x	-	-	X	-	
Ancillary activities of mainstream industries	-	X	x	x	X	
Households	-	x	x	-	x	

Reconciling supply and use information

5.182. The supply of environmental protection products by the environment industry, the environmental protection expenditure accounts and the account leading to national expenditure on environmental protection are closely related but not exactly the same, so it is worth explaining exactly how they relate to one another. The EPEA constitute derived data rather than a primary source, but the fact that there are accounting identities linking the entries helps to improve data consistency and plausibility. Indeed, since it is not always easy to obtain the information needed for the supply of products by the environment industry, the interaction with the EPEA is often used to improve both sets of estimates.

5.183. Table 5.13 attempts to show this relationship diagrammatically. The box on the left shows the supply coming from the environment industry in the column headed “production”. The column headed “imports” shows the other source of supply of environmental protection products. The entry for non-environmental protection products below the left hand box is a reminder that much of the economy lies outside the scope of the environment industry.

5.184. The box on the right shows the entries in the EPEA. Those which are shaded are the ones which appear in the calculation of the national expenditure on environmental protection services in Table 5.8.

5.185. Blank cells indicate that the cell is zero by definition. A cell containing “(0)” indicates that it is theoretically possible that there might be an entry there but in practice it is usually safe to assume the figure is either zero or insignificantly small.

5.186. The arrows between the two boxes give an indication of which data set is likely (but not certain) to provide the more reliable estimates. For the two rows where the arrows appear in parentheses, all data sources are very tenuous and this is more a hypothetical link than one which can be implemented in current practice.

5.187. For the EPEA, the environment industry is a source of data on the supply of environmental protection services, products used for environmental protection capital formation and connected and adapted products.

Table 5.13 Links between the supply by environmental industry and imports and the environmental protection expenditure account

	Supply			Intermediate consumption			Capital formation		Final consumption		
	Production	Imports		Specialist environmental protection	Ancillary activities	Non-environmental protection activities	Specialist producers	Other producers	Households	Government	Exports
Environmental protection services											
- Non-market	X		→				X		X	X	
- Market	X	X	↔	X	X	X	X	X			(0)
- Ancillary	X		→	(0)	(0)	X					
Environment-specific materials	X	X	(←)	X	X	X	(0)	(0)	(0)	(0)	(0)
Environment-specific equipment	X	X	←	(0)	(0)	(0)	X	X	(0)	(0)	(0)
Cleaner technologies	X	X	←	X	X	X	X	X	(0)	(0)	X
Cleaner products	X	X	(←)	X	X	X	(0)	(0)	X	X	X
Other products	*	*		*	*	*	X	*	*	*	*

5.188. The main differences between the two sets of data are as follows.

(i) The EPEA only include the *expenditures* of resident units, whatever the origin of the products (domestic production or imports) whereas the environment industry covers the *production* by residents units, whether used domestically or exported.

(ii) Not all entries for a full production account for the environment industry are shown. These would include all ancillary production and all capital formation for that industry. For the EPEA, only ancillary activity, intermediate consumption, final consumption and capital formation in environmental protection products are included except for capital formation in non-specialist equipment used for environmental protection.

5.189. The data in the shaded cells which go from the EPEA to the national expenditure on environmental protection form a subset of the full supply and demand entries. As explained above, intermediate consumption by the environmental protection industry on its own products is excluded to avoid double counting.

Transfers relating to environmental protection services

5.190. A full discussion of the role of transfers and in particular environmental taxes appears in Chapter 6. The present section concentrates on procedures which will help identify the flows needed for the compilation of the elements in the expenditure accounts relating to financing from other sources.

5.191. In order to have information available from which to include the impact of transfers on the financing of environmental protection expenditure, it is necessary to start with a fairly general description of all transfers related to environmental protection.

5.192. The following procedure is proposed and illustrated schematically in Table 5.14.

A table of intra-governmental transfers which shows who pays and who receives each transfer should be established. Many transfer payments are between different levels of government, for example from central government to an environmental fund or to local authorities. Transfers which are identified by both the donor and the beneficiary in the basic data should be set aside, as for example in the case when basic data include investment grants from the central state to local authorities as well as the corresponding investment undertaken at the local level. However, there may also exist "open-ended" transfers where information on the counterpart entry does not appear in the basic data available; for example, transfers to a government agency whose annual report is not available. In such a case, the transfers can constitute a basis to estimate the expenditure of that agency.

A table of transfers among sectors. Normally, transfers will go only from the government sector to the other sectors (households, corporations, and non-profit institutions) but the reverse can be true; for example, large donations or ear-marked pollution taxes. The same principles apply as above: if the expenditures which correspond to (are financed by) the transfers are included in the primary data, the transfers should be consolidated (netted) out to avoid double counting. Some kinds of transfers will have no counterpart in basic data by definition (for example international co-operation).

Table 5.14 Tables of transfers related to environmental protection services

	Donors							
Beneficiaries	Federal govern-ment	Federal funds	Regional govern-ments	Regional funds	Municipalities	Other	***Total received (1)***	Balance (1)-(2)
Intra-governmental transfers								
Federal government								
Federal funds								
Regional governments								
Regional funds								
Municipalities								
Other								
Total given (2)								
Preferential loans to other sectors								
Industries								
Households								
Total preferential loans								
Cash grant equivalent of loans								
Transfers to other sectors								
Industries								
Households								
Rest of the world								
Total transfers to other sectors								
Total transfers including loans								

D Extensions and applications of the accounts

5.193. This section deals with the extension and application of the framework presented in earlier sections. Linking expenditure with physical data is an important way to try to quantify the relationships between the expenditure undertaken and the environmental damage avoided. In order to assess the changes over time free from the effects of inflation, the compilation of satellite accounts in constant prices is also discussed.

5.194. Two practical instances implementing the proposals in this chapter follow. The first relates to the estimation of environmental protection expenditure in Germany. The second concerns the estimation of research and development expenditure in Canada.

1 Links to physical data

5.195. As for other satellite accounts, the usefulness of accounts of environment-related activities and expenditure can be enhanced by making links with physical data. This is particularly so with emissions collected, treated or avoided, the tax bases for environmental taxes (fuel use, vehicles in circulation, etc.) as well as protection equipment and facilities. The main instruments for this linking are physical flow accounts (for example the links to emissions described in Chapter 4). Because physical data or indicators about environmental protection equipment and facilities are necessary for the compilation of emissions (and emission accounts), the links between physical data on equipment and monetary expenditure need to be established.

5.196. Some links are easy to establish, in particular links to treatment capacities, or waste or waste water treated. One example is the relationship between waste water management and actual discharges to water and the quality of rivers. This link is useful to explore whether the amounts spent have been used efficiently and whether spending is at an adequate level in relation to changes in emissions and water quality. However some links are more difficult. Expenditure data on pollution abatement measures are normally not available at a sufficiently detailed level (by air pollutant, say). Abatement measures often reduce emissions for several pollutants and not just one. Further, emissions are the result of many factors, including the level of activity and savings in the use of raw materials or energy, as well as other measures not described in environmental protection accounts. The result is that linking physical data on emissions with a description of environmental protection expenditure for some domains, mainly air emissions, requires a careful and detailed analysis.

5.197. For linkages to the physical data, the environmental protection accounts must, as far as possible, use the same classifications that are used in the physical flow accounts. Experience has already shown that environmental expenditure and environmental taxes can be presented using the same industry classifications as used in the physical flow accounts, thus providing consistent information for each industry or branch of production on such items as energy use, energy taxes paid, air emissions and expenditure on the protection of air. Such data sets facilitate attributing the changes in emissions (including emissions avoided) to the different factors that caused these changes.

2 Time series and constant prices

5.198. The introduction of environmental protection goods and services leads to discontinuities over time. For example, because in many countries neither cars without catalytic converters nor petrol containing lead are sold any longer, a long time series of expenditure on cars or petrol is not likely to be strictly consistent over the time period. This is a problem in current price series but is even more acute in constant prices.

5.199. Suppose the car with a catalytic converter is regarded as being a joint product, a car without a converter and a “bundle” of environmental protection services represented by the converter. The introduction of the converter would then represent the introduction of a new product into the expenditure patterns of the purchaser of the car. Treatment as a new product has the same effect as treating the addition of the converter as a quality effect so that the quantity of cars purchased in constant price terms will be higher than if the “new product” effect is ignored and the cost of the converter simply treated as an increase in the price of cars.

5.200. A more direct example concerns the addition of an advanced treatment module to waste water treatment. Installation gives rise to an increase in the expenditure (and prices of waste water treatment services) that should be treated as a quality change converted to volume terms and not a just a pure price increase.

5.201. This effect is not necessarily treated analogously across the accounts. New products bought by households as final consumers, for example a trash compactor, will give rise to an increased volume measure. The same is true for new products bought by non-market producers. The problem, therefore, is particular to market producers other than those producing environmental protection goods and services. It is impossible for an analyst to pronounce on whether increased spending on environmental protection increases or decreases the growth of the economy without knowing whether the increased costs have been treated as a price or volume effect. Selective collection of waste is generally more expensive than non-selective collection, but positive environmental effects are higher. Purification of water before distribution may become more expensive when the quality of the water in the environment decreases, although the final product remains the same (drinkable) water. To the extent that costs are treated as a price effect, growth rates based on constant prices of a year before and those based on a year after the introduction of the new environmental protection will differ from each other even though both treat environmental protection as a price effect. The more the impact of environmental protection is treated as a quality or volume effect, the more this will increase growth rates on an older price base, but when the new quality is built in to the new price base, the growth rate will tend to be lower.

3 Environmental input-output analysis - German experience

5.202. The main purpose of an environmental protection input-output table (EIOT) is to investigate structural and other effects on the total economy of producing environmental protection services (Schäfer and Stahmer, 1989). This linkage is the only way in which the effectiveness of environmental protection measures can be examined, and to this end the EIOT is designed to match the physical input-output tables (PIOT) (Stahmer, Kuhn, and Braun, 1996), thus building a bridge between environmental protection measures and material and energy flow accounts. This bridge is made by the use of identical classifications and the parallels between the data in physical and monetary units. As in the environmental protection expenditure account, the EIOT separates internal and external environmental protection services and fixed capital formation for environmental protection.

5.203. The Federal Statistical Office of Germany has calculated a comprehensive EIOT which links the German national accounts and the European SERIEE system for the reporting year 1990. The calculation procedure was based to some extent on a former EIOT that had been produced for Germany for 1980 and 1986.

5.204. In general, the task is to break down the regular input-output table into non-environmental and environmental sections. The required statistical information is mainly found in the expenditure aggregates as presented in earlier sections of this chapter. For the German EIOT, detailed figures for different expenditure categories by industries (operating expenditure for different types of commodity groups, compensation of employees, consumption of fixed capital and gross fixed capital formation by commodity groups) for the most important environmental domains according to the CEPA classification were available or estimated. The frame of reference and starting point for the EIOT, in terms of the total economy, was the input-output table at producers' prices. The input-output table distinguishes 58 industries, but it was impossible to show this degree of detail in the German EIOT. Therefore an aggregation into 15 industries was made, with industries which are environmentally important shown separately wherever possible.

5.205. As with the expenditure accounts, the EIOT highlights internal and external environmental protection services for industries and fixed capital formation for environmental protection as part of the total gross fixed capital formation.

5.206. ***Internal services*** result from ancillary activities and are produced and used for own purpose. They are shown in the EIOT not as separate industries but as parts of the industries to which they belong.

5.207. In Germany, ***external environmental protection services*** supplied to others are produced by general government and by private and public enterprises. For external services, separate industries are distinguished within the EIOT. The total output value of these new industries is the benchmark figure for the distribution of output among users of external environmental protection services. The output value was mainly based on the aggregation of data of general government for sewage and waste disposal functions (fees, reimbursements) and turnover figures of private and public enterprises. For a description of the input side in the EIOT, the intermediate consumption needed for the production of external services had to be determined by commodity group, along with the components of gross value added. The distribution of the total output value and the external services imported among the user industries and private consumption was needed for the use side. For the EIOT the results of the 1990 PIOT on physical waste and sewage volumes disposed of externally formed the starting-point. These volume figures were multiplied by average disposal charges to estimate purchases of environmental protection services by industries and final use categories. Due to limitations in primary data, the EIOT did not include secondary production of external disposal services by non-environmental industries but this is probably not very important in Germany.

5.208. The third important dataset in the EIOT concerns ***fixed capital formation*****,** which was again divided into specific environmental domains and commodity groups, as part of the fixed capital formation of the total economy.

5.209. By adding expenditure for internally produced disposal services and purchases of external services, total branch-specific environmental protection expenditure could then be obtained, which enabled a comprehensive comparison of the expenditure of the different industries.

4 Environmental Research and Development - Canadian experience

5.210. Expenditures by the Canadian federal government on environmental research and development (R&D) represented between 8 per cent and 9 per cent of total federal government R&D spending between fiscal year 1995-96 and 1998-99. Intramural[3] environmental R&D expenditures represented 6 per cent of total federal intramural R&D spending; these expenditures were equal to CAN$85 million in 1998-99, a 14 per cent drop from 1995-96. Federal extramural[4] R&D expenditures on environment, equal to $44 million in 1998-99, fell by 12 per cent from 1995-96.

5.211. In comparison, industry spending on environmental R&D (intramural[5] spending only) represented 2 per cent of total industry R&D in 1995. Led by engineering offices and the scientific services industry, environmental R&D spending made by Canadian industry totalled $165 million, up 22 per cent from the 1993 level. In fact, environmental R&D spending was made by two categories of firms, those whose principal or secondary production is environmental goods and services and those that are users of environmental products.

Data sources

5.212. Statistics Canada estimates environmental R&D spending by industry and government from two surveys, the *Research and Development in Canadian Industry Survey* and a survey on federal scientific activities.

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[3] Intramural government R&D spending - government spending on R&D excluding non-program costs.

[4] Extramural government R&D spending: R&D performed outside departmental program.

[5] Intramural industry R&D spending: expenditures for R&D performed within a firm.

5.213. Statistics on industrial R&D expenditures attributable to pollution abatement and control and environmental protection are derived from the industrial survey and are available from 1990 to 1995. Firms surveyed include both companies and industrial research institutes[6]. These firms cover those claiming an R&D tax credit, firms reported by government organisations as R&D contractors or grantees, firms reported by other companies as financing or performing R&D, and firms identified from a variety of other sources as potential R&D performers. R&D expenditures only cover intramural expenditures; that is, expenditures performed within the firm as opposed to R&D performed for a firm by contractors.

5.214. In the 1995 industrial survey, firms were asked to estimate the "percentage of total R&D expenditures attributable to prevention, treatment and reuse of pollutants and wastes". R&D was defined as follows:

> The systematic investigation carried out in the natural and engineering sciences by means of experiment or analysis in order to gain new knowledge and create new or significantly improved products or processes devoted to the reduction or elimination of pollutants and wastes.[7]

5.215. Federal government R&D was allocated by socio-economic objective, based on the Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets (NABS) produced by Eurostat. The control and care of the environment/protection of the environment objective was defined as follows:

> Scientific activities into the control of pollution, aimed at the identification and analysis of the sources of pollution and their causes, and all pollutants, including their dispersal in the environment and the effects on man, species (fauna, flora, micro-organisms) and biosphere. Development of monitoring facilities for the measurement of all kinds of pollution is included. The same is valid for the elimination and prevention of all forms of pollution in all types of environment.

Challenges

5.216. There is under-coverage of environmental R&D expenditures due to limitations in data coverage, definitions and overlap with other types of R&D spending.

Coverage

5.217. Some caution is required in adding figures on industry environmental R&D to estimates of business environmental protection expenditures due to variations in the universe of the different surveys used. The industrial R&D survey covered specific types of firms:

> firms that claimed an R&D tax credit or that were identified by other organisations or companies to perform R&D are included;
>
> both enterprises and industrial research institutes were covered. Indeed, in many instances, environmental R&D is conducted by an institute for a particular industry and is funded through a joint effort by industry, industry suppliers and government;
>
> the industry coverage was a mix of users and producers of environmental goods and services;

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6 Industrial research institutes dedicated to research projects for a specific industry, such as paper and allied products industry, and funded jointly by industry, governments and universities.

7 The 1996 definition was broadened to include a question on the existence of important potential environmental benefits related to total R&D reported. These environmental benefits were defined as potential energy savings; reduction in use of raw materials or waste generation either from increased efficiency, recycling or closed-loop systems; and design changes resulting in products that are less damaging to the environment in their use or disposal.

in addition, only intramural expenditures were estimated through the industry R&D survey, which excludes the contracting out of R&D services (included in other business environment surveys).

5.218. On the government side, the federal government data are the only estimates available of R&D spending related to environmental protection. There is no information on the size of the environmental R&D performed by provincial and municipal governments.

Definitions

5.219. The definitions of environmental R&D are limited as shown above. They related to pollution abatement and control R&D only and excluded R&D with environmental benefits if it was not performed for pollution abatement and control purposes. Further work is required to clarify the definition of environmental R&D expenditures and to expand the definition to cover R&D in areas such as pollution prevention, energy conservation, etc.

Overlap with other types of R&D

5.220. There is some overlap between statistics on environmental R&D and statistics on energy R&D. Government and industrial R&D on energy technologies include projects on energy conservation, fossil fuel recovery, renewable energy, as well as R&D on nuclear power and other fuel systems. Expenditures on energy R&D, while not specifically aimed at conservation or climate change for instance, may contribute to reduction of air pollution (for example, greenhouse gases) through lower fossil fuel consumption. The problem is to distinguish between R&D on energy conservation and substitutes and R&D on fossil fuel development or nuclear power.

Distinction between financing and execution of R&D

5.221. Statistics Canada's data on environment R&D do not provide a distinction between those agents who finance the R&D and those who execute the R&D, except for federal government R&D. At the federal level there is a distinction between intramural R&D which is performed by the department itself and extramural R&D spending which comprise expenditures on R&D performed outside federal government departments but on behalf of the federal government. Industrial estimates of environmental R&D include intramural R&D; that is, R&D performed inside the firm. However, there is no information on the source of funding of industry R&D.

Chapter 6 Accounting for other environmentally related transactions

A Chapter overview

1 Objectives

6.1. Chapter 4 discusses how to link monetary flows associated with production, consumption and accumulation with physical flows, not only for these activities but also covering the absorption of natural resources and ecosystem inputs and the generation of residuals. The part of the SNA covered corresponds to the goods and services account, that part which is reflected in supply and use tables and input-output tables.

6.2. Chapter 5 looks in particular at environmental protection expenditure and explores how this can be portrayed within the system elaborated in Chapter 4. This involved identifying certain products and activities particularly relevant to the environment and showing how these can be identified in the supply and use tables.

6.3. Government not only provides environmental services but also intervenes in the use of environmental services. One way it does this is to control use of the environment through legislation. This process is sometimes referred to as “command and control”. One example concerns restrictions on landfill sites. Another instance is legislation to ensure restoration of the environment after a production process ceases; for example, when a mine closes. Another way government intervenes in the use of the environment is by levying environmental taxes. Increasingly, though, governments are moving away from legislation as a means of protecting the environment and instead are moving to “cap and charge” policies. In practice to date, this has meant issuing a licence, sometimes free, sometimes for a fee, which entitles the owner to some sort of exclusive right to use a given environmental asset or some part of it. Emissions trading permits and fishing licences are examples. Whenever a monetary transaction results from these interventions, it is recorded in the SNA and the major objective of this chapter is to examine what sort of transactions are involved and how they are recorded.

6.4. Once all these types of transaction have been enumerated, a complete set of satellite accounts, fully consistent with the SNA but identifying all environment-related transactions can be articulated. The last section of this chapter (Section E) shows how this can be expressed within an extended matrix presentation such as the social accounting matrix (SAM) presented in Chapter XX of the 1993 SNA. This too can be augmented by the sort of physical data discussed in chapters 3 and 4 to produce a hybrid SAM. This is the fullest form of a NAMEA and it is described briefly here as a means of seeing the integration of all the flows discussed in chapters 3 to 5 and the present one.

2 Economic instruments

6.5. For the present purposes we are concerned with only those instruments invoked by government in relation to the use of environmental assets or media[1]. An economic instrument is a means by which decisions or actions of government affect the behaviour of producers and consumers by causing changes in the prices to be paid for these activities. Environmental taxes fall into this category, as do direct charges for government-provided environmental services. In fact the boundary between these two is rather fluid and may change noticeably over quite a short period of time.

6.6. Of increasing importance is the role of charging for the use of environmental media. In some countries, government is assumed to be the public guardian of environmental resources and thus controls them on behalf of the public at large. In other countries, environmental resources are mainly held privately but even so, if there is a charge levied by the owner on the user this needs to be recorded in the accounts. Both these circumstances are discussed in this and subsequent chapters.

Taxes *versus* fees for a service

6.7. Not very long ago, the taxes paid by households and businesses on their property contributed to the costs of government (often local government) for a variety of services including the provision of piped water and the collection of refuse. In many countries in recent years, these services have been separated from general government services and the charges made to households and businesses regarded as payments for a service rather than a tax. Within the national accounts, it matters less who provides the service than whether the charges made relate to the service and are sufficient to cover all or most of the costs of providing it. Thus payments for garbage collection may be a payment for a service even if it is entirely government run. It is increasingly seen, though, that services which can recover their costs through direct charges operate in the private sector with government concentrating on those services where support from government funds is deemed to be in the public interest. Fees which represent a payment for a service should be covered in the flows already described in previous chapters.

6.8. The role of taxes in the management of environmental resources is one of discouraging particular forms of expenditure by imposing a tax which increases the price of the products or the costs of production of the activities concerned. Sometimes the revenues from such taxes may be designated to remedy particular forms of environmental damage. Even where no such direct link exists, it is interesting to have a measure of taxes with an environmental base so that subsequently these amounts can be contrasted with estimates of the environmental damage associated with the activities being taxed. The definition and measurement of environmental taxes are discussed in Section B.

Property income and property rights

6.9. Assets may be acquired, disposed of or used up and, in the case of non-financial assets, all these events are recorded in the capital account of the SNA. (Similar transactions in respect of financial assets are recorded in the financial account but they are not the subject of concern here. Unless otherwise specified, "asset" is taken to refer to a non-financial asset throughout the SEEA.) Once an asset is acquired, it is entered in the balance sheet of the owner, and this value is altered by any disposal, using up or other change in the volume or value of the asset. Chapter 7 is devoted to establishing the extent of environmental assets, placing a value on these and tracking the changes in their value in balance sheets. The interest in the present chapter is to consider transactions that occur when the asset is used in a production process.

[1] For a survey of the use of economic instruments for environmental protection in OECD countries see OECD (1994a).

6.10. In the SNA, production gives rise to income, value added, which is part of GDP. Value added is partitioned between the return to labour (compensation of employees), payments to government of other taxes on production (less any similar subsidies) and operating surplus which represents the initial return from the use of produced assets (fixed capital) and any non-produced assets. From this the producer must make a payment to the owners for the use of any non-produced and financial assets he has been lent. In order to identify such payments, it is necessary to consider how the ownership and use of assets are recorded. Another way of describing this is to say we need to investigate property income and property rights.

6.11. The SNA defines an asset as an entity over which an ownership right can be enforced and from which the owner can derive benefits by holding or using it over a period of time (1993 SNA, paragraph 10.2). By definition, then, all assets are economic assets. In common usage, assets may also be described as property (not to be narrowly interpreted as applying only to land and buildings). Property rights are the rights which establish ownership of an asset and thus the right to determine who may and may not use it. Property income is the income flow which the owner of a non-produced or financial asset receives from allowing some other unit to make use of the asset. Most property income relates to the interest and dividends paid for the use of financial assets. Property income relating to the use of non-produced assets is called rent and in many cases relates to rent on land.

Using some other unit's assets - rents and rentals

6.12. If an enterprise owns a produced asset such as a car or a tractor which it leases out, the income earned is part of production and is included in the value of output and GDP. This is not the case for financial leasing, where the payments from the user to the owner are recorded as financial transactions. Payments for the use of another unit's car or tractor are treated as final or intermediate consumption as the case may be. These payments are called rentals in the SNA to distinguish them from rents. Whereas rent is an income coming from leasing out a non-produced asset, rental is an income coming from the leasing out of a produced asset. Rental income contributes to GDP. Rent (and other property income) represents a redistribution of operating surplus from the unit using the non-produced (or financial) asset to the owner of the asset.

Recognising new property rights and new assets

6.13. Increasing control over the right to use different environmental assets, either natural resources as inputs or environmental media as sinks for residuals, has meant that this right has become scarce. In doing so it acquires a monetary value and thus comes to be regarded as an asset in and of itself giving rise to property income. The institutionalisation of these rights is another form of economic instrument that is relevant to the environment. Acquisition of these rights and disposal of them must therefore be recorded in the capital account, just as acquisition and disposal of land has always been subject to such recording.

6.14. The recognition of such property rights and the creation of legal instruments which give them effect is a new and developing field. Not all of these are described in the SNA because in 1993 not all of them existed. The use of the radio spectrum for mobile phones is a case in point. Nor can the description here be exhaustive and cover every eventuality. However, some instances are discussed at length in Section C in order to illustrate the considerations which must be taken into account when determining the appropriate recording associated with the appearance of such an asset.

The cost of using one's own assets - consumption of fixed capital

6.15. Property income flows and rentals are recorded in the SNA only when the user of an asset is not also the owner of the asset. Using one's own assets also gives rise to income though this is not separately identified as such. If a farmer owns both land and a tractor, part of his operating surplus represents income arising from the use of these assets. There are, in the SNA, no entries recorded for imputed rent on the land or imputed rental on the tractor. However, the tractor was a produced good which must be paid for by the farmer. It is treated as capital so the cost is not included in intermediate consumption. Instead, the cost is spread over a period of time corresponding to the period during which the tractor is in use (its "life") and is recorded in an item known as the consumption of fixed capital. In aggregate, this is the item which distinguishes gross and net domestic product and it is the deduction from measures of production necessary to derive a measure of income consistent with the idea of keeping fixed capital intact.

6.16. Consumption of fixed capital is not a new concept in the SNA but increasing environmental consciousness has meant a re-examination of what the concept covers and how it should be measured and recorded. Particular instances of concern are drilling platforms which, when no longer required, can no longer be left *in situ* or simply sunk at sea and nuclear power stations which must be carefully decommissioned at the end of their useful lives. Legislation to enforce these clean-up costs is another form of economic instrument introduced for environmental policy purposes. The implications of these considerations are considered in Section D.

3 Identifying all environmental flows in the accounts

6.17. The versions of the hybrid supply and use tables described in Chapter 4 do not contain details covering the issues discussed in Chapter 5 and in the present chapter. In Section E, the location of environmental flows throughout the income and capital accounts of the SNA is discussed. The means to express these in matrix form in order to reach a hybrid version of a full national accounting matrix is also portrayed.

6.18. Like the hybrid accounts in Chapter 4, the matrix in Section E also contains the physical extensions for resource input and residuals outputs. Also like the accounts in Chapter 4, no changes are made to the fundamental accounting principles of the SNA, so that the macro-economic aggregates and other indicators coming from the full hybrid accounting matrix are still strictly consistent with the regular national accounting totals.

4 Scope and limitations of the accounts

6.19. It is not possible in a text the length of this chapter to enter into all the details of the national accounting treatment of the intangible non-produced assets created by the establishment of new property rights. In some cases, the novelty of the devices being introduced is such that the correct treatment within the 1993 SNA is still the subject of some discussion. The consequences of new conventions on property rights, for example those which might be invoked concerning the buying up of carbon sinks in other countries as might happen under some version of the Kyoto protocol may well provoke further discussion and controversy in the future.

6.20. The borderline between taxes and payments for services is fuzzy, as indicated above. If it is desired to create series which are comparable over time within one country or across a number of countries, it may be desirable for those ends to consider taking a different position on which payments are taxes and which represent intermediate or final consumption. It should be carefully noted, though, that some variations of this nature may lead to results which are not strictly consistent with the national accounts as published.

6.21. Lastly it should be noted that there are some asymmetries in the 1993 SNA which carry over to the presentations suggested here. From an environmental point of view, it may be very relevant to consider the rent element of operating surplus due to a unit for the use of his own non-produced asset or the use of one owned by someone else but for which no rent is charged explicitly. Equally, while costs for the using up of fixed assets in the form of consumption of fixed capital are regarded as a deduction from gross income, the decline in value of non-produced assets is not. Chapter 10 discusses how the accounts might be modified to achieve symmetrical treatment of these issues.

B Environmental taxes

1 Environmental taxes and specific taxes

6.22. Although few environmental taxes are directly earmarked for environmental protection activities, there is an obvious interest in seeing how the revenue from such taxes compares to the cost of the use made of the environment. Not all damage arising from this use is remedied through environmental protection activities, of course, but the potential link between this source of revenue and the possible costs (to be discussed in Chapters 9 and 10) is another reason to delineate exactly what is meant by an environmental tax and so a means of identifying such taxes is also given in the chapter.

6.23. In the environmental protection expenditure account, the term “specific taxes” is used for a sub-set of taxes that contribute to the financing of environmental protection. The revenue from specific taxes is regarded as being earmarked for environmental protection. The term “hypothecated” is often used by economists to describe taxes which are earmarked for a specific purpose. The earmarked, or hypothecated, tax is used to subsidise the production of environmental protection services; to finance non-market activities; to finance investment grants, gross capital formation of non-market specialist producers; or to pay other current or capital transfers for environmental protection. Specific taxes are taken into account in the analysis of financing of environmental protection with the exception of those taxes already included in national expenditure; for example, the proceeds from earmarked landfill or water pollution taxes which are part of the cost of production of environmental protection activities (see Chapter 5 for detail).

2 Environmental taxes and sales of environmental protection services

6.24. When classifying government receipts, the distinction between taxes and sales of services is sometimes difficult. Whatever the name of the payment (rate, charge, fee, etc.), when the payment is seen to be commensurate with the service provided, the payment is classified in national accounts in general as well as in the SEEA as purchase of services.

3 Environmental taxes in general

6.25. Environmental taxes are an important economic instrument for environmental protection. One focus is on revenue data for environmental taxes, thereby providing information on the structure and importance of environmental taxes within the taxation system. Such information is useful in a policy context of “green” fiscal reform. A basic idea of “green” fiscal reform is to change the structure of taxation systems so as to reduce the tax burden on labour and to increase the tax burden on the use of the environment (the so-called "double dividend").

6.26. OECD, Eurostat, the IEA and the European Commission's Directorates General for Environment and Taxation have developed a statistical framework on environmental taxes (Eurostat, 2001b). The framework started from the following definition of environmental taxes: "a tax whose tax base is a physical unit (or a proxy of it) that has a proven specific negative impact on the environment". It was felt that the tax base provides the only objective basis for identifying environmental taxes for the purpose of international comparisons. This definition puts emphasis on the potential effect of a given tax in terms of its impact on the costs of certain activities or the prices of certain products. Other criteria such as the name given to a tax or the purpose of a tax as expressed by the legislator or the fact that the revenues from a tax are earmarked for environmental purposes were therefore not used although these latter criteria can still be useful when identifying environmental taxes in a national context.

6.27. The definition gives an idea of the key concept that should be measured. It also provides a guideline for the assessment of newly introduced taxes. However, the definition still leaves room for debate on borderline cases (for example VAT on energy products or taxes on the purchase of land, tourism, resource extraction, etc.). The key issue for ensuring international comparability is therefore the list of environmental tax bases (see Box 6.1) as agreed by the institutions involved. These tax bases (often physical units) allow for a direct link with physical accounts.

Box 6.1 Categories of environmental tax bases

- Measured or estimated emissions to air
- Measured or estimated emissions to water
- Energy products
  - Energy products used for transport purposes
  - Energy products used for stationary purposes
- Transport
  - Based on distance driven (per kilometre, per mile)
  - Import or sales of vehicles
  - Annual vehicle taxes
  - Other
- Waste water discharges (not measured)
- Agricultural inputs (fertiliser, pesticides)
- Waste
  - General waste collection and treatment (waste collection, landfill)
  - Individual products (packaging materials, batteries, tyres, lubricant oils, etc.)
- Ozone depletion (CFCs, halons)
- Noise

Source: Eurostat, 2001b.

6.28. Since for an individual country there may be rather few environmental taxes, the following aggregated groupings of environmental taxes may be used:

Energy taxes (including CO_2 taxes)
Transport taxes
Pollution taxes (on emissions to air and water, waste, packaging, pesticides, CFC, noise, etc.)
Resource taxes (water abstraction, sand and gravel, etc.)

6.29. It should be noted that resource taxes (as part of environmental taxes) do not include taxes on oil and gas extraction. The SNA specifies that these should be treated as payments of rent to the government as owner of the resources and not as taxes (1993 SNA, paragraph 7.133). The SEEA follows this recommendation as explained in Chapter 7. These payments to government generate important revenues in a limited number of countries. Even if such payments were to be classified as taxes, they should not be classified as environmental taxes for a number of reasons.

It is the use of fossil fuels rather than the extraction *per se* which is environmentally harmful (setting aside the question of leakages and spills during extraction).

The price of fossil fuels is largely determined by the world commodity markets and taxes levied in a particular country have negligible influence on this price.

Given that few countries possess significant oil and gas reserves, including these payments as environmental taxes would lead to lack of comparability for this item across countries with and without reserves.

6.30. The basis for the identification of environmental taxes will often be tax revenue statistics. A list of taxes must be set up which allows environmental taxes to be separated from all other taxes and assigned to the detailed or aggregated classification above. Allocation of tax payments by detailed industries can be made, possibly by using the physical tax basis to disaggregate the aggregate revenue figures when no direct sources are available.

4 Environmental taxes within the national accounting framework

6.31. National accounts have their own classification of taxes. Three main categories of taxes are distinguished. ***Taxes on production and imports*** cover 1) taxes payable when goods and services are produced or imported – known as ***taxes on products*** and 2) taxes on the ownership or use of assets used in production and on the labour employed – known as ***other taxes on production***. Taxes on household income and wealth taxes paid every tax period are described as ***current taxes on income, wealth, etc.*** The third category of taxes covers ***capital taxes*** which are those levied infrequently and irregularly on the value of assets and those levied on capital transfers.

6.32. Only taxes on production and imports appear within the supply and use framework. In order to incorporate current taxes on capital and on income, wealth, etc., it is necessary to expand the supply and use framework towards a full matrix presentation of national accounts by adding the allocation of primary income, secondary distribution of income and capital accounts. A first attempt to categorise environmental taxes with respect to national accounts is given in Table 6.1. (The exact allocation will depend on the precise nature of the taxes).

Table 6.1 Classification of environmental taxes

Type of tax	Accounting classification
Energy products Imports or sales of vehicles Agricultural inputs (fertiliser, pesticides) Individual products (packaging materials, batteries, tyres, lubricant oils, CFCs, halons, etc.)	***Taxes on products***
Measured or estimated emissions to air or water, waste water discharges, waste Annual vehicle taxes Noise	***Other taxes on production*** when paid by producers ***other current taxes on income, wealth, etc.*** when paid by households as consumers

6.33. Table 6.2 shows the magnitudes of the various taxes in the SEEAland data set and those which can be identified as environmental in nature. Information about the types and levels of taxes applying in OECD member countries can be found via a link on the home page of the Environment Directorate on the OECD web site (www.oecd.org/env/policies/taxes).

Table 6.2 An example of identifying environmental taxes

Billion currency units

	Taxes on products			Other taxes on production	Taxes on income		Total
	Environ-mental protection services	Clean products	Other goods and services		Corporations	Households	
Environmental taxes			3.0	2.0		2.0	7.0
Transport taxes				0.7		2.0	2.7
Levies on noise nuisance				0.2			0.2
Water pollution tax				1.1			1.1
Energy and carbon tax			3.0				3.0
Other taxes and subsidies	0.3	0.1	66.6	2.0	22.5	63.5	155.0
Value added tax	0.3	0.1	49.3				49.7
Excise duties			16.6				16.6
Import duties			4.5				4.5
Other taxes on production and imports			7.8	4.5			12.3
Other taxes					22.5	63.5	86.0
Subsidies			-11.5	-2.5			-14.0
Total	0.3	0.1	69.6	4.0	22.5	65.5	162.0

Source: SEEAland data set.

C Property rights and property income

1 Property income

6.34. Property income is the term used in the SNA to describe the payment made to the owner of a non-produced or financial asset by a unit who, with the permission of the owner, makes use of the asset in the course of an accounting period. Most property income arises from the use of financial assets and the property income flows are described as interest and dividends. Property income in respect of non-produced assets is described as rent. The concept of economic rent includes the notion of the benefit received by the owner from exploiting the asset himself as well as the payment from another user. This extension is not discussed in the present chapter but is explored in Chapter 7.

6.35. The SNA mentions only rent of land and rent on subsoil assets explicitly as being included within the coverage of rent. However, the set of non-produced assets is wider than just land and subsoil assets. The definition and classification of environmental assets is discussed in Section B of Chapter 7 but for the present purpose it is sufficient to regard the set of naturally occurring entities as the assets of interest.

6.36. Fishing licences are mentioned within the SNA in the context of the fee charged to recreational anglers for engaging in their sport. When the fee is payable to the government, this payment is regarded as a tax. When it is payable to an angling club, say, it would be regarded as a fee for a service. However, there are a few countries, typically island states in the Pacific, who issue fishing licences to permit foreign enterprises to conduct commercial fishing within the Exclusive Economic Zone (EEZ) of the country. When these licences are payable annually and cover the right to fish in those waters only for the year covered, these licences should be regarded as a form of rent also. It is possible to consider permission to extract water from a water course in the same way.

Characteristics of rent

6.37. Rent is a current transaction and relates to a payment due within a year for the use of the asset in question for that period only. There may be a lease in existence which guarantees some degree of continuity of permission to use the asset, but the payment itself falls due annually. If the using unit ceases to exist (for example, the farmer dies or an enterprise goes bankrupt) then the lease will normally cease to exist. Even where a lease exists, the level of rent may be subject to a price increase every year or may even be completely renegotiated each year. Payments of rent may depend on the level of output of the user (as in share-cropping for example). Normally the user of the asset has no entitlement to sub-contract the use of the asset. Normally if there is an annual tax levied on the asset it is payable by the owner of the asset who may or may not pass this on to the tenant. The cost of the rent will represent a charge on value added and depress the value of the disposable income and saving of the enterprise paying the rent, while increasing the value of disposable income and saving of the owner.

6.38. None of these characteristics is definitive when taken individually but together they give some indication of the characteristics likely to exist when payments for the use of a naturally occurring asset should be treated as rent.

2 Property rights

6.39. The 1993 SNA introduced a new category of assets called non-financial intangible non-produced assets among which is an item called leases and other transferable contracts. The characteristic of intangible non-produced assets is that they entitle their owners to engage in specific activities or to produce certain specific goods and services and to exclude other institutional units from doing so except with the permission of the owner. These attributes are what economists refer to as property rights.

6.40. The leases themselves are not produced but are legal constructs designed to permit or inhibit certain actions. They may control, for example, who may use a piece of software, who may extract a natural resource and under what conditions, or which sports club has the services of a particular player.

6.41. Not all leases represent assets. For example, the tenant of a house or apartment often is party to a lease which is a document which spells out the responsibilities of the landlord and the tenant and may be used as the basis for settling any disputes between them. Usually the lease itself will not have an economic value. However, if the rental payable on the house were fixed and the lease entitled the tenant to sub-contract his tenancy, the lease would acquire a value if the rental the tenant could charge exceeded the rental he had to pay the landlord.

Acquisition of property rights

6.42. It is important to note the distinction between the right to control use of an asset and the asset itself. In this context it is only the right of usage which is designated an intangible non-produced asset. Within the

SEEA, we are interested only in property rights in so far as they apply to environmental assets; in practice these are the same natural assets which can be the subject of property income.

6.43. The right to exercise control over an asset may come about by a number of mechanisms.

One way in which an asset comes into being is simply the recognition of traditional rights. Codification of who has the right to build on or mine in which piece of land is one example.

Environmental assets in common ownership may come to be regulated by government. In effect, government explicitly assumes ownership of the asset and then allocates or sells this to individual users or classes of users.

Government may issue entitlement to use an asset free or may auction or otherwise sell the asset. By number, this is the most frequent way such property rights are acquired.

Change in prices, together with the initial conditions of a lease, may endow a previous contract with a value. The instance of the lease on a house quoted above is an example.

6.44. There is no link between the type of asset subject to an agreement to transfer property rights and the way in which this agreement is arrived at. Fishing quotas are a case in point. They may be acquired by recognition of traditional rights. They may be allocated by government either free or at an arbitrary figure or they may be bought and sold by means of a market. A fisherman who acquires his quota through one of the first two ways and then discovers the market price is higher may be able to sell his quota to a third party as in the case of a house lease.

Characteristics of property rights

6.45. A property right constitutes an intangible non-produced asset only if the right to use the asset is (or was) conveyed for a period exceeding a year. Sometimes the right of use will be indefinite. Almost certainly, some legal documentation will exist to evidence control over the property right. If the agreement is for a year only, even if it is renewable, then this agreement is commonly called a licence and the payment due under it is treated as rent as described above. It should be noted, though, that it is the period of the agreement which determines whether the payment constitutes rent or acquisition of an intangible asset and not the use of the word "licence" alone.

6.46. Where property rights are acquired by purchase the total cost will be negotiated at the outset. This cost is seldom subject to adjustment or renegotiation during the period of its validity. The transactions for the sale and acquisition of property rights are recorded as capital transactions and do not affect the saving of either the asset owner or user. If the cost is not met in full at the time the property right passes from the (original) owner to the new owner/user, the difference will be recorded in terms of financial assets and liabilities between the two parties.

6.47. The right to use the asset may itself be separately saleable or, at least, transferable to a new owner of the unit holding the property right. (In many cases the property right may be the most important feature of the unit). If a tax on the right to use the asset is levied, it is likely that the user will be responsible for paying this.

6.48. As before, none of these characteristics is definitive but together they give an indication of the likely characteristics existing when payment for the use of a naturally occurring asset should be treated as the acquisition of an intangible non-produced asset (property right).

Examples of environmental property rights

Fishing rights

6.49. Historically, no ownership rights were established over fish in the deep oceans. This has led to depletion of fish stocks to dangerously low levels in some instances. While it is impossible to designate ownership over such fish, it is possible to limit the amount of fish that may be legally caught by an individual, an enterprise or a country. Such quotas are agreed by national and international agreement.

6.50. Usually a quota is assigned on the basis of historical catches. If someone who is awarded such a quota wishes to leave fishing, he may usually sell his quota to someone else. Because of the shortage of quotas, a market in fishing licences may quickly develop.

6.51. When quotas are agreed for a period of time (or indefinitely) they represent the acquisition of an intangible non-produced asset. One of the beneficiaries may be governments when, by international agreement, the wild stocks of particular fish species in the open oceans are allocated among a number of nations.

6.52. The question of placing a valuation on fishing quotas is discussed in detail in Chapter 8 and depends crucially on the determination of the resource rent of the quantity and nature of the fish covered by the quota. Briefly, when fishing quotas are freely bought and sold on an open market, this is the value the SNA ascribes to the quota. In a well functioning market, this value will represent the net present value of the expected future resource rent of the catch. When there is no market in quotas, it may be appropriate to place a value on the quota by estimating this discounted value of the future resource rents.

Emissions permits

6.53. Emissions permits designate the amount of specific emissions, for example greenhouse gases, that may be generated before triggering a penalty payment. As with fishing rights, the quantity of emission permitted is often based on historical patterns. Such permits may be used simply as regulatory mechanisms but more realistically by allowing the permits to be traded, and in particular to be traded internationally, they provide an incentive for a producer to reduce his emissions so that he may realise the value of the emissions permit by selling or leasing it.

Accounting entries for tradeable permits

6.54. When a tradeable permit is issued, the unit issuing the permits (almost always government) creates the asset and records this creation in its other changes in assets account. If the permit is sold (maybe by auction or maybe at a predetermined price), then the sale and purchase are recorded in the capital accounts of the two units involved. If it is issued free, but has a positive value, determined e.g. on markets or through net present value calculations, it is still recorded in the same way as sale and purchase in the capital account, but in addition a capital transfer of the same size is made from the issuer to the new owner of the permit. This transfer exactly cancels the acquisition of the permit so the lending or borrowing position of each of the two units is unaffected.

6.55. Tradeable permits may be of infinite duration or for a fixed period. The value of a tradeable permit is determined in the market but it is assumed that the value is consistent with a net present value representing the value of the permit for each of the years for which it is valid, suitably discounted. If the life length of the permit is fixed, as each year passes, the market value will decrease, reflecting the approach of the expiry date. This decrease in the value of the tradeable permit is recorded as disappearance of an intangible non-produced asset in the other changes in assets account.

6.56. For as long as they are valid, permits may be traded and any actual trading is recorded as before in the capital account. The market value of permits may rise and fall in response to changing supply and demand patterns, giving rise to holding gains and losses on the permits. These holding gains and losses are recorded in the revaluation part of the other changes in assets account.

6.57. The introduction of tradeable permits aims to limit the production giving rise to environmental damage by legislative means, implemented *via* a capital market mechanism. While the existence of tradeable permits is expected to influence production behaviour, it does not show up in the production account but in other SNA accounts dealing with the acquisition of assets. Even when an annual licence is issued for the use of environmental assets, this would only feature in the production account if it were classified as a tax on production which, an indicated above, is unlikely to be the case. Instead it would be recorded as a payment of rent in the distribution of primary income account.

D The environmental consequences of disposing of fixed capital

1 The problem

6.58. As well as considering the impact on the environment as production occurs, it is necessary to consider what costs are incurred to prevent environmental problems when production ceases. Typical instances include the following:

nuclear power plants must be decommissioned and final storage of nuclear waste must be provided;

oil rigs and other mining equipment must be dismantled and removed;

landfills, which when operation ceases, must be sealed, gas and leakage collection systems completed, and supervision equipment installed.

6.59. These may be referred to briefly as ***terminal costs***; that is, those where the costs can be and should be anticipated during the production periods prior to closure and provision made for them to be met during the life of the asset. Another type, which we may categorise as ***remedial costs,*** occurs when production has already ceased and no provision was made while production was in progress for remedial action to be taken. Examples are the rehabilitation of sites contaminated by past activities; for example, storage of fuels, former landfill and mining sites.

6.60. These costs are associated with measuring the use of produced capital in the SNA and it is useful first to review the concept of consumption of fixed capital and how it should be recorded.

2 Consumption of fixed capital

6.61. The using up of manmade capital is taken into account in a production account by means of an allowance for consumption of fixed capital. This is usually referred to by commercial accountants as depreciation and thought to be the writing-off of the original costs of the assets involved over their useful life. More properly though, the consumption of fixed capital shows the decrease in the net present value (NPV) of the future income stream to be expected from the use of the asset, a sum which should be deducted from income and converted to another form of capital if the capital base is to remain intact.

6.62. The economic assumption is that the cost to purchase the asset, either new or at any period of its useful life, is equal to the NPV. If the asset costs more than the NPV, it would not be a good investment; if the NPV exceeds the asset price, the seller of the asset could ask for more. It is often assumed that, in the absence of inflation, the cumulated value of the consumption of fixed capital must be equal to the original purchase price of the asset. However, it does not necessarily follow that the original purchaser will benefit from the whole of the NPV. For example, hire cars may be sold to individuals or aeroplanes sold to a foreign airline after only a few years of service. The original purchasers keep their capital intact by allowing for the decline in value only between the point of acquisition and time of disposal of the asset. To include the whole of the value would be to overstate the deduction from income and understate national income.

6.63. Even making the calculation for consumption of fixed capital does not ensure that capital is kept intact. It would be if the sum for consumption of fixed capital were immediately reinvested or even if it were set aside as a financial asset against the day when the asset would eventually be replaced. However, the owner of the asset may decide to spend the amount of consumption of fixed capital *as if* it were current income. In the SNA, this expenditure would be recorded as current expenditure but it would result in a decline in net worth. It is important to recognise that the correct valuation of consumption of fixed capital does not depend on the creation of a "sinking fund" for the eventual replacement of the asset. It is simply a calculation of what proportion of receipts must be excluded from a measure of income to permit the *possible* maintenance of capital intact.

3 Terminal costs

6.64. Consider two prototypical examples. Power plants and oil rigs are assets where most of environmental protection costs are actually incurred at the end of their useful life as some sort of decommissioning activity. In contrast, landfill sites have costs which may be ongoing throughout their use as well as appearing when the use terminates.

Power plants and oil rigs

6.65. The case was discussed above where an asset such as a car or an aeroplane was sold before the end of its useful life so that the cumulated value of consumption of fixed capital will be less than the purchase price. For some assets, instead of a positive disposal value, there will be actual disposal costs, a sort of negative disposal value. If such items are disposed of and the owning enterprise continues in business, these costs will be deducted from income, possibly by including them as part of intermediate consumption. There is a question about whether this is a conceptually correct recording, as well as the issue of what happens if the asset is disposed of and the costs incurred only at the end of the life of the owning enterprise when there is no income against which to set these costs.

6.66. It was stated above that the NPV of the expected earnings from the deployment of an asset on acquisition should be at least as great as the purchase price to make the purchase cost effective. When a hire car is purchased, the sum of the disposal value plus the NPV of the expected earnings must together equal the acquisition price. If it is known in advance that there will be significant disposal costs, the expected earning capacity of the asset must be enough to cover both the acquisition price and the disposal cost if the purchase is to be cost effective.

6.67. The value of an asset at any point in time should be determined by discounting the income to come in future years. If instead of income, there are costs to be incurred in future, these also should be built into the value of the asset, discounted as for income. Any potential buyer of the asset would have to factor the disposal costs as well as the earning potential of the asset into his decision to buy and the price to offer. The prospect of disposal costs affects the value of the asset throughout its life. Consumption of fixed capital should still be calculated as the change in the value of the asset between the start and end of the accounting period but now this will take account of the disposal costs as well as the income earning capacity of the asset. Just before the end of its life, the asset will have a negative value showing that it actually represents a liability to the enterprise which is about to face the disposal costs. The disposal costs should be recorded as capital formation when they are actually incurred but the deduction of these costs from income *via* consumption of fixed capital will have been made progressively over the life of the asset just as the "replacement costs" are. If the enterprise has indeed set aside a "sinking fund" with the sums calculated as consumption of fixed capital, then this amount will be enough to offset the disposal costs. At that point, even a firm going out of business will have a financial asset being converted to capital formation to bring the total capital value for the produced asset back to be exactly zero.

6.68. Ignoring inflation for simplicity, the basis of the calculation of consumption of fixed capital should be such that its cumulated value over the asset life length should be exactly equal to the initial cost of the asset less any disposal value plus any decommissioning costs. This is a general statement and applies to the case where an asset is disposed of early (with a positive value), to the normal case where there is neither a disposal value nor cost, as well as to the case of interest here.

6.69. If the decommissioning activity also includes improvement or restitution of the production site to its condition prior to the start of production this part counts as fixed capital in the form (usually) of land improvement. In this case, though, the fixed capital has been paid for in advance of its being put in place rather than afterwards. The cumulative value of consumption of fixed capital during the life of the production site has covered the costs of both the acquisition of the assets at the beginning (or during) production and of decommissioning when production ceases.

6.70. No new financial asset needs to be created for the "sinking fund". It will be part of the enterprise's portfolio of financial assets, though its purpose might be earmarked in advance.

Practical recommendations

6.71. Nuclear agencies increasingly put aside part of their revenue to cover both decommissioning costs and storage of nuclear waste. Sometimes the size of these provisions may be determined not within the industry by consideration of the life length of the plant and present expected decommissioning cost but by legislation. Whatever the basis for calculating the provision, when the size of such provision is known, and if it is certain that the consumption of fixed capital estimates for the industry made for the national accounts do not take terminal costs into account, it is appropriate to add the amount of the annual provisions to the existing consumption of fixed capital estimates.

6.72. Although national accountants regularly revise many of the data series they work with, they seldom revise estimates of consumption of fixed capital except for the effect of price changes. Given that the expected useful life length of the asset may change, say because a newer technological model has become available, in principle the estimates of consumption of fixed capital should change to reflect the new situation. Changes in the amount of provisions (or costs of) decommissioning should be taken into account in the same way. In practice this may not happen, and one of the following approximations may have to be used.

6.73. Even when estimates for decommissioning costs have been made during the life of the asset, it may prove that these estimates do not exactly match the actual costs. In such cases (or when no allowance has been made at all) there are two alternatives open for recording this adjustment in the accounts. The first is to record the costs as positive capital formation, (viewing this as improvement to the site where the asset to be decommissioned is situated) with an immediate write-off in consumption of fixed capital. Immediate write-off of capital expenditure is not normally advocated in the SNA but in this case it could be regarded as a form of correction to the accounts which avoids retrospective adjustment to the time series of consumption of fixed capital over the asset's life.

6.74. The alternative suggestion is to treat the decommissioning costs as intermediate consumption. In this case the effect on net national income will be the same as above but the pattern of input coefficients in an input-output table would be radically changed and any calculations involving productivity studies will be distorted. If the enterprise is decommissioning equipment just prior to going out of business, this may be realistic but when the business continues it is less desirable.

6.75. Both the latter two suggestions are means of keeping the value of net worth after decommissioning correct but both mean that some costs which should conceptually have been set against a measure of income where capital is kept intact have been ignored. As long as users of national accounts continue to concentrate on gross measures of production rather than on income, this will not be a significant concern for them.

Landfill sites

6.76. Landfill sites may be designated in order to reclaim land, either from the sea or from the state in which it was left by previous economic activities such as quarrying for construction materials. The reclaimed land has an economic value in excess of the site before reclamation but this may be at the expense of environmental damage due to leaching of toxins into surrounding land, water and air. Other landfill sites may originate as greenfield sites in which case the economic value is likely to decrease during use and only recovers its original value by purposive restoration. Here too, environmental damage may be associated with the use of the site unless specific measures are taken.

6.77. One of the consequences of leaching from waste sites is that the damage may be felt, and recorded, by other economic activities. For example, leaching of chemicals may reach an aquifer used for water supply into agricultural land and thus reduce crop yield. In a more tolerant age, this was often just regarded as the farmer's bad luck. Increasingly, compensation for the farmer from the waste site operator is sought.

6.78. When landfill sites are legally authorised, the active control and operation of the site forms part of economic activity as conventionally measured. In the case of illegal, unauthorised dumping there is no associated economic activity of operating the landfill site to be measured. (It may lead to increases in other costs by the owner of the land used or by the public authorities in the case of roadside dumping.) The environmental implications are the same as for abandoned (legal) landfill and mining sites and are discussed in the section on remedial costs below.

6.79. Some landfill sites may be operated in a way that environmental damage is either inhibited or reduced on a continuing basis during the time the site is being used for dumping waste. If so the associated costs should be identified as environmental protection directly. Sometimes, there may be provisions in place to restore the site once it is no longer to be used for depositing waste. In this case, the procedures to be used are similar to those described above for power plants and oil rigs. Increasingly, the value to be placed on terminal costs is known from legislation which prescribes the clean up activities to be carried out. Note that these costs may not restore the full environmental capacity of the land, for example to good agricultural land, but may simply ensure it is environmentally safe.

6.80. When land reclamation is the motivation behind the operation of a landfill site, part of the output of the activity represents fixed capital formation as land improvement. The value of the output will be represented by the increase in the market value put on the resulting reclaimed land. Note the importance for this valuation of ensuring that any remaining environmental damages are known and estimated.

Practical recommendation

6.81. As in the case for power plants and oil rigs, the most practical solution for making estimates for the terminal costs for landfill sites may be to use the costs prescribed by legislation on mandatory clean up costs.

4 Remedial costs

6.82. The situation is different when remedial action is necessary after, sometimes long after, a landfill site has been closed and the original operator has left. For completeness we include illegal dumping sites here also. Two aspects need consideration. The first is the restoration of the land area to enable it to be used for some other purpose. (This is relevant only to the case where the site was originally a greenfield one since otherwise the "restorative" character of land reclamation is presumed in the motivation for the activity.) The second is to ensure no harmful emissions from past waste deposits leach into the surroundings causing environmental damage.

6.83. The accounting treatment of land restoration is straightforward. The costs of the restoration are treated as land improvement and are included in fixed capital formation. This is the situation in the national accounts and no additional estimates should be needed for the SEEA. In the balance sheet, the value of the land improvement is aggregated with the value of the underlying land value (a non-produced asset) and no longer separately distinguished. If the improved land provides a service in perpetuity either as land under buildings or as agricultural or recreational land which does not degrade, there may be no consumption of fixed capital to take into account. If there is degradation, the issues of putting a money value on this degradation are the same as those for degradation of land in general.

5 Summary

6.84. The 1993 SNA does not discuss specifically how to treat decommissioning costs or the treatment of managed landfill sites. What follows are recommendations based on an interpretation of the SNA. The recommendations are consistent with the capital services approach to measuring capital stock which various experts have pronounced to be consistent with the SNA and which is incorporated in recent manuals published by the OECD on the measurement of capital stock and productivity (OECD, 2001a and 2001b). Nevertheless, it should be clearly stated that this is not the practice in common use for estimating consumption of fixed capital in the SNA context at present. The matter has not been widely discussed in national accounting circles though perhaps it should be since a good measure of income on a net basis presumes that all appropriate costs of maintaining produced capital intact have been taken into account. If and when such a discussion leads to a formal clarification of the SNA position on terminal costs, then this section of the SEEA should be reviewed. In the meantime, the following summary of the conceptually correct way of handling these issued is put forward.

6.85. The total value of capital formation to be recorded for an asset over the whole of its life is the cost at acquisition (recorded as positive fixed capital formation), less any receipts from its sale (recorded as negative capital formation), plus any terminal or decommissioning costs (recorded as positive fixed capital formation). Each of these is recorded when it actually takes place.

6.86. The sum of these entries (adjusted as necessary for inflation) shows the amount which the enterprise owning the asset has to account for as consumption of fixed capital over the life of the asset.

6.87. If decommissioning costs are not taken into account, consumption of fixed capital will be too low, net operating surplus and (net) national income will be too high.

6.88. At any point in time, the sum of the original value of the asset less the present value of any receipts expected on disposal plus any terminal costs should exactly equal the sum of the residual value of the asset plus the cumulated consumption of fixed capital (assuming all entries are properly adjusted for inflation). The simplest case to consider is an asset which has no disposal value and no terminal costs. At the start of the asset's life, the whole value is embodied in the asset and the consumption of fixed capital is zero. At the end of the life, the value embodied in the asset is zero and the cumulative value of consumption of fixed capital is equal to the original value of the asset. At any intermediate point both the value embodied in the asset and the cumulative consumption of fixed capital to date will have changed but the total will remain constant (always assuming no inflation.)

6.89. At the end of a produced asset's life, the residual value in the balance sheet should be exactly zero. This means one of the following situations should exist.

The asset no longer exists; for example, an oil rig has been dismantled and sold as scrap;

The asset exists but no longer presents risk of damage in future; for example, a nuclear power station has been safely decommissioned.

Land used in production should have been returned to its original state; for example, landfill sites and mines should have been reclaimed. The value of the terminal costs, recorded as fixed capital formation represents the cost of "improving" the assets to these desired states.

6.90. If no estimates of terminal costs have been made during the life of the asset, they can be recorded when they occur as either capital formation and instant write-off *via* consumption of fixed capital or as intermediate consumption. Users should be alerted to the impact of these pragmatic solutions to the path of investment, the pattern of asset values and the consequences for technological and productivity studies.

E Locating economic instruments within the SNA

1 Tabulating redistributive processes

6.91. In order to see where the economic instruments described above appear in the national accounts, it is necessary first to recapitulate the essential features of the income and capital accounts of the SNA. What follows is much abbreviated and simplifies some of the details of the SNA in order to aid clarity for those not intimately familiar with the finer points of the system. Readers wanting further information should refer to the 1993 SNA or consult someone working in the national accounts area.

6.92. For simplicity, we consider only three groups of units within the national economy. All production is done by enterprises. Households are consumers only. Government acts as a redistributor of funds including through the provision of public services. (For simplicity, we include the production activities of government with enterprises so that we may concentrate on the redistributive nature of government actions.) In addition we must consider the rest of the world in so far as it interacts with the national economy.

6.93. The supply and use tables or input-output tables show a figure for value added and this is the starting place for the subsequent accounts. The first of these is the ***generation of income account*** which shows how value added is used to pay taxes on production, compensation of employees and consumption of fixed capital. Though it is not exactly how the SNA shows them, it is simplest for the representation we are considering here to show taxes on products in this account also. Some environmental taxes appear in this account under both tax headings. These may be paid by enterprise and households and are received by government. In addition there may be tax transactions with the government and residents of another country *via* the rest of the world account. Any subsidies paid by government relating to production are also shown in this account. By convention, they are shown on the same side of the account as taxes but with the opposite sign; that is, as negative payables instead of positive receivables and vice versa. Any value added not accounted for by one of the other items in the account is designated net operating surplus.

6.94. The ***distribution of primary income account*** shows how net operating surplus, compensation of employees and taxes on products and production are augmented by the receipts and depleted by payments of property income. Within property income we wish to distinguish rent on land and rent on other natural assets. These may be paid by any of the three groups of national units and received by any. Because of the SNA conventions on residence, there will be no such payments involving the rest of the world; any such transaction are always routed through a national unit even if a *de facto* unit must be set up to ensure this. The balancing item on this account is the balance of primary incomes.

6.95. The ***secondary distribution of income account*** covers payments and receipts of all sorts of transfers. These include payments of income tax, social insurance contributions and benefits as well as private transfers. The account is very important in explaining how redistribution of income occurs but has few entries relating to the environment. However, any transfers made to, say, environmental pressure groups or those undertaking environmental protection on a non-profit basis will appear here. The resulting balancing item on this account is the disposable income of the group of units concerned. This is used in the following account, the ***use of income account***, either to satisfy consumption needs or is saved. Among consumption needs will be those purchases of environmental services and environmental goods discussed in Chapter 5.

6.96. Saving is either used for investment purposes or is redeployed through financing borrowing and lending. The details of the ***capital account*** are discussed in Chapter 7 but here it is sufficient to note that this account contains details of acquisition and disposals of land and property rights and also shows capital expenditure related to environmental protection, mineral exploration, land improvement, major environmental protection projects and related to the net increase of cultivated plants and animals.

6.97. A schematic presentation of these accounts is shown in Table 6.3. Not all groups of units are involved in all transactions. For example, only enterprises and government are charged with consumption of fixed capital. For some transactions, one group of units make payments and another receives payment. For example, enterprises and households pay taxes; government receives them. Only enterprises and Rest of the World pay dividends but all groups of units, including (other) enterprises may receive them.

Table 6.3 Schematic presentation of income and capital accounts

Account	Item	Enterprises Payable	Enterprises Receivable	Government Payable	Government Receivable	Households Payable	Households Receivable	Rest of the World Payable	Rest of the World Receivable	Total
	Imports/Exports							-	+	+ -
Generation of income account	*Value added*		+							+
	Environmental taxes on products	-			+	-				
	Other taxes on products	-			+	-				
	Other taxes on production - environmental	-			+	-				
	Subsidies on production - environmental	+			-					
	Other taxes on production - non environmental	-			+	-				
	Subsidies on production - non-environmental	+			-					
	Compensation of employees	-		-			+	-	+	
	Consumption of fixed capital	-		-						
	Net operating surplus	-								-
Distribution of primary income account	*Net operating surplus*		+							+
	Rent on land	-	+	-	+	-	+			
	Rent on other natural assets	-			+					
	Interest	-	+	-	+	-	+	-	+	
	Dividends	-	+		+		+	-	+	
	Balance of primary income	-		-		-				-
Secondary distribution of income account	*Balance of primary income*		+		+		+			+
	Taxes on income, wealth etc.	-			+	-		-	+	
	Transfers to environmental organisations	-	+	-		-				
	Other current transfers	-	+	-	+	-	+	-	+	
	Disposable income	-		-		-				-
Use of income account	*Disposable income*		+		+		+			+
	Consumption of environmental services			-		-				-
	Other final consumption			-		-				-
	Saving/Balance on current account	-		-		-		-		-
Capital account	*Saving/Balance on current account*		+		+		+		+	+
	Capital formation - mineral exploration	-								-
	Capital formation - land improvement	-								-
	Capital formation - net increase in cultivated biological resources	-								-
	Other capital formation	-								-
	Acquisition less disposal of property rights	-			+					
	Acquisition less disposal of land	-	+	-	+	-	+			
	Capital transfers	-	+	-	+	-	+	-	+	
	Net lending or borrowing	-		-		-		-		-

6.98. The right most column of Table 6.3 shows the total for each transaction across the whole economy. For many of the items there is no entry. This is because many of the items are redistributive in nature and so total payments must be equal to total receipts. In addition, the balancing items of the account appear first as a payable in one account and then as a receivable in the next so these also cancel. Non-cancelling items in the total column are shaded and illustrate a familiar identity. Imports less exports plus value added equals final consumption plus capital formation. It is because the income and capital accounts reduce on consolidation to this GDP identity, that for some analyses of economic activity, supply and use tables are sufficient. However, as is clear from the bold entries and our interest in environmental transactions, we need to investigate the income and capital accounts if we wish to have a complete picture not just of the interaction between the economy and the environment but also of the role played by the different units in the economy.

2 *Portraying redistribution in a matrix form*

6.99. Just as the goods and services account, that is the basic GDP identity just quoted, can be expanded into a very useful matrix form *via* the supply and use tables so the other accounts can be expanded into a matrix presentation also. When only national accounts elements are considered, the result is a social accounting matrix (SAM) as explained in Chapter XX of the 1993 SNA. But here too a hybrid version can be established by adding physical information on the use of natural resources and ecosystem inputs and on residuals generated. This hybrid SAM is also a NAMEA, in fact a much fuller expression of one than the versions considered in Chapter 4.

6.100. One of the reasons that national accounts tables are sometimes difficult to understand is that they try to portray a three dimensional table on a two-dimensional piece of paper. In almost all cases, the information to convey is what sort of transaction is being considered, who pays and who receives. It is possible to show who pays and who receives for any given transaction, or for any recipient which transactions are made by which payers or conversely for any payer which transactions are made by which recipients. The simplest tables, but least informative, are those which give a list of transactions but with no information on either payers or receivers. Often, of course, what happens in practice is that a table of many transactions is given with a heading which states the payer and receiver (if relevant) and the list of transactions is repeated for different headings.

6.101. The supply and use tables presented in chapters 3 and 4 conform to this scenario. In the supply table, a list of products is given for the industries which make them; that is, the "what" and "from whom" are detailed but not the "to whom". The use table shows "what" and "to whom" but not "from whom". As long as products and industries use different classifications, these two tables cannot be combined in a single two-dimensional table. An input-output table can be seen as a means of avoiding the third dimension by mapping the product and industry classifications into one another.

6.102. Consider the row for other current transfers from Table 6.3. This shows there are four possible (groups of) payers and four possible recipients. A full articulation of transfers would involve a four by four matrix with 16 entries to replace the eight in Table 6.3. What Table 6.3 actually shows is the row and column totals of the full four by four matrix; or, if we included row and column totals and made it a five by five matrix, it would be these totals which appear in Table 6.3.

6.103. Table 6.4 gives an example of how to expand a simplified version of the secondary distribution of income account. For simplicity it is assumed there are no transactions with the rest of the world. As with the earlier matrix presentations, for each account, receipts are entered along a row and payments are entered down the matching column. The complete matrix of which this is a part appears as a chequer board with squares on the diagonal representing each of the rows in Table 6.3 expanded to show all the payers and receivers and balancing items in elements just below the diagonal.

6.104. The top left hand block of the table shows the entries for the balance of primary incomes for the three groups of units in the national economy. This block appears at the intersection of the columns for the distribution of primary income account and the rows for the secondary distribution of income account.

Table 6.4 Illustration of a secondary distribution of income account in matrix form

		Distribution of primary income account			Secondary distribution of income account		
		Enterprises	Government	Households	Enterprises	Government	Households
Secondary distribution of income account	Enterprises	Balance of primary income					Other current transfers to enterprises from households
	Government		Balance of primary income		Taxes on income to government from enterprises *plus* other current transfers to government from enterprises		Taxes on income to government from households *plus* other current transfers to government from households
	Households			Balance of primary income		Other current transfers to households from government	
Use of income account	Enterprises				Disposable income		
	Government					Disposable income	
	Households						Disposable income

6.105. The top right block of entries shows the transactions for the secondary distribution of income and appears on the main diagonal of a full SAM. The items in the bottom right block of the table are the balancing items for this account, disposable income. Since, as its name implies, the secondary distribution of income account is redistributive in nature, and since in this case there are no entries for the rest of the world, total disposable income has the same total value as the balance of primary income. The significance of the elaboration is that the distribution of the same amount of income is different after secondary redistribution has taken place. This block, like that for the previous balancing item, the balance of primary income, appears below the diagonal where the rows and columns for two adjacent accounts intersect.

6.106. Two observations can be made from comparing Table 6.4 and Table 6.3. Because the transactions involving taxes are restricted to only one unit, government, being the receiver, the matrix format does not add much information in this case. On the other hand, for transfers (and it would be so if we had included taxes paid to and by the rest of the world) the matrix format allows much greater detail to be specified. The cost is that the physical size of the table increases quite considerably. Further, when a SAM is actually compiled in practice, the words in the entries are omitted and the user is left to remember what sort of transactions occur at each of the intersections. Nor are the time series aspects of the system obvious from what is essentially a cross-sectional presentation. For these reasons, a matrix presentation is often used to explain or illustrate some of the inter-relationships of a full system but the actual detailed tables are still presented as expansions of individual parts of the full matrix in normal two-way tables. However, conceptualising the system in matrix format is a powerful way of investigating other dimensions of the accounts and deploying the flexibility inherent in the system as the following examples illustrate.

3 Exploiting the potential of a matrix formulation of the accounts

6.107. Table 6.5 shows a schematic version of a matrix presentation of the supply and use tables augmented by the complete sequence of accounts of the SNA together with the physical data on natural resource and ecosystem inputs and residual outputs. The largest section, which covers the national economy, has the block diagonal appearance described above when discussing the expansion of the secondary distribution of income account. To the right and below are two borders, the first covering the transactions with the rest of the world economies and the second flows to and from both the national environment and that of the rest of the world.

6.108. In this format, the role of the interactions between the national economy and the rest of the world is immediately clear. Apart from imports and exports, for most developed countries the other flows, though important, tend to be relatively small compared to the magnitude of the flows within the national economy. For less developed countries, though, this may not be the case and seeing at a glance the importance of inflows of migrants' earnings *via* transfers from abroad or debt interest payments in property income due abroad can give a vivid picture of the dependence of the country on the international economy.

6.109. The first two rows and columns of Table 6.5 correspond to the hybrid supply and use table in Figure 4.1 though some compaction has been used simply for reasons of space. The entries for trade and transport margins and for taxes less subsidies on products are omitted from the first column. The residuals generated by consumption and capital formation are shown in a combined row. Later elaborations of the accounts for consumption and capital formation show how these residuals can be associated with the activity generating them.

Environmental taxes

6.110. Table 6.5 does not show any entries for taxes explicitly. In order to make these explicit, some further manipulation of the table is necessary. If our interest is to look at all types of taxes so that we may identify the impact of environmental taxes through the matrix it is helpful to add a row and matching column for total taxes. This row and column are filled by partitioning other flows to separate the tax element from the rest.

6.111. The first step is to add an explicit entry for the taxes on products and imports which must be added to the value of goods and services (row Tax, column 1) to bring these up to market prices. Row and column 2 are then partitioned to show the generation of income account separately from the production account. The new row and column 2a correspond to the previous production account at basic prices, giving a balancing item of value added at basic prices. In row and column 2b, other taxes on production are separated out from value added and shown as a payment in the row for taxes and a receipt in the tax column. (The point of this is better seen when there is further disaggregation showing that it is enterprises which pay the tax and government which receives it.) In fact the receipt of taxes on products including taxes on imports are shown in the same entry in the column for tax receipts.

Table 6.5 A hybrid national accounts matrix

			National economy							Rest of the World	National environment	Rest of the world environment
			Goods and services (products)	Production (industries)	Distribution of primary income account	Secondary distribution of income account	Use of income account	Capital account	Financial account			
			1	2	3	4	5	6	7	8	9	11
National economy	Goods and services (products)	1		Intermediate consumption			Final consumption	Capital formation		Exports		
	Production (industries)	2	Output								Residuals from production	Residuals from production
	Other residual generation										Residuals from consumption and capital formation	Residuals from consumption and capital formation
	Distribution of primary income account	3		Value added	Property income					Primary income flows from the ROW		
	Secondary distribution of income account	4			Balance of primary income	Current transfers				Current transfers from the ROW		
	Use of income account	5				Disposable income						
	Capital account	6					Saving	Capital transfers		Capital transfers from the ROW		
	Financial account	7						Net lending or borrowing	Acquisition and disposal of financial assets			
	Rest of the World	8	Imports		Primary income flows to the ROW	Current transfers to the ROW		Capital transfers to the ROW	Net lending to or borrowing from the ROW		Residuals from the ROW economy	
	National environment	9		Environmental inputs to production			Environmental inputs to consumption			Environmental inputs to ROW economy		
	Residuals	10		Residuals re-absorbed by production				Waste going to landfill sites				Cross-boundary residual out-flows
	Rest of the world environment	11		Environmental inputs to production			Environmental inputs to consumption				Cross-boundary residual in-flows	

6.112. The next step is to separate out that part of current transfers which represent payments and receipts of current taxes on income, wealth etc. The payments are moved down to the row for tax payments; the receipts are moved right to the column for tax receipts. Again, this exercise is more interesting when the payments are divided between enterprises and households and the receipts shown accruing to government. A similar exercise could be done to separate capital taxes from other capital transfers, though this is not shown in Table 6.6. The extension of these manipulations to distinguish those taxes deemed to be environmental in nature is straightforward.

Table 6.6 Introducing taxes in the matrix

			National economy									
			Goods and services (products)	Production (industries)	Generation of income account	Distribution of primary income account	Secondary distribution of income account	Use of income account	Capital account	Financial account	Rest of the World	Tax receipts
			1	2a	2b	3	4	5	6	7	8	Tax
National economy	Goods and services (products)	1		Intermediate consumption				Final consumption	Capital formation		Exports	
National economy	Production (industries)	2a	Output									
National economy	Generation of income account	2b		Value added at basic prices								Taxes on products, imports and production
National economy	Distribution of primary income account	3			Value added at market prices	Property income					Primary income flows from the ROW	
National economy	Secondary distribution of income account	4				Balance of primary income	Current transfers other than taxes on income, wealth etc.				Current transfers from the ROW	Taxes on income, wealth, etc.
National economy	Use of income account	5					Disposable income					
National economy	Capital account	6						Saving	Capital transfers		Capital transfers from the ROW	
National economy	Financial account	7							Net lending or borrowing	Acquisition and disposal of financial assets		
	Rest of the World	8	Imports			Primary income flows to the ROW	Current transfers to the ROW		Capital transfers to the ROW	Net lending to or borrowing from the ROW		
	Tax payments	Tax	Taxes on products and imports		Other taxes on production		Taxes on income, wealth etc.					

6.113. Chapter 4 described how an input-output table can be used to derive the total import content or total environmental content of a given pattern of final demand. Once a table such as Table 6.6 has been completed, a new input-output table can be derived and the same processes used to derive direct and indirect effects of taxes on final demand.

Disaggregating households and household consumption

6.114. As noted, in practice the rows and columns for the income accounts (numbers 3 to 7) are disaggregated to show the various groups of units concerned (broadly speaking institutional sectors in SNA terminology) including identifying households where appropriate. One of the main motivations behind the idea of a SAM is to be able to focus attention on households, their income and consumption quite as much as on production. Many SAMs therefore disaggregate households by type of household, often by income level.

This means that different pairs of rows and columns show the income and expenditure patterns of high-income families, middle-income families and low-income families for example.

6.115. However, as well as introducing new rows and columns to disaggregate a previous heading, one can also use this device to introduce a new classification. In the case of the environment, we may well want to distinguish the reasons for which consumption is undertaken and not just the products purchased. This means we may group under a heading for transport all expenditure on public transport and the costs of running a private car. If we disaggregate the original column where consumption for all households was shown in order to display the cross-classification of products bought and their function or purpose (let us say according to COICOP) then we must introduce the same number of corresponding rows. In each of these rows, we can identify the expenditure for a given purpose and the residuals generated also classified according to purpose or function. This allows us to combine residuals coming from food consumed at home and in a restaurant and to make a distinction between residuals coming from paper products used for hygiene and cleaning (kitchen towels for example) from those used for entertainment (books and newspapers for example). An example of how this functional classification can be introduced is given in Table 6.7. It is, of course, possible to carry out successive disaggregation so that, for example, households can be disaggregated by income level as well as disaggregating consumption expenditure by purpose. The only limits to the number of disaggregations which can be incorporated come from the imagination to construct inter-related disaggregation, data limitations and the size of the page on which the matrix is to be portrayed.

Table 6.7 Example of disaggregating household consumption

				National economy										
				Goods and services (products)	Production (industries)	Distribution of primary income account	Secondary distribution of income account	Use of income account		Capital account	Financial account	Rest of the World	National environment	ROW environment
								Inputs to functions	Total use					
				1	2	3	4	5a	5b	6	7	8	9	11
National economy	Goods and services (products)		1		Intermediate consumption			Purchases by consumers		Capital formation		Exports		
	Production (industries)		2	Output									Residuals from production	Residuals from production
	Other residual generation												Residuals from capital formation	Residuals from capital formation
	Distribution of primary income account		3		Value added	Property income						Primary income flows from the ROW		
	Secondary distribution of income account		4			Balance of primary income	Current transfers					Current transfers from the ROW		
	Use of income account	Outputs of functions	5a						Final consumption				Residuals from consumption	Residuals from consumption
		Total use	5b				Disposable income							
	Capital account		6						Saving	Capital transfers		Capital transfers from the ROW		
	Financial account		7							Net lending or borrowing	Acquisition and disposal of financial assets			
	Rest of the World		8	Imports		Primary income flows to the ROW	Current transfers to the ROW			Capital transfers to the ROW	Net lending to or borrowing from the ROW		Residuals generated by non-residents	
	National environment		9		Environmental inputs to production			Environmental inputs to consumption				Environmental inputs to the ROW economy		
	Residuals		10		Residuals re-absorbed by production					Waste going to landfill sites				Cross-boundary residual out-flows
	ROW environment		11		Environmental inputs to production			Environmental inputs to consumption					Cross-boundary residual in-flows	

4 A hybrid accounting matrix for the SEEAland data set

6.116. Table 6.8 contains an example of a full accounting matrix for the SEEAland data set. It builds on the SEEAland tables in chapters 3, 4 and 5 and is consistent with similarly designated tables in other chapters also. It was in such a format that the concept of a NAMEA was first popularised by Statistics Netherlands.

6.117. The first row and column of Table 6.8 represents a ***goods and services account***. The second row and column show a production account. Together, these two rows and columns cover exactly the same range of monetary data as was shown in Table 4.2. The totals for products and industries agree exactly between the two tables. The degree of detail within products and industries are different however. In Table 6.8 the distinction is between environmental services, cleaner and connected products and other goods and services. This means that the entries in these rows and columns can also be matched with the data appearing in tables 5.6 and 5.7. In such a case, one would expect the data in Table 6.8 to contain information on ancillary activities measured in the same way as secondary activities as described in Chapter 5.

6.118. One strength of the matrix presentation is that any sort of disaggregation can be used for products and industries. Usually, these will be according to the conventional classifications, CPC and ISIC respectively, though as can be seen from this specific example attention may be concentrated on only part of the classification with the reminder aggregated.

6.119. Since Table 6.8 is a hybrid account, the generation of residuals from production as well as the inputs of natural resources, ecosystem inputs and residuals into production are also shown. These figures exactly match those given in Table 4.3.

6.120. One difference introduced in the production account of Table 6.8 as compared with Table 4.2 is the disaggregation of value added into that part representing consumption of fixed capital and the remaining, net, value added. The entry for consumption of fixed capital occurs in the column for production and a row which will be used to record entries in the SNA capital account. This item should contain entries for use of all produced assets including the environmental consequences of them as discussed in Section D.

6.121. The row and column labelled 2b represent the generation of income account and together with the row and column for tax receipts and payments (respectively) convert the balancing item from the production account which is value added at basic prices to a total at market prices as described in connection with Table 6.6. The figures for taxes in Table 6.8 are consistent with those shown in Table 6.2 and in Table 5.10.

6.122. The distribution of primary income account is shown in row and column 3. This shows the impact of property income on the distribution of primary income. Part of this property income is the rent payable on environmental assets which is discussed in Chapter 7.

6.123. Row and column 4 represent the secondary distribution of income account and, in particular, how transfers affect the allocation of income among sectors. Taxes on income are explicitly identified so they can be aggregated with taxes on products and on production in the special row and column for taxes. If information is available on the current grants, or transfers, made between sectors to finance environmental protection these can be shown by further disaggregating other transfers in this account. These flows are implicit in Tables 5.8 and 5.9 and would have been explicitly identified if a table such as Table 5.14 were compiled. Other transfers are simply shown in this table on the diagonal element where row and column 6 intersect. In practice, this element would be disaggregated to show the flows between different sectors.

6.124. Rows and columns 5 relate to household consumption. The way this is presented is consistent with the discussion above to allow for two different disaggregations of consumption to be shown. The entry on row 1 shows a disaggregation by product. By having a separate set of rows and columns for functions, this alternative classification can be given in row 5a. For reasons of space and because the product disaggregation chosen in row 1 is so close to a functional disaggregation separating environmental functions from others, only a single figure appears in the table. In addition to monetary flows, the volume of residuals generated by consumption activities can be shown in the columns to the far right of the table.

6.125. The use of income account in row and column 5b shows how disposable income is either spent on final consumption, either by households or government, or is saved.

6.126. The capital account is shown in row and column 6. In monetary terms, this account shows how saving is used to acquire new capital or is lent to other sectors. Because borrowing and lending must offset one another, it is this account which is at the heart of the identity that savings and investment must be equal. It is also the account which shows whether the economy is operating in a way to maintain total non-financial capital.

6.127. The balancing item linking the use of income account and the capital account, saving, is measured net, but capital formation is typically measured gross because this is the measure of new capital put in place. It is thus necessary to add back the value of consumption of fixed capital before balancing this account. This account also includes the acquisition and disposal of property rights. Sale and purchase of land is one example; the sorts of permits discussed in Section C are another.

6.128. Saving can be redistributed by means of capital transfers and these also are shown in this account. Again it is possible to specifically identify those which relate to environmental protection. Any other capital transfers would appear in the box where the sale and purchase of property rights is shown. They can be disaggregated by sector in a manner similar to that shown for current transfers.

6.129. The other feature of this table is the addition of physical information. The data in columns 11a and 11b show the flows of residuals. Here, for reasons of space, the only detail given is the distinction between the national environment destination and that of the rest of the world. For each of these columns, a breakdown by type of residual is possible as in Table 3.12 and Table 4.3. Similarly, the rows for residuals, natural resources and ecosystem inputs at the bottom of the table can also be disaggregated.

6.130. Column 8 relates to the rest of the world economy. In the upper part of the column, exports of goods and services are shown flowing from the national economy to that of the rest of the world. In the lower part of the column, flows of natural resources and ecosystem inputs from the national environment to the rest of the world economy are shown. Natural resources which are first extracted by residents and then exported, for example fish caught by national trawlers, will appear in the upper section of the column. Only natural resources directly extracted by non-residents appear in the lower entries; for example, fish caught in national waters by non-resident trawlers. The first are recorded in this table in monetary terms (though physical data is usually also available) and the second in physical terms only (though the usefulness of assigning a monetary value to these also will be discussed in later chapters).

6.131. The entries in the upper part of the columns for residuals, corresponding to the rows for national and rest of the world economies, show the extent of residual generation by economic activity and whether this flows to the national environment or to that of the rest of the world. The entry in row 8 shows the extent of residuals generated by non-residents operating within the national territory. This can be compared with the extent of residuals generated in the rest of the world by residents in the course of production and consumption (shown respectively in rows 2 and 5a, column 11b).

Table 6.8 A hybrid accounting matrix (NAMEA) for SEEAland

		Goods and services (CPC)				Production (ISIC)	Generation of income account	Distribution of primary income account	Secondary distribution of income account	Household consumption
Economic sphere		1a	1b	1c	Total 1	2a	2b	3	4	5a
		Trade and transport margins				*Intermediate consumption*				*Household consumption*
Goods and services (CPC)										
Environmental protection services	1a					*9*				*3*
Cleaner and connected products	1b					*1*				*1*
Other goods and services	1c		*0*	*0*		*655*				*344*
Total products			*0*	*0*		*664*				*347*
		Output at basic prices								
Production ISIC)	2a	*14*	*1*	*1,272*	*1,286*					
						Net value added at basic prices				
Generation of income account	2b					*518*				
							Net domestic product at market prices	*Property income*		
Distribution of primary income account	3						*588*	*100*		
								Balance of primary income	*Other transfers*	
Secondary distribution of income account	4							*588*	*641*	
Household consumption	5a									
									Disposable income	
Use of income account	5b								*588*	
						Consumption of fixed capital				
Capital account	6					*104*				
Financial account	7									
		Taxes less subsidies on products					*Taxes less subsidies on production*		*Taxes on income*	
Taxes										
Environmental taxes	Tax a			*3*	*3*		*2*		*2*	
Other taxes	Tax b	*0*	*0*	*67*	*67*		*2*		*66*	
		Imports of products								
Rest of the world	8		*0*	*363*	*363*					
Total for the economy		*14*	*1*	*1,704*	*1,719*	*1,286*	*592*	*688*	*1,297*	*347*
From the national environment						*Inputs to production*				*Inputs to consumption*
Natural resources	9a					256				1
Ecosystem inputs	9b					118				23
From the ROW environment										
Natural resources	10a					5				1
Ecosystem inputs	10b					3				1
Residuals						*Residuals re-absorbed by production*				
Generated by national economy	11a					7				
Cross boundary flows from ROW	11b									

Monetary flows (in italics) in billions of currency units; physical flows in million tonnes

Use of income account	Capital account	Financial account	Taxes	Rest of the world	Total for the economy	National environment	Rest of the world environment	Net flows to (+) and from (-) the environment		
5b	6	7	Tax	8		11a	11b			**Economic sphere**
Government consumption	*Gross capital formation*			*Exports of products*						Goods and services (CPC)
2	*0*				*14*				1a	Environmental protection services
					1				1b	Cleaner and connected products
157	*146*			*403*	*1,704*				1c	Other goods and services
159	*146*			*403*	*1,719*					Total products
						Residuals from production				Production ISIC)
					1,286	275	5		2a	
			Taxes less subsidies on products and on production							Generation of income account
			74		*592*				2b	
					688				3	Distribution of primary income account
			Taxes on income							Secondary distribution of income account
			68		*1,297*				4	
Household consumption by purpose (COICOP)						*Residuals from consumption*				Household consumption
347					*347*	47	1		5a	
					588				5b	Use of income account
Saving	*Purchase and sale of property rights*					*Residuals from capital formation*				Capital account
82	*3*				*189*	73			6	
	Net lending									Financial account
	40				*40*				7	
										Taxes
					7				Tax a	Environmental taxes
					135				Tax b	Other taxes
		Current balance/net lending to the rest of the world				*Residuals generated by non-residents*				Rest of the world
		40			*403*	6			8	
588	*189*	*40*	*142*	*403*	*9,012*	401	5	37		Total for the economy
				Inputs to ROW economy						
				1	258			-258		
				2	143			-143		
					6			-6		
					4			-4		
	Waste going to landfill sites						*Cross-boundary residual out-flows*			
	26				33		4	373		
						Cross-boundary residual in-flows				
						8		1		

6.132. The bottom right-hand segment of the table shows the flows between the national and rest of the world environments only; that is, just the cross-boundary flows of residuals carried by environmental media in both directions.

6.133. The row for residuals near the bottom of the table shows the amount of residuals reabsorbed by production and also the amount destined for landfills, in the capital column. This recording of the disposal of residuals in landfill is the working assumption in the SEEA but the alternative of immediate disposal to the environment is discussed in Chapter 3. Cross boundary residual flows to the environment of the rest of the world are also shown in this row.

6.134. The rightmost column of the table shows the balancing items or net flows to the environment (if positive) and from the environment (if negative). Such balances are not shown for the economy rows separately because they consist of the aggregation of the physical measures for products which are not shown in this table together with the physical measures for natural resources, ecosystem inputs and residuals which are shown. The total for the whole column, including those items not shown explicitly here, is still zero.

6.135. In this rather simplified set of monetary accounts, only imports and exports of products to and from the rest of the world are shown in monetary terms but the physical flows to and from the rest of the world feature as in Table 4.3.

6.136. This table omits a number of other flows which would appear in practice in a full set of national accounts. For example, Table 6.8 contains no information on transactions in financial assets and liabilities. Although Table 6.5 shows where entries for other transactions with the rest of the world would appear, no data values are shown here. Both current and capital transfers to and from the rest of the world could contain entries relevant to the financing of environmental protection expenditure.

5 Adding other physical data

6.137. The whole idea of a hybrid account is to combine in the same presentational tables monetary data on economic flows and corresponding physical flows. Although such an account can be constructed to be entirely compatible with the SNA, the paragraphs above show how variations in the economic classifications are possible as in the case of taxes or how alternative classifications can be combined. Further, it is possible to add other data to the basic framework and one obvious candidate is information on labour. The national accounts show how much is paid by industries to households as compensation of employees but there is not even a head count of employees included in the main flow accounts, though the SNA strongly recommends this be added as supplementary information. Within an accounting matrix, whether a purely monetary SAM or a hybrid one, a detailed labour accounting matrix can be added showing not just the number of employees but information relating to the gender, age, and skill level to give only three examples. From this it is possible to relate generation of residuals to the level and type of employment. For example, intensive agriculture or commercial mining results in large residual generation but few employees; peasant agriculture and artisanal mining may well lead to high levels of employment (though not necessarily income) and proportionately smaller levels of residual generation.

6.138. Analysis of the results of combining physical and monetary data must pay attention to the cross-correlations involved. A suggestion that low-paid women are more environmentally conscious than middle income men may in fact simply reflect that the former are mainly employed as shop assistants and in the health services where the latter work in road transport and construction. Within these constraints, though, adding labour considerations to the accounting matrix is an important step towards considering economic, environmental and social issues simultaneously.

Chapter 7 Asset accounts and the valuation of natural resource stocks

A Chapter overview

1 Objectives of the chapter

7.1. The basic model for the SEEA accounting system is to show how natural resources and ecosystem inputs are drawn into the economy, and products and residuals are generated. Chapters 3 to 6 discuss aspects of product and residual generation and the means to combat the latter. This chapter turns attention to the use of natural resources and ecosystem inputs in order to assess whether the stocks of these assets are being persistently depleted or degraded. In order to monitor the rate of depletion of a specific environmental asset, it is necessary to measure the stock of the asset at the start of an accounting period and to account for all the changes which occur during that period to give the stock level at the end of the period. For natural resources, these changes are likely to be quantitative. For ecosystems, the qualitative changes may predominate. An accounting process which links opening and closing stock levels in an accounting period is called an asset account. This chapter describes how to compile asset accounts for different sorts of environmental assets in both physical and monetary terms.

7.2. Physical information on the degradation of ecosystem inputs is a necessary basis for all attempts to place a valuation on degradation. However, the debate on the necessity and means of establishing monetary values for degradation is much more controversial than the debate on valuing depletion. While the physical aspects of degradation are discussed in this chapter, the question of valuation techniques is postponed to Chapter 9. In contrast, the present chapter addresses both the physical measures and monetary valuation of the depletion of natural resources.

7.3. The discussion of physical flows in Chapter 3 and the development of the supply and use tables there and the discussion of the integration of these flows with the corresponding monetary flows in chapters 4 and 6 are essential background to this chapter. The chapter is mainly theoretical and draws significantly on the economic accounting system of the SNA. It is not possible in the space available to give a complete review of all national accounting techniques and practices, but at the same time enough detail has to be provided for those national accountants who wish to understand the interface between the SNA and the SEEA. The result is that statements are sometimes made which non-accountants may have to take on trust or seek out a colleague who can help them find fuller underlying explanations. Equally, national accountants reading this chapter will find some simplification of national accounting issues peripheral to environmental accounting for the benefit of non-accountant readers.

2 Defining environmental assets

7.4. The starting point is to take the definition of an asset in the economic accounts and consider whether and how far this definition needs to be extended to cover the set of environmental assets of interest. Integral to this is the development of a classification of environmental assets. This is the subject of Section B.

7.5. Because the SEEA accounts are seen as an extension of those of the SNA, it is necessary to spend some time examining the relationship between the asset classification in the SNA and that proposed here for the SEEA. Different perspectives can be taken depending on whether the interest is in physical measures of assets or their monetary valuation. Both possibilities are examined since different sorts of analysis require one or the other, or sometimes both.

7.6. When looking at how changes in assets are incorporated in monetary accounts, it is necessary to make a clear distinction between those assets which are regarded as being "produced" (that is, those which come into existence as products resulting from economic production) and those which are "non-produced" (that is, those that occur as a result of purely natural processes). As with any dichotomy there are problems at the boundary and these are also discussed in Section B.

3 The form of an asset account

7.7. Section C introduces the idea of an asset account, initially in physical terms. The simplest form of an asset account shows how the closing stock of the asset can be calculated from the opening stock by adding and subtracting the changes which have taken place during the accounting period, generally a year. Asset accounts thus recall the accumulation accounts of the SNA. In the SNA, though, the accounts are usually drawn up for all assets of an institutional unit or sector; that is, the main interest is based on the criterion of ownership rather than the nature of the asset, though a disaggregation of assets by type is common at a second level. The SEEA asset accounts in contrast are concerned in the first instance with the nature of the asset and only secondarily (and not always) with the ownership of the asset by the various sectors of the economy.

7.8. The SNA asset account distinguishes four categories of changes in the assets recorded in the balance sheets. The first two of these are the sets of transactions recorded in the capital and financial accounts of the system. The third category, other changes in the volume of asset accounts, includes economic appearances and disappearances, and exceptional events such as natural disasters. Economic appearances relate not to physical appearances but rather the case where a pre-existing entity is drawn into the economic sphere by acquiring an economic value. Economic disappearances cover the symmetric case when an asset loses its value or leaves the economy. The fourth and last category of changes is recorded in the revaluation accounts and includes valuation changes due to the effects of price changes.

7.9. In an asset account in the SEEA, some variations to the SNA categories are adopted. Economic appearance and disappearance are replaced by additions to and deductions from stock levels with some consequential changes for entries recorded as other changes in assets, though these still include price changes, the effects of catastrophic losses and change of ownership.

7.10. Section C discusses briefly how physical asset accounts may be compiled for each main class of environmental asset. More detailed information for minerals, forests, aquatic resources and land are given in Chapter 8.

4 Valuation

7.11. For many environmental assets, the type of information which is of interest in physical terms will reflect the physical characteristics of the asset and the uses to which it is put. This means that physical accounts for different sorts of assets are often of a rather specific character and do not lend themselves to aggregation or integration in a wider set of accounts. By contrast, the rationale for monetary accounts is that a consistent basis of valuation may be applied precisely so that aggregation across asset classes is possible and comparison can be made with non-environmental assets in terms of their respective contributions to the nation's wealth. Section D discusses the theoretical basis for valuation of assets in the SNA and the SEEA. Those who do not wish to be drawn into the technical details may wish to read only the summary at the very end of the section which gives the key factors needed to determine values of different sorts of assets.

7.12. In order to convert an asset account in physical quantities into one in monetary terms, it is necessary to find a suitable means of determining the value of specific assets. Generally speaking, the SEEA uses the same principles of valuation as in the SNA but there are two restrictions on valuing assets based on the benefits yielded which must be addressed first.

7.13. Although the SNA is elaborated in purely conceptual terms, even in the manual itself and more particularly when accounts are actually compiled, it is recognised that some pragmatic compromises must be allowed in practice. The classification of assets is one case in point. Often a valuation is available only for a combination of assets; for example, for a building and the land on which it is situated as a single "package". This inhibits valuing all the assets in the SEEA classification in the same detail and with the same articulation as in physical terms. The areas where this is a particular problem are discussed in the first part of Section D.

7.14. The second issue concerns the identification of the benefits and uses of assets such as those discussed in Section B. In the market, the only question of interest is how much will someone pay for this asset. The issues of the benefits or uses of the asset are purely internal to the unit purchasing the asset and are not separately identified in the system. If two houses have identical physical characteristics, but one is situated with a spectacular view and the other facing a brick wall, the former will, in all probability, command a higher price. In effect the direct use benefits of the two houses are the same but the former has a much higher indirect use than the latter. Many financial assets contain, explicitly or implicitly, option and bequest benefits. Increasingly, techniques are being introduced into national accounting to separate out some of these different characteristics, especially when trying to distinguish quality change from price change.

7.15. The preferred method of valuing assets is by market price but this is very often not available for environmental assets. If environmental assets were valued in the market place as a matter of course, they would be absorbed within the SNA and the SEEA would be a different sort of satellite account, one which worked within the SNA boundaries rather than extending them. In practice land is the only non-produced asset which is widely valued and land has indeed been included in the SNA since its inception.

7.16. In the absence of market prices, other means of valuation have to be developed drawing on what market transactions are available and, where these are missing, on estimation methods based on the economic theory of price and value. This in turn leads to discussing the expected life length of the asset, the resource rent it provides and what sort of discount factor should be used to value future returns at the present time. These issues form the subject of the latter part of Section D.

7.17. In general, the market price of an asset should include an implicit valuation of all the benefits it can bestow on the owner. Even here there are complications. The valuation a household places on the durables it owns may be higher than the market price because they include sentimental value which would be recognised by members of the family but not others. Similarly, some of the benefits from environmental assets may accrue to persons other than the owner of the asset and thus not be included in the market price. This may especially affect option and bequest values when the benefits will accrue non-specifically to future generations.

7.18. This chapter concentrates on establishing valuations which are consistent with market prices as presently observed. Issues relating to the valuation of other aspects of environmental benefits and functions are discussed in Chapter 9.

5 Asset accounts in monetary terms

7.19. Section E shows how the valuation principles in Section D can be applied to the physical accounts presented in Section C to derive monetary asset accounts. The difference between physical quantities and economic volumes, first raised in Chapter 4 is relevant here again also. Since the principles to be applied vary from one type of environmental assets to another, there are separate sub-sections on the main assets.

7.20. The other issue addressed in Section E is the question of who owns the asset and who benefits from its exploitation. This is important in the context of how economic instruments are brought to bear on the management of environmental assets.

6 Linking asset accounts and flow accounts

7.21. The portrayal of the hybrid accounts in Table 6.5 includes all the flows connected with transactions in the system but no information about the level of stocks of assets. Section F shows how the presentation in Table 6.5 can be extended by the addition of the asset accounts to show the explicit linkage between stocks and flows in the system.

7.22. There is a direct link between the entries in the asset account, including the question of ownership, and the entries which appear in the flow accounts. This is an area where quite different views are held about whether and how the flow accounts should be brought into strict conformity with the asset accounts. This discussion of measuring the effects of depletion within the flow accounts is postponed until Chapter 10 when it can be combined with a discussion on measuring the effects of degradation based on the discussion of valuation in Chapter 9.

B Environmental assets in the SEEA

7.23. The starting point for the consideration of the extent of environmental assets to be included in the SEEA is the coverage of assets in the SNA.

1 Environmental assets in the 1993 SNA

7.24. In economic accounting the definition of an asset is associated with the conferring of economic benefits on the owner of the asset. Thus the 1993 SNA, for example, defines assets as:

> entities over which ownership rights are enforced by institutional units, individually or collectively, and from which economic benefits may be derived by their owners by holding them, or using them, over a period of time (1993 SNA, paragraph 10.2).

7.25. These benefits relate either to primary income derived from the use of the asset or simply to the fact that the asset in question represents a store of wealth which can be exchanged for another asset (including cash) which in turn fulfils one of these two conditions.

7.26. One feature of the revision of the SNA in 1993 is the extended treatment given to assets and the recommendation for more careful and complete compilation of balance sheets and the accounts linking the balance sheets at the start and the end of the accounting period. Because interest in linking environmental issues to the economic accounts was already evident at that time, particular attention was paid to specifying among the full set of economic assets those relevant to the environment:

> …naturally occurring assets over which ownership rights have been established and are effectively enforced, qualify as economic assets and [are to] be recorded in balance sheets. [Such assets] do not necessarily have to be owned by individual units, and may be owned collectively by groups of units or by governments on behalf of entire communities. In order to comply with the general definition of an economic asset, environmental assets must not only be owned but be capable of bringing economic benefits to their owners, given the technology, scientific knowledge, economic infrastructure, available resources and set of relative prices prevailing on the dates to which the balance sheet relates or expected in the near future (1993 SNA, paragraphs 10.10 and 10.11).

7.27. Environmental assets that do not meet the above criteria fall outside the asset boundary of the 1993 SNA. In particular, environmental assets over which ownership rights cannot be established are excluded. These include elements of the environment such as air, major water bodies and ecosystems that are so vast or uncontrollable that effective ownership rights cannot be enforced. Likewise, resources whose existence has not been clearly established by exploration and development (speculative oil deposits for example) or that are currently inaccessible (remote forests for example) are not considered assets in the 1993 SNA. The same is true for resources that have been established geologically or are readily accessible but that bring no current economic benefit because they cannot be profitably exploited under prevailing economic or technological conditions.

7.28. Despite these restrictions, a number of important environmental assets are included in the SNA as economic assets. A distinction is made between those assets which come into being as a result of economic production and those which occur in nature but which are drawn into the economy. These assets are described as produced and non-produced respectively. For biological resources, the words cultivated and non-cultivated are used as synonyms for produced and non-produced. For cultivated resources, a further distinction is made between plants and animals which yield the same product repeatedly over a period of time, such as dairy cattle and rubber trees, and those which yield a product only once, such as beef cattle and timber. These distinctions are discussed in greater length in Annex 1 together with the detailed SNA definitions of the component items.

7.29. Table 7.1 shows in bold type the environmental assets covered within the 1993 SNA in the context of the classification hierarchy used there. There are also some assets included in the SNA which are not themselves environmental assets, but are closely related to them and their exploitation. These are also included in Table 7.1 in italic type.

2 Environmental assets and functions

7.30. In the SNA, an asset, even an environmental asset, is defined in terms of the "benefit" limited to the provision of income or a stock of wealth which can be converted to monetary terms. For the SEEA, the concept of an environmental asset is linked to the provision of environmental "functions" as explained in Chapter 1.

7.31. This extension is predicated on the notion of an environmental function. The environment is defined as the naturally produced physical surroundings on which humanity is entirely dependent in all its activities. The various uses to which these surroundings are put for economic ends are called environmental functions. When the use of one function is at the expense of the same or another function now, or is expected to be so in the future, there is competition of functions. Thus the function of a water body as a sink for residuals and a source of drinking water are in competition. The high seas provide a habitat for fish but over-fishing of one species may destroy another which preys on the first. The sea is then no longer a habitat for the latter species.

Table 7.1 Environmental assets within the 1993 SNA

AN.1	Produced assets				
	AN.11 Fixed assets				
		AN.111 Tangible fixed assets			
			AN.1114 Cultivated assets		
				AN.11141 Livestock for breeding, dairy, draught, etc.	
				AN.11142 Vineyards, orchards and other plantations	
		AN.112 Intangible fixed assets			
			AN.1121 Mineral exploration		
	AN.12 Inventories				
		AN.122 Work in progress			
			AN.1221 Work in progress on cultivated assets		
AN.2	Non-produced assets				
	AN.21 Tangible non-produced assets				
		AN.211 Land			
			AN.2111 Land underlying buildings and structures		
			AN.2112 Land under cultivation		
			AN.2113 Recreational land and associated surface water		
			AN.2119 Other land and associated surface water		
		AN.212 Subsoil assets			
			AN.2121 Coal, oil and natural gas reserves		
			AN.2122 Metallic mineral reserves		
			AN.2123 Non-metallic mineral reserves		
		AN.213 Non-cultivated biological resources			
		AN.214 Water resources			
	AN.22 Intangible non-produced assets				
		AN.222 Leases and other transferable contracts			

7.32. Competing environmental functions mean that the environmental elements which provide the functions translate into economic entities. They are scarce in that more of one entails less of the other. A sacrifice has to be made of some of the competing functions and thus opportunity costs are necessarily involved in making the trade-off of functions. Some but not all of these trade-offs may translate into monetary terms.

7.33. Three types of competition among environmental functions can be distinguished: spatial, quantitative and qualitative. Spatial competition occurs when the amount of space available is inadequate to satisfy existing or expected future wants. For example space for transport or agriculture may be at the expense of space for ecosystems. Quantitative competition covers such natural resources as oil, copper or groundwater which may become quantitatively insufficient in the future. Qualitative competition covers the case where changes in the type of species or substances cause changes to other possible uses such as physiological functioning and habitat for other species.

7.34. Tracing the forces leading to competition of functions shows that the current use of the environment for production and consumption inhibits current and future availability of environmental functions, including those needed for future production and consumption. It is the need to maintain these functions in future and to investigate how present economic activity threatens them which explains the need to integrate environmental and economic accounting in both physical and monetary terms.

3 Environmental functions, benefits and uses

7.35. The functions provided by the environment yield a benefit to the economy. In Chapter 1 the functions were characterised as falling into one of three categories: resource functions, sink functions or service functions. Whichever of the three types of function is considered, the economy benefits from the use made of the function. One way to extend the SNA asset boundary is thus to express the benefits yielded by environmental assets in terms of the uses made of them. The benefits recognised in the SEEA can be grouped into two broad categories, use benefits and non use benefits.

7.36. ***Use benefits*** include both direct and indirect benefits. ***Direct use benefits*** include the use of environmental assets as sources of materials, energy or space for input into human activities. ***Indirect use benefits*** do not change the physical characteristics of the environment and are sometimes described as being "non-consumptive". The amenity benefit of landscape is one example.

7.37. Use benefits also include option and bequest benefits. ***Option benefits*** are those derived from the continued existence of elements of the environment that may one day provide benefits for those currently living. ***Bequest benefits*** are also derived from the continued existence of elements of the environment because they may one day provide benefits for those yet to be born. An example of these types of benefits is that derived from maintaining a rain forest to protect future sources of genetic material for drugs or hybrid agricultural crops.

7.38. In addition to these use benefits, an environmental entity may simply have an ***existence benefit***. That is, without any prospect of the entity being of use to humans now or in the future, it is desirable to maintain the existence of the entity.

7.39. The inclusion of option, bequest and existence benefits effectively broadens the scope of the SEEA asset boundary to include all land and natural resources. In addition, ecosystems are included in the SEEA asset boundary on the grounds that they provide a variety of services that bring indirect use benefits to humans. These services include, among many others, the cleansing of polluted air and water. Some environmental assets appear more than once within the classification, once in their own right and again as an integral part of another asset. This is so for soil and land and also ecosystems. This is useful when considering the physical aspects of environmental assets. It does not give rise to problems of double-counting in monetary terms because usually it is only the "integrated" asset for which a monetary value can be established. To the extent that the soil, for example, could be valued separately from land, the value of land would decrease by a matching amount.

7.40. While the SEEA asset boundary is in principle very broad, for practical reasons the environmental accounts actually compiled in any one nation will be much narrower. Actually accounting for each and every environmental asset would require an enormous amount of information, much, if not most, of which will not exist in most countries. Even for those assets for which useful information exists, building asset accounts may not be straightforward. Some benefits, such as carbon sequestration, may be more easily quantified in physical terms, so the practical possibilities for compiling physical asset accounts are less restricted than for monetary accounts.

4 The SEEA asset classification

7.41. The classification of environmental assets used in the SEEA is presented in summary form in Table 7.2. The complete version of the classification is presented in Annex 1. In this table, assets are grouped according to three broad asset categories; natural resources, land and surface water, and ecosystems. The assets included within each of these categories are described in more detail below.

Natural resources in the SEEA (EA.1)

7.42. Natural resource assets are defined as those elements of the environment that provide use benefits through the provision of raw materials and energy used in economic activity (or that may provide such benefits one day) and that are subject primarily to quantitative depletion through human use. They are sub-divided into four categories: mineral and energy resources, soil resources, water resources and biological resources.

Mineral and energy resources (EA.11)

7.43. Mineral and energy resources include subsoil deposits of ***fossil fuels***, ***metallic minerals*** and ***non-metallic minerals***. In the SEEA, these include not only the proven reserves (which are equivalent to the "subsoil assets" category AN.212 of the 1993 SNA) but also probable, possible and speculative resources. The latter categories are included on the grounds that these provide option and bequest benefits in so far as they may one day provide direct use benefits. (In practice, some countries use a more expansive definition of reserves even for the SNA because of the way in which the basic data are available.) Substantive discussion of these categories appears in Section E and in Chapter 8 in the section on mineral and subsoil deposits.

Table 7.2 SEEA asset classification

EA.1 Natural Resources
EA.11 Mineral and energy resources (cubic metres, tonnes, tonnes of oil equivalents, joules)
EA.12 Soil resources (cubic metres, tonnes)
EA.13 Water resources (cubic metres)
EA.14 Biological resources
EA.141 Timber resources (cubic metres)
EA.142 Crop and plant resources, other than timber (cubic metres, tonnes, number)
EA.143 Aquatic resources (tonnes, number)
EA.144 Animal resources, other than aquatic (number)
EA.2 Land and surface water (hectares)
EA.21 Land underlying buildings and structures
EA.22 Agricultural land and associated surface water
EA.23 Wooded land and associated surface water
EA.24 Major water bodies
EA.25 Other land
EA.3 Ecosystems
EA.31 Terrestrial ecosystems
EA.32 Aquatic ecosystems
EA.33 Atmospheric systems
Memorandum items – Intangible assets related to environmental issues (extended SNA codes)
AN.1121 Mineral exploration
AN.2221 Transferable licenses and concessions for the exploitation of natural resources
AN.2222 Tradable permits allowing the emission of residuals
AN.2223 Other intangible non-produced environmental assets

Soil resources (EA.12)

7.44. Soil resources include soil found on agricultural land as well as that found elsewhere within the national territory. There is no corresponding asset category in the 1993 SNA since soil is included with the land it covers.

7.45. In practice, it is agricultural soil that is of greatest importance in most countries from a natural resource perspective and it is likely that most countries would focus their soil accounts here. The ecological functions of soil are implicitly included. Topsoil that is extracted from one place and used to supplement soil elsewhere may be of sufficient importance in some countries to warrant compilation of an account. Sand and gravel resources are generally defined to be part of non-metallic mineral resources rather than soil resources. In some instances, the distinction between topsoil and sand and gravel is not clear-cut and it may be the case that topsoil resources end up included in the measurement of sand and gravel or vice versa.

7.46. It must be recognised that estimating the total stock of soil resources in physical terms may be very difficult, even for countries with sophisticated land statistics. Thus, the physical account for soil may show only the change in soil resources from one period to the next. Since soil forms very slowly, in practice the only change that would be shown in such an account would be the depletion of agricultural soil due to erosion or the extraction of topsoil. It should be noted that qualitative degradation of soil due to compaction, salinisation, loss of organic matter and other impacts of economic activity are accounted for in principle elsewhere in the classification. The loss in monetary value due to degradation of agricultural soils or depletion in the form of erosion is implicitly included in the value of agricultural land. The loss of ecological functions due to soil degradation is implicitly included in the measures of terrestrial ecosystems.

Water resources (EA.13)

7.47. Water resources are defined as the water found in fresh and brackish ***surface water*** and ***groundwater*** bodies within the national territory. In the case of surface water, the volume in artificial reservoirs and watercourses is included in addition to that in natural water bodies. The water of the oceans and open seas is excluded on the grounds that the volumes involved are so enormous as to make any stock measure meaningless and that extraction for human use has no measurable impact on them.

7.48. The 1993 SNA recognises only groundwater resources as a distinct asset and then only "aquifers and other groundwater resources to the extent that scarcity leads to the enforcement of ownership and/or use rights, market valuation and some measure of economic control." (This is the definition of AN.214 given in the annex to Chapter XIII of the SNA.) The SEEA extends this to include all groundwater resources on the basis that those that do not provide current use benefits may one day do so and, therefore, provide option and bequest benefits.

7.49. Surface water is not recognised as an explicit asset in the 1993 SNA. It is only mentioned in the SNA asset classification in association with land areas that are within the asset boundary. Surface water is, however, not fundamentally different from many other natural resources in that it can be extracted from the environment and brought into the economic system for use in a variety of ways. The SEEA therefore recognises surface water resources as environmental assets because they provide use benefits.

7.50. In some countries, the quantity of water found in surface and groundwater bodies is also enormous and the value of compiling a stock estimate for all such water is questionable, to say nothing of being a daunting task. In such countries, a pragmatic approach to water resource accounting could be to focus on only those water bodies that are in close enough proximity to human populations to play an important role in provision of water for human and industrial use.

7.51. This leads to a possible consideration that it is only water available for use which should be counted. One of the problems of water is that it may be in the wrong place or be available at the wrong time to be beneficial. Flood water, for example, may be plentiful but not necessarily useful.

7.52. The ecological functions of water are included in the SEEA under aquatic ecosystem assets (EA.32).

Biological resources (EA.14)

7.53. Biological resources include ***timber resources***, ***crop and plant resources***, ***aquatic resources***, and ***animal resources other than aquatic*** that bring use benefits today or that may do so in the future. Each category of biological resource in the SEEA asset classification is subdivided into cultivated and non-cultivated sub-categories.

7.54. The cultivated biological resources recognised in the SEEA are very similar to what the 1993 SNA calls cultivated fixed assets (AN.1114) and work in progress on cultivated assets (AN.1221). The non-cultivated biological resources recognised in the SEEA include those recognised as economic assets in the category of the same name in the 1993 SNA (AN.213). In addition, the SEEA includes non-cultivated resources that provide no current use benefit but that may one day do so (that is those with current option and bequest benefits). In practice, this means that conceptually all non-cultivated biological resources within the national territory fall within the SEEA asset boundary.

7.55. For both environmental and economic accounting, a key decision has to be made about when the growth in biological assets is regarded as being production and when not. The basic criterion concerns how far the process is controlled by human intervention. Fish raised in a fish farm are regarded as produced; those caught on the high seas are non-produced. Cattle and sheep raised on farms for milk, wool and meat are produced; wild game is non-produced. This leads to the usage of the words cultivated and non-cultivated to replace produced and non-produced for biological resources.

7.56. Inevitably, though, there are boundary problems between what is cultivated and what is not. A typical example concerns forests. A virgin forest in a remote area is non-produced. One which is planted, tended, felled and replanted on a regular cycle with continual labour inputs is produced. But which category applies to a forest where, once the initial planting is done, nature is left to take its course with little if any human intervention until it is mature enough for felling?

7.57. The SNA defines cultivated fixed assets as “livestock for breeding, dairy, draught, etc. and vineyards, orchards and other trees yielding repeat products that are under the direct control, responsibility and management of institutional units” and work in progress on cultivated assets is defined as “livestock raised for products yielded only on slaughter, such as fowl and fish raised commercially, trees and other vegetation yielding once-only products on destruction and immature cultivated assets yielding repeat products”. Extensive discussion has shown that these definitions are not sufficiently precise. It needs to be clear that control over the harvesting is not sufficient to establish that a biological asset is produced. If it were, any legislation controlling the use of virgin forests would be sufficient to cause a designation of “produced”.

7.58. In defining non-cultivated biological resources, the SNA specifies “animals and plants that yield both once-only and repeat products over which ownership rights are enforced but for which natural growth and/or regeneration is not under the direct control, responsibility and management of institutional units”. It is proposed, therefore, that the definition of cultivated assets, even in a purely SNA context, should be expanded by replacing the words “that are” with those in bold italics in the following phrase to read “livestock for breeding, dairy, draught, etc. and vineyards, orchards and other trees yielding repeat products ***whose natural growth and/or regeneration is*** under the direct control, responsibility and management of institutional units”.

7.59. Further, it should be understood that the processes involved must constitute production in the SNA sense and not consist of just legislative control. Examples of production are (i) control of regeneration; for example, seeding, planting of saplings, controlling the fertility of livestock; and (ii) regular and frequent supervision of the animals/plants to remove weeds or parasites, attend to illnesses, or restrict the area over which animals may roam to be within a supervised or otherwise designated area. It should normally be the case that the process of production has to be one that was classified to the corresponding industrial activity (agriculture, forestry or fishing). It is not sufficient that it only be part of government administration. Further, the level of this production activity has to be significant relative to the value of the resource and directly connected with the forest, animal or fish stock in question.

Land and surface water in the SEEA (EA.2)

7.60. Whereas the 1993 SNA includes only land areas over which ownership has been established and that can be put to economic use (1993 SNA, paragraph 12.18), the SEEA explicitly includes all land on the grounds that it might one day provide use benefits even if it does not today.

7.61. Land and surface water assets are defined as the areas within the national territory that provide direct or indirect use benefits (or that may provide such benefits one day) through the provision of space for economic and non-economic (for example recreational) human activities. Land and surface water assets are sub-divided into five categories: land underlying buildings and structures; agricultural land and associated surface water; wooded land and associated surface water; major water bodies; and other land.

7.62. Within the SNA, recreational land is one of the exhaustive categories of land. The principle basis for the SNA categorisation is that of economic value. Thus land which is used for both agriculture and recreation is treated as one or the other, depending on whether its value as agricultural land exceeds that of its value as recreational land or *vice versa*. In the SEEA, the categories are determined by use. Since recreational land typically has a dual use, it can legitimately be allocated to two headings. In order to have a categorisation where the sum is that of the total available land area, recreational land can be shown as an “of which” item under the relevant headings. The aggregate of all recreational land across all categories can be shown as a proportion of the total but could also be included in the specific sub-components.

Land underlying buildings and structures (EA.21)

7.63. Land underlying buildings and structures corresponds to the 1993 SNA asset category of the same name (AN.2111) except for the qualification on recreational land just noted. The SEEA asset classification goes beyond that of the 1993 SNA, however, in identifying sub-categories of land underlying buildings and structures ***within urban areas*** and ***outside urban areas***. The definition of an urban area will vary from country to country, but a working definition is any area where at the time of the most recent census there was a population of 1000 or more persons and a population density of 400 or more persons per square kilometre.

Agricultural land and associated surface water (EA.22)

7.64. Agricultural land and associated surface water is equivalent to the 1993 SNA category “land under cultivation” (AN.2112) except for the qualification on recreational land noted above and the exclusion of plantations included in EA.23 below. The SEEA goes beyond the 1993 SNA in identifying specific sub-categories of agricultural land: cultivated land, pasture land and other agricultural land.

7.65. ***Cultivated land*** is defined in the SEEA as land used for the growing of crops on a cyclical basis (for example, grain or vegetables) or a permanent basis (vineyards, orchards, etc.). Land that is normally cultivated but that has been allowed to go temporarily fallow is included in the cultivated land category. ***Pasture land*** is that which is used for the grazing of livestock and includes both land which has been improved through drainage or clearing and land which is in an essentially natural state. ***Other agricultural land*** includes small areas of wooded land, surface water, feedlots and miscellaneous land found within agricultural holdings.

7.66. Soil associated with agricultural land is classified as a natural resource in the SEEA, as discussed above.

Wooded land and associated surface water (EA.23)

7.67. Wooded land and associated surface water in the SEEA includes forested land and other wooded land. Forested land is defined as land under cultivated or non-cultivated stands of trees of a size of more than 0.5 hectares with crown cover of more than 10 per cent and on which trees are able to grow to a height of 5 metres or more at maturity. Other wooded land is defined as land either with a tree crown cover of 5-10 per cent of trees able to reach a minimum height of 5 metres or with a crown cover of more than 10 per cent of trees not able to reach a height of 5 metres.

7.68. Forested land is, in principle, classified by the SNA with other land under cultivation (AN.2112). Some wooded land may be included either in the residual SNA heading of other land and associated surface water (AN.2119) or omitted from the SNA altogether if the land is so remote or so protected that no economic value is envisioned in the foreseeable future.

7.69. The value of the ecological functions provided by wooded land, to the extent that this can be calculated, is captured in the value of forest ecosystems (EA.313).

Major water bodies (EA.24)

7.70. Major water bodies are defined in the SEEA as bodies of water large enough to be separately identified from the surrounding land. The size at which a water body can be considered "major" is, of course, dependent upon the resolution of the underlying land statistics. With the advent of geographic information systems technology and remotely sensed land statistics, it is possible to collect and manipulate large volumes of detailed land statistics. In countries in which these technologies are available, a "major" water body is likely to be defined to be smaller than in countries with more basic land statistics.

7.71. The 1993 SNA asset classification has no specific category for surface water bodies though, as in the SEEA classification, all the land categories include associated water. To the extent that major water bodies meet the criteria for definition as economic assets, they are implicitly included in the 1993 SNA as part of other land and associated surface water (AN.2119).

Other land (EA.25)

7.72. This residual category includes all land not previously allocated to one of the other headings in this section. It includes those parts of the SNA categories of recreational land (AN.2113) and other land (AN.2119) not included in any other SEEA category. Areas of recreational land not included in previous headings, such as sports facilities and open recreational spaces appear in this heading but again can be shown as an "of which" component. For geographically compact and densely populated countries, it is probable that all the land of the territory will be included in one or other of the SNA categories. For countries with large, sparsely populated areas, especially if these are climatically harsh, there may be areas with no foreseeable economic value. These would be excluded from SNA assets but included within the SEEA asset boundary and fall in the present category.

Ecosystems in the SEEA (EA.3)

7.73. The third broad category of environmental assets recognised in the SEEA is ecosystem assets. Ecosystems can be defined simply as groups of organisms and the physical environment they inhabit (Ricklefs, 1990). They are recognised as assets in the SEEA for their provision of indirect use benefits for humans in the form of a variety of services, including the cleansing of fouled air, water and soil, protection against solar radiation, regulation of geochemical flows and others. Even measuring the services provided by ecosystems is difficult and measurement of the basic stock is even more so. Nevertheless, it is important to recognise that conceptually such a stock exists and it is this stock which represents the environmental asset in the SEEA.

7.74. With the exception of natural resources that provide direct use benefits, the individual organisms and physical features that make up ecosystems are not classified as unique assets in the SEEA. This reflects the fact that it is not generally the components of ecosystems that benefit humans, but the systems as a whole. However, because natural resources are recognised as specific assets, some elements of the environment appear twice in the SEEA asset classification, once as natural assets and again as components of ecosystems. Thus, forests that are used as a source of timber are classified as natural resource assets. Since these same forests provide other benefits as well (carbon absorption for example), they are also classified as ecosystem assets. This reflects the fact that these forests provide more than one kind of benefit. As natural resources, they provide direct use benefits, while as components of ecosystems they provide indirect use benefits. It is necessary to recognise both roles of forests and other biological resources if a complete picture of the benefits provided to humans by the environment is to be captured in the SEEA. Note, though, that the inclusion of ecosystems as a separate category, like that of the inclusion of soil, means that there is an element of double counting in the SEEA classification, deliberately introduced to enable different environmental aspects to be examined.

7.75. Three types of ecosystem assets are recognised in the SEEA; ***terrestrial ecosystems***, ***aquatic ecosystems*** and ***atmospheric systems***[1]. Each of these is further sub-divided according to the major types of sub-systems found on the planet. Still further sub-division is possible to meet the needs of individual countries. For example, forest systems could be further sub-divided into coniferous, deciduous and mixed wood sub-categories, each of which could be sub-divided again according to naturalness of the forest.

7.76. A few services are general to all three broad systems. They all play a role in regulating global material and energy flows, absorbing human wastes, and providing environmental amenities. Other services may be offered by some systems and not by others. If it is desired, countries may further subdivide the ecosystems headings in their asset classifications to identify each of the services provided by a specific environmental system and attempt to provide separate statistics for each service.

C The accounting entries for an asset account

7.77. The structure of an asset account is shown in Table 7.3. As explained at the outset of the chapter, the objective is to enumerate the causes of change in the level of stocks throughout the year so that the opening and closing stock levels can be reconciled.

7.78. Most of the changes are the effect of either economic activities or natural processes. One of the differences between the SNA and the SEEA is the way in which these different types of changes are recorded

1 The term “atmospheric systems” is used instead of “atmospheric ecosystems” because the atmosphere is abiotic whereas ecosystems by definition include biotic and abiotic elements.

so that it is important to separate them. Sometimes an exact separation will not be possible and in those cases a judgement should be made as to the dominant cause in order to make the corresponding attribution.

Table 7.3 A generic asset account for a physical asset

Opening stock levels		
	Increases in stocks	
		Due to economic activity
		Due to regular natural processes
	Decreases in stocks	
		Due to economic activity
		Due to regular natural processes
		Due to natural disasters (net decrease)
	Changes due to economic reclassification	
Closing stock levels		
	Changes in environmental quality	
		Due to natural processes
		Due to economic activity

1 Units of account

7.79. Natural resources, land and ecosystems may be described in physical quantities using units such as hectares, tonnes or cubic metres. Physical accounts may also be compiled by quality classes. For example, forest, measured in hectares or cubic metres, may be subdivided on the basis of cover species, ownership, management regimes, naturalness, degrees of defoliation, and so on. Annex 1 which shows the detailed asset classification proposed for the SEEA includes suggestions on alternative units for measurement for different assets. The subject is also discussed in Chapter 3 where accounts in physical units are elaborated and in Chapter 8 where resource accounts for different resources are discussed.

7.80. Obviously for an account such as that portrayed in Table 7.3 to be workable, each line must be expressed in the same units. For assets such as water and atmospheric systems there is no meaningful way of measuring total stock levels. Further, it will often be impossible to express a quality change in terms of the same units as other entries. In these cases, the additive asset account is augmented or even replaced by a series of environmental indicators which express the change in terms of some other units. One example is using an air quality index to measure changes in the quality of air; another is the use of changes in nutrients to represent changes in soil. The health status of forests and the quality of water bodies may also be studied by means of supplementary physical accounts.

2 Asset accounts in the SNA

7.81. The SNA describes an asset account in the annex to Chapter II (1993 SNA Table 2.7) but it is little known and not in common use. It is, however, a very useful device to explain how the various accumulation accounts can be combined to account for the changes between the opening and closing balance sheets. The principles behind this relationship are explained in 1993 SNA paragraph 10.15 and shown schematically in 1993 SNA Table 13.2. The accumulation accounts consist of the balance sheets and three flow accounts. The ***capital account*** covers transactions in non-financial assets and the ***financial account*** covers transactions in financial assets and liabilities. There is another account, the ***other changes in assets account,*** which itemises the causes of change to the value of assets appearing in the balance sheet which the SNA does not regard as being due to transactions. Nonetheless, it is essential in reconciling the opening and closing balance sheets. In terms of the SNA accounts, the following identity must hold:

stock levels as in the opening balance sheet
plus entries on non-financial assets in the capital account
plus entries on financial assets from the financial account
plus entries from the other changes in assets account
equals stock levels as in the closing balance sheet.

7.82. The structure of an SNA asset account for a non-financial asset can be portrayed as shown in Table 7.4.

Table 7.4 An asset account for a non-financial asset

Opening stocks
Entries in the capital account
Gross fixed capital formation
Consumption of fixed capital
Changes in inventories
Acquisitions less disposals of valuables
Acquisitions less disposals of non-produced non-financial assets
Entries in the other changes in assets account
Economic appearance of non-produced and produced assets
Natural growth of non-cultivated biological resources
Economic disappearance of non-produced assets
Catastrophic losses
Uncompensated seizures
Other volume changes in non-financial assets n.e.c.
Nominal holding gains/losses
Changes in classifications and structure
Closing stocks

7.83. Many uses of the SNA focus on the role of produced and financial assets. For these, most of the changes between the stock levels in the opening and closing balance sheets will be shown in the capital account for produced assets and in the financial account for financial assets and liabilities. For these assets, the other changes in assets account is simply the place to record exceptional events and revaluations due to changes in relative and absolute prices.

Economic appearance and disappearance

7.84. When the 1993 SNA extended the asset boundary to bring in more non-produced assets including environmental assets, it was recognised that provision had to be made to record their entry into the balance sheet and, sometimes, their exit from it. The other changes in assets account accommodates such entries also. The SNA uses the terms "economic appearance" and "economic disappearance" to cover these entries, describing them as the way non-produced items come to be treated as being within the SNA asset boundary.

7.85. There are basically three ways in which items may cross into the asset boundary. A new non-produced asset may be created by constructing a legal instrument; the establishment of fishing quotas or emissions permits are examples. New environmental assets may be recorded as coming into existence other than through production processes. This includes the discovery of new mineral deposits and natural growth of biological resources; both involve a quantitative addition to the stock. The third way an asset is created is through a change in conditions such that something which had no economic value previously acquires one. This may be due to changes in relative prices, to the possibilities opened up by new technologies or changes in legislation or consumer taste. There are corresponding ways in which assets may cross out of the asset boundary.

7.86. Within the SNA, the existence of an associated physical quantity is irrelevant to whether something is treated as an asset or not. These examples of how items come to be treated as an asset show that there may or may not be an associated physical quantity and, even when there is, there may or may not be a change in this quantity. It is only the acquisition (or loss) of economic value which determines when economic appearance (or disappearance) is recorded.

Other non-transactional changes in assets

7.87. A significant cause of change may be the effect of a natural disaster on any assets including natural resource stocks and ecosystems. By convention, these are shown as a special type of decrease of assets but it should be remembered that for some assets a disaster may lead to a physical increase; for example, a flood leading to an increase in the volume of water present in a given area.

7.88. The terms economic appearance and disappearance are used only in the case of non-produced assets (though this includes intangible non-produced assets as well as the tangible non-produced assets which correspond to the non-produced environmental assets of interest in the SEEA). By definition, produced assets cannot come into existence through "economic appearance" with the only exception of valuables and historic monuments; they appear as a result of production and are recorded as such in the capital account. They are normally eliminated from the balance sheet by means of the allowances for consumption of fixed capital which is also recorded in the capital account. Sometimes, however, there may be events which necessitate a sudden complete elimination from the accounts of the remaining value of a produced asset; for example, through unforeseen obsolescence. These are recorded as other changes in assets.

7.89. An important cause of change in the other changes in asset accounts relates to changes in prices either due to increases (or decreases) in the overall price level or changes in relative prices. Revaluation changes always reflect the change in the value of an asset; that is, they always affect something which is classified as an asset both before and after the price change. If the value of a non-produced asset before the price change was zero, or becomes so after the price change, then this change is recorded under appearances and disappearances as noted above. Changes in value of non-produced assets which can be attributed to changes in the physical attributes of the asset are also so classified. If the asset is produced, the effect of a price change which reduces the value to zero is recorded as an other change in assets as described in the previous item.

7.90. The last cause of change is the effect of economic reclassification. Land previously used for agriculture may be built over and so may change from being classified as cultivated land to being classified as land under buildings. As another example, when a public enterprise is privatised, although it retains ownership of its assets they may move from the public to the private sector.

3 Asset accounts for environmental assets in the SEEA

7.91. The SNA shows how an asset account can be compiled for non-produced assets as well as for produced and financial assets. However, within the SEEA, the fact that the asset boundary has been extended has a significant consequence for the resulting asset account, quite apart from the obvious fact that for environmental assets, the entries the SNA places in the other changes in assets account are much more significant than those appearing in the capital account.

7.92. Within the SNA, an entity can only be classified as an asset if it is owned and if it may derive economic benefits to the owner. Some of the SEEA assets have no economic values. Nonetheless, they are within the SEEA asset boundary as they bring indirect use benefits, option and bequest benefits or simply existence benefits which cannot be translated into a present day monetary value. It may be because the exact future use is unforeseen and so cannot be valued in terms of today's system of economic prices even before discounting is considered. This explains why some entities with zero monetary value are treated as assets in the SEEA but not in the SNA.

7.93. A consequence of this wider asset boundary is that entities cross it much less frequently than is the case for SNA assets. Basically, once an environmental asset is within the SEEA asset boundary, it stays there, regardless of what happens to its monetary value, until it ceases to exist. Non-produced assets such as emission permits which have no associated physical attributes are categorised by the SNA as intangible. The treatment of these assets is not at issue here so we put them to one side. For the remaining non-produced assets (tangible non-produced assets in the SNA; non-produced environmental assets in the SEEA), in place of economic appearance and disappearance we are interested in changes in the assets whether these are in quantity terms only or also in monetary terms. To make this distinction from the SNA clear, the previous categories of economic appearance and disappearance are replaced in the SEEA by the terms additions to and deductions from stock levels. It should be remembered that these relate only to non-produced environmental assets. Increases and decreases in produced biological assets will continue to be recorded as capital formation or changes in inventories, as appropriate, in the capital account.

7.94. The following sections indicate in more detail exactly which sort of items are to be included under the different headings. This explanation is given in terms of the classification of "other accumulation entries" which appear in the SNA. These items are the entries which are not the result of economic transactions and which have to be included in the asset account along with the economic transactions to explain the accounting relationship between the opening and closing balance sheets. It proves to be the case that these are sufficiently comprehensive that they cover all the changes to environmental assets which should be captured in an SEEA asset account also. In fact, only two of the SNA items are not relevant. One of these relates to financial assets and liabilities; the other to the special case of valuables and historical monuments.

Changes due to transactions

7.95. For produced assets, the main transactions concern the acquisition less disposal of these assets, referred to as gross fixed capital formation and changes in inventories.

7.96. **Gross fixed capital formation** relates to the acquisition less disposals of fixed assets. Fixed assets are themselves defined as produced assets which are used repeatedly or continuously in production processes for more than one year. Gross fixed capital formation is further disaggregated into three sub-headings, all of which are relevant for environmental accounting. ***Tangible fixed assets*** cover animals such as dairy cattle, sheep reared for wool, fruit bearing trees, vineyards, and so on. ***Intangible fixed assets*** cover mineral exploration. Land improvements are included in the last subheading, ***additions to the value of non-produced***

non-financial assets. This includes decontamination of polluted land, restoration of quarries or landfill sites as well as measures designed to improve the quality of agricultural land.

7.97. **Inventories** are stocks of produced goods held by producers that are intended for sale, use in production or other use at a later date. Unlike fixed assets, inventories are used once only which is why animals and plants which provide a benefit only when they are slaughtered or harvested are included here. At the level of the national economy, changes in inventories record the balance of all acquisitions and disposals of inventories by producers during the accounting period. Inventories are separated into materials and supplies, work in progress, finished goods and goods for resale. For environmental accounting the relevant category is a subdivision of work in progress related to ***work in progress on cultivated assets***.

7.98. For single-use cultivated biological assets, the growth until harvesting should be recorded as work in progress under the heading of change in inventories. The growth of animals and plants that will be used repeatedly or continuously in production when they reach maturity is recorded as gross fixed capital formation, unless they are being cultivated or reared for sale by specialist producers. In the latter case, the growth until maturity is treated as work in progress.

7.99. **Consumption of fixed capital** shows the decline in value of a fixed capital asset due to its use in production during the period between an opening and closing balance sheet. Consumption of fixed capital should appear in the production account, reducing gross value added to net value added. Net value added is thus a measure of income which assumes the level of assets can be kept intact. To the extent that gross capital formation exceeds consumption of fixed capital, the level of fixed assets in the economy is increasing. If consumption of fixed capital exceeds gross fixed capital formation, then the economy is not maintaining the level of its fixed capital stock.

7.100. Consumption of fixed capital applies to all fixed assets, including those cultivated biological assets which are considered to be fixed assets and land improvement. It also applies to costs of mineral exploration which have been recorded as fixed capital.

7.101. **Acquisitions less disposals of non-produced non-financial assets** relates to the purchase and sale of land or of mineral and energy resources. In principle it could also cover the sale of a virgin forest or similar environmental asset but these are unlikely to occur often in practice. It also covers the acquisitions less disposals of intangible non-produced assets. Thus sales and purchases of fishing quotas, emissions permits and similar licences are recorded here.

Changes not due to transactions

7.102. There are three categories of changes not due to transactions in the SEEA asset account, as in the SNA asset account, but here the headings are additions to stock levels, deductions from stock levels and other changes in stock levels.

Additions to stock levels

7.103. This heading includes items from the SNA other changes in assets account, namely economic appearance of non-produced assets (SNA item K.3), natural growth of non-produced biological assets (SNA item K.5) and part of changes in classification and structures (part of SNA item K.12).

7.104. ***Discoveries*** include gross additions to the level of proven reserves. These are recorded in the SNA as economic appearance of non-produced assets, that is a transfer to the economy. Discoveries of subsoil assets which are not yet proven and natural growth of biological assets without an established monetary value do not appear in the SNA but should in principle be covered by the SEEA.

7.105. ***Reclassification due to quality change and reclassification due to change in function.*** As an example one may consider the case in which agricultural land is used as built-up land. The SNA would record the change in economic use as change in classification and structure and the increase in value as part of the economic appearance for built-up land. If an asset is reclassified from a produced asset to a non-produced asset, it will be included here also (though offset by a compensating change for produced assets).

7.106. The item ***natural growth of non-cultivated biological assets*** is self-explanatory.

Deductions from stock levels

7.107. This heading includes items from the SNA other changes in assets account, namely from economic disappearance of non-produced assets (SNA item K.6). It also includes reclassification from non-produced to produced asset status (again part of item K.12 and again offset by a corresponding heading under produced assets). In principle, part of other volume changes not elsewhere classified (n.e.c.) (SNA item K.9) relating to degradation of environmental assets should be included here also. As with all degradation of environmental assets, placing a value on this may be difficult in practice.

7.108. ***Extraction of natural resources*** is recorded in the SNA as part of economic disappearance of non-produced assets. It includes depletion of natural resources and reductions in the level of exploitable subsoil resources. Depletion in the SNA covers the reduction in the value of deposits of subsoil assets as a result of physical removal and using up of the asset. It also covers the depletion of natural forests, fish stocks in the open seas and other non-cultivated biological resources as a result of harvesting. The valuation of depletion in the SEEA is discussed below in Section D and in more detail in Chapter 10.

7.109. ***Environmental degradation of non-produced assets*** includes degradation of land and water resources and other natural assets due to economic activity. It also includes the decrease in value of such environment-related assets as emissions permits. Although degradation is reflected in the asset accounts discussed in this chapter, its valuation is particularly complex and a separate chapter (Chapter 9) is devoted to its discussion.

7.110. The item ***Reclassifications due to quality change and due to change of functions*** is explained in paragraph 7.105 above.

7.111. The SEEA physical accounts do not treat as deductions from stock items which continue to exist but are no longer economically viable, though the monetary value will decrease correspondingly. While the SNA records subsoil resources as entering and exiting the asset boundary depending on economic viability, the physical SEEA accounts will maintain the recording of such deposits once discovered until they are extracted or otherwise physically disappear.

Other changes in stock levels

7.112. This item covers the remaining (parts of) items from the SNA other changes in assets account which cannot be attributed to the interaction between the economy and the environment as well as one which is related simply to the change in ownership from one economic unit to another.

7.113. ***Catastrophic losses*** (SNA item K.7) cover the effects of earthquakes, volcanic eruptions, tidal waves, hurricanes, droughts, floods and other natural disasters as well as wars and toxic spills which can be more immediately traced to human intervention. The possibility exists of treating some or all of the elements of this item differently in an alternative version of the SEEA account.

7.114. ***Uncompensated seizures*** (SNA item K.8) rarely occur but can in theory affect environmental as well as other assets.

7.115. ***Degradation of produced assets*** is included in the SNA as part of other volume changes in non-financial assets not elsewhere classified (remaining part of SNA item K.9).

7.116. ***Nominal holding gains and losses*** (SNA item K.11) affect only monetary valuations of the accounts and represent the change in value of an asset due simply to the overall change in prices (nominal gains or losses) or changes due to movements in relative prices (real holding gains and losses). The content of this revaluation item was discussed in more detail above under the SNA account.

7.117. ***Changes in classifications and structure*** (the remaining part of SNA item K.12) involve no change in value or volume of an asset but relate mainly to the change of ownership from one type of unit to another.

The form of the account

7.118. Table 7.5 shows a schema which could in principle be completed for any type of SEEA asset. The shaded cells in the table indicate where, in principle, entries are possible. While such an account could be drawn up in monetary terms for some of the assets, for some others only physical accounts are likely to be possible at the moment. For some assets, water for example, there may be no comprehensive stock measure available and yet it is both practicable and useful to draw up a table of changes in the stocks in a format like this.

7.119. At the present time there is unlikely to be sufficient information available to draw up either stocks of ecosystems assets or a comprehensive measurement of changes during a year in exactly the same manner as for other environmental assets. There is no reason in principle, though, why an asset account for an ecosystem could not be constructed. It may be more useful, though, to concentrate on measuring changes in quality rather than just changes in quantity as exemplified in Table 7.5. Most often such changes will relate to degradation. Examples include the acidification or eutrophication of land and water and defoliation of timber. However, there will also be instances of amelioration especially as a result of activities designed to restore environmental functions.

Table 7.5 A SEEA asset account

	Produced assets	Natural resource stocks					Land
		Mineral and energy	Water	Biological resources			
				produced	non produced		
Opening stocks							
Changes due to transactions							
Gross fixed capital formation							
of which land improvement							
Changes in inventories							
of which work in progress on cultivated assets							
Consumption of fixed capital							
Acquisitions less disposals of non-produced assets							
Additions to stock levels							
Discoveries							
Reclassifications due to quality change							
Reclassifications due to change of functions							
Natural growth							
Deductions from stock levels							
Extraction of natural resources							
Reclassifications due to quality change							
Reclassifications due to change of functions							
Environmental degradation of non-produced assets							
Other changes in stock levels							
Catastrophic losses and uncompensated seizures							
Degradation of produced assets							
Nominal holding gains/losses							
Change in classifications and structure							
Closing stocks							

4 Accounting entries for specific resources

7.120. Table 7.6 is an elaboration of Table 7.5 with specific entries for each type of asset. The entries are relevant to the following two questions: (i) Can we measure the stock levels in physical terms? and (ii) What are the main changes which affect the stock levels? The entries also prepare the ground for the discussion on valuation in Section D.

Table 7.6 Accounting entries for different sorts of environmental assets

	Mineral and energy resources	Soil resources	Water resources
Stock levels	Quantity possible Value possible	Quantity possible Value included in land	Quantity possible (at least partially) Value doubtful, some included with land
Changes due to transactions			
Gross capital formation [Gross fixed capital formation and Changes in inventories]			
Consumption of fixed capital			
Acquisitions less disposals of non-produced assets	Theoretically possible	Included with land	Unlikely except as included with land
Additions to stock levels			
New additions [Discoveries and Natural growth]	Discoveries		Natural inflows, precipitation, returns of abstracted water
Reclassifications due to quality change	Reappraisals (e.g., probable to proven)		
Reclassification due to change of functions			
Deductions from stock levels			
Deductions [Extraction of natural resources and Environmental Degradation of non-produced assets]	Extraction	Soil erosion	Natural outflows, evapotranspiration, abstraction
Reclassifications due to quality change	Reappraisals (e.g., proven to probable)		
Reclassification due to change of functions			
Other changes in stock levels			
Catastrophic losses and Uncompensated seizures	Unlikely	Possible	Possible
Valuation changes	Probable	Included with land	Probably not relevant
Changes in classifications and structure	Possible	Included with land	Possible

Biological resources		Land and surface water	Ecosystems
Cultivated	Non-cultivated		
Quantity possible Value possible	Quantity usually possible Value usually possible	Quantity possible Value possible	Some quantity measure may be possible (e.g., area) Value usually possible only as part of the value of a composite asset
Growth (positive) Harvesting (negative) Natural death (negative)		Land improvement	
May be subsumed under harvesting		Decline in value of improvements to land	
Not applicable	Theoretically possible	Occurs regularly	
Possible conversion from non-cultivated status	Growth Possible conversion from cultivated status		Possible
			Possible
		From one land category to another	Possible
Possible conversion to non-cultivated status	Harvesting Natural death		Possible
		From one land category to another	
Possible	Possible	Possible	Possible
Probable	Probable	Probable	Not relevant
Possible	Possible	Possible	

Mineral and energy resources

7.121. In principle, stock levels of mineral and energy resources can be measured in physical terms. This will almost certainly involve expert estimations by geologists and other specialists. Since all mining companies wish to have a good estimate of the size of the deposit on which they are working or at least a good idea of the minimum size, such estimations should, in principle, be available. The scope of mineral and energy stocks in the SEEA is discussed in more detail in Section E.

7.122. Additions to stock levels come from new discoveries or reappraisals of the quantity and quality of previously known stocks. Although reappraisals are usually thought of as increasing the stock level, sometimes they may lead to downwards revisions.

7.123. Catastrophic losses are fairly unlikely in relation to mineral and energy resources. Flooding of mines is possible but the deposits continue to exist and could in principle be recovered. Fire may destroy an oil well but this contingency is usually well guarded against.

7.124. Valuation changes are regularly observed in respect of subsoil deposits. Changes in ownership, say in moving from the public to private sector, are theoretically possible.

Soil resources

7.125. Measures of soil resources will exist, if at all, in physical terms only, the value of soil being included in the value of land.

7.126. Some extraction may take place from one area for transport to another but it is improbable that this would be significant even within a country and even less likely internationally. The most likely entries concern soil erosion, often due to deforestation or overgrazing.

7.127. Major disasters such as flooding or drought can have a significant effect on both the quality and quantity of soil resources.

Water resources

7.128. Not all categories of water resources may be measurable in terms of stock levels, and comprehensive valuations are, at the moment, unlikely.

7.129. The hydrological cycle adds to water supply by river inflows and precipitation and deducts from it by river outflows and evapotranspiration. The other major deduction comes from abstractions for economic use but eventually almost all water so extracted is returned to the environment.

7.130. Traditionally it has been supposed that the abstraction of water for economic purposes is marginal when compared with the natural recycling of water as it moves down rivers, evaporates and falls again as precipitation. Increasingly there is concern that this may not be so, at least at some locations and at some times. This is therefore where a supplementary set of physical accounts can be extremely valuable. There is a detailed discussion of this in Chapter 8.

7.131. As with soil resources, much interest in water accounts focusses on the quality of water and not just the physical quantity available.

Biological resources

7.132. Although the physical processes of biological resources growing and yielding products is similar for cultivated and non-cultivated resources, they are recorded very differently in the standard economic accounts.

7.133. Stock levels of cultivated resources are measured in both volume and value terms. For non-cultivated resources, either exact measures or reasonable estimates of quantity are likely to be available and valuation will usually be possible. Some exceptions may occur (for example, for fish stocks) but increasingly, in order to monitor the conservation of stocks, detailed estimates have to be made.

7.134. For cultivated biological resources, growth is regarded as output and may enter into stocks as either fixed capital or work in progress. Harvesting and natural death are recorded as negative capital formation. Because of this offsetting of growth and harvest, there is seldom any explicit entry for consumption of fixed capital in respect of cultivated biological assets.

7.135. For non-cultivated biological assets, growth, harvest and natural death will be recorded as additions to and deductions from stock levels.

7.136. Neither sale nor purchase of non-produced assets applies to cultivated resources since they are produced. They could apply to non-cultivated resources, but happen infrequently.

7.137. Conversion from non-cultivated to cultivated status, or in the reverse direction for reasons of conservation, is possible. Unforeseen obsolescence is not applicable to biological resources, but catastrophic losses, valuation changes and changes in ownership may be recorded for both cultivated and non-cultivated biological resources.

7.138. Chapter 8 contains details of accounts for forests and aquatic resources where many of these issues are dealt with in greater detail.

Land and surface water

7.139. Generally speaking, the volume of land does not change, though its classification may easily change. The quality of agricultural land in particular is also subject to change as a result of economic activity. Start and end of year stocks therefore should vary very little if at all in total, though their composition may change.

7.140. Technically, land may appear through reclamation from the sea, for example, or it may be "improved" by drainage or reclamation from use as a landfill site.

7.141. It is difficult to separate changes in land quality from changes in soil quality and data sources may determine how this is recorded.

7.142. Chapter 8 discusses in detail analyses of land classified by different types of cover and use.

Ecosystems

7.143. These are the most difficult environmental assets to quantify. A comprehensive measurement of all the environmental services provided by ecosystems is conceptually possible but not comprehensively covered by this handbook. Some accounting for the appearance and disappearance of ecosystem features may be possible in a limited form of account.

D Valuation

7.144. As explained in the introduction, this chapter concentrates on valuation of assets as observed in the market and as recorded in the SNA. It contains a discussion of when the assets may not be separable for purposes of valuation and then explains the principles of valuation in the SNA. It also notes two alternative bases of valuation which are frequently quoted in relation to environmental assets.

7.145. As mentioned in the introduction, those who wish to bypass the detail in this section may go straight to the summary given in Section 5.

1 Asset classifications of the SNA and SEEA

7.146. Section B elaborates a classification scheme for environmental assets where each environmental function falls in a different category of the classification. This is entirely appropriate when studies have environmental functions as the main focus of attention. It is difficult to adopt such a precise delineation when valuation is concerned. For some assets the ambiguity when valuation is concerned is easily apparent. Often the valuation given to a house covers both the building itself and the plot of land on which it is built. The value of a forest may also cover both the value of the standing timber and the land from which it grows. But some aspects of valuation go beyond the assets recognised in the SNA. The value of the forest may include the value of the ecosystems supported by it. The first step therefore in considering how to convert physical asset accounts to monetary terms is to look at the interaction between categories of environmental assets in the context of valuation. This is portrayed in Table 7.7.

7.147. For mineral and energy resources, the environmental category includes the SNA category "subsoil assets" and also some deposits which are not included in the SNA either because it is felt that it is difficult to determine the value of the benefits they represent or because no claim of ownership has been established over them. The most common difference between the two classifications will be that the SEEA includes and the SNA excludes deposits classed as "probable", "possible", "potential" and "speculative".

7.148. Soil resources present particular difficulties because it is hardly possible to think of valuing the soil of agricultural land separately from the value of the land itself. It is for this reason that the SEEA recommends that soil be measured in physical units only and that its monetary value be included with land.

7.149. Similar arguments apply to surface water. The SEEA asset category EA.13 is treated as being measurable in physical terms only. Monetary valuations of water are included in the categories for land and major water bodies. Both the SNA and the SEEA include "associated surface water" with agricultural and wooded land when it is either not practical or not desirable to try to split either the physical or monetary measures of two entities so closely linked.

7.150. For groundwater, the SNA and SEEA classifications resemble each other in a way similar to the categories relating to mineral and energy resources. Established aquifers are treated in both classifications as assets; the SNA does not include aquifers known of but of no immediate value because they are too remote or difficult for extraction.

Table 7.7 Links between SNA and SEEA classifications

SNA classification / SEEA classification		Produced			Non-produced							
		AN.11141 Livestock, etc.	AN.11142 Vineyards, etc.	AN.1221 Work in progress on cultivated assets	AN.2111 Land under buildings	AN.2112 Land under cultivation	AN.2113 Recreational land	AN.2119 Other land	AN.212 Subsoil assets	AN.213 Non-cultivated biological assets	AN.214 Water resources	Not within the SNA asset boundary
EA.11	Mineral and energy resources								x			x
EA.12	Soil resources				(x)	(x)	(x)	(x)				(x)
EA.131	Surface water					(x)	(x)	(x)				x
EA.132	Groundwater										x	x
EA.141	Timber resources		x	x						x		x
EA.142	Crop and plant resources		x	x						x		x
EA.143	Aquatic resources	x		x						x		x
EA.144	Other animal resources	x		x						x		x
EA.21	Land under buildings				x		x					
EA.22	Agricultural land					x	x					
EA.23	Wooded land		x?			x	x	x		x?		x
EA.24	Major water bodies						x				x	x
EA.25	Other land						x	x				x
EA.3	Ecosystems	(x)	(x)	(x)		(x)	(x)	(x)		(x)	(x)	

(x) Not separately valued

x? May appear in this box only because of the difficulty of separating it from another asset

7.151. In principle, land under buildings should be similar in both systems but in practice much of this land in the SNA will appear included with buildings (when, as is typically the case, the building has greater value than the land on which it stands). If it happens that the land has greater value than the building, then the value of this building may appear in the SNA category of land under buildings.) This is one category though where in principle there is no land outside the SNA boundary.

7.152. Land under cultivation in the SNA covers all agricultural land and some wooded land in the SEEA. All agricultural land appears in the SNA category of land under cultivation. However, some wooded land may lie outside the SNA boundary; for example, virgin forests too remote for economic use or not subject to ownership. Some wooded land may not appear in land under cultivation simply because it is impossible to separate it from vineyards, orchards, cultivated forests, etc. or from the non-cultivated forest resources which occur on it; therefore, it will appear grouped with those assets.

7.153. Both classifications have a category of other land but the two categories will not correspond exactly because of inclusions and exclusions relating to other assets. The SNA category recreational land does not include any land under buildings or cultivation (it is an exclusive if not exhaustive classification) but includes some open public spaces and sports amenities the SEEA puts in other land. Because it includes associated surface water, recreational land may also include some water bodies which the SEEA puts in major water bodies. The SEEA category of other land also includes any non-wooded land which is not covered by the SNA. (In practice, for geographically small or densely populated countries it is unlikely that any land is excluded from the SNA asset boundary but this may not be the case for large sparsely populated areas especially where these areas are climatically severe.)

7.154. The SEEA category of ecosystems has no counterpart in the SNA classification and is included in the SNA valuations only to the extent that a valuation of another category automatically includes an element relating to some ecosystem aspect. Recreational land is a case in point but as noted above it may be so for non-environmental assets such as buildings also. Some of the techniques to be discussed in Chapter 9 could in principle be used to put a value on ecosystems.

7.155. This examination of the two classifications shows that, in terms of Table 7.7, SNA categories may span a number of SEEA headings but that these are always related; for example, different forms of biological assets or different classes of land. On the other hand, a SEEA asset may cover a category in the SNA coming under the heading produced, one which is non-produced and still have some aspects excluded. This can be characterised as a three-way division of assets:

assets which are produced by economic activity and used in economic activity;

assets coming from nature but used in economic activity;

assets coming from nature and not used in economic activity.

7.156. This three-way division of environmental assets will prove to be important in investigating the place of the accounting entries in the SNA sequence of accounts and the principles of valuation underlying these entries.

2 Valuation of assets in 1993 SNA

7.157. The SNA is unambiguous about how assets are to be measured. If at all possible, market prices are to be used. This is usually possible for produced assets and for land. In some countries it may also be true for subsoil assets though this depends to some extent on institutional arrangements. In many European countries, for example, subsoil assets are deemed to be the property of the government and are not sold, so no market prices exist.

7.158. When market prices do not exist, the next choice is to estimate the net present value of future benefits accruing from holding or using the asset. Economic theory asserts that this is in fact how market prices of assets are determined. If the value of the future benefits did not at least equal the market price, the asset would not be a cost-effective purchase. Thus the net present value should be compatible with market prices although determining the parameters needed to calculate the net present value may be difficult.

7.159. If there are no market prices and it is not possible to calculate the net present value of an asset, then the cost of producing it may be used as a lower bound on its value. Again the argument runs that it would not be worthwhile to construct the asset unless the benefits were expected to be at least as great as the costs.

Terminology for the use of capital

7.160. A vehicle, building or piece of heavy machinery may be bought by an enterprise to assist in the production process. The items are valued, whenever possible, by the price paid for them on an open market. However, the costs are not regarded as part of intermediate consumption but as ***fixed capital formation***. The reason is that the items provide services over a period of time and are "paid for" over the same period, the life length of the asset in question. Another way of looking at this is to say the asset disappears over a period of time by an amount representing the reduction in value of the asset in each year in question. The extent of the disappearance is referred to as the ***consumption of fixed capital*** (CFC).

7.161. The ***gross operating surplus*** of an enterprise represents the ***benefit*** to the owner of using all his assets in the year in question. It can also be described as the value of the flow of ***capital services*** rendered by the assets in the same period or the ***economic rent*** generated by the use of the assets. The value of the assets can, in principle, be estimated by calculating the ***net present value*** of the gross operating surplus or economic rent to be generated for each of the future years when the assets will be still in service. Since a higher value is put on money today than on money in the future, the economic rent for each future year is discounted to reach an appropriate value in today's terms. The discount rate is applied once for each year for which the economic rent is distant. The sum of all the discounted rents throughout the life of the asset is called the net present value of the asset.

7.162. With use, and over time, the value of assets generally decline. The value of capital services rendered, or used up, represents a decline in value. Set against this is an income element. This is due to the fact that the future benefits have become one year closer and may be called ***the effect on the NPV of time passing***. If the value of the assets at the start of the year is V and the discount rate is r, then the income element can be expressed as rV. For this reason, this income is regarded by economists as representing the ***return to the capital*** used by the firm. For the firm as a whole, this item is the ***net operating surplus***. The decline in the value of the asset is referred to as the ***consumption of fixed capital*** and is the difference between the value of the capital service flows rendered (and thus used up) and the income element which arises in the same period.

7.163. The expressions gross operating surplus, net operating surplus and consumption of fixed capital are very familiar to national accountants and are widely used in the SNA. The other formulations come from economic theory but are increasingly being incorporated into national accounting work as evidenced by two recent manuals, one on the measurement of capital stocks and one on measuring productivity (OECD, 2001a and 2001b). These various concepts are inter-related and different identities can be used to express this inter-relationship (assuming for simplicity at present that there are no taxes or subsidies on production). Because of the inter-changeability of the terminology, all these formulations represent the same relationship between the variables. Some of these are spelled out in Box 7.1 for easy reference. The value of consumption of fixed capital can be deducted from gross operating surplus to reach a figure of net operating surplus and from gross fixed capital formation to reach a figure of net fixed capital formation. Almost everywhere in the SNA when the word "net" is used it means that the consumption of fixed capital has been deducted from the aggregate in question. This is true for measures of domestic product and national income as well as measures restricted to capital only.

7.164. In certain circumstances, it is possible for either the decline in value of an asset (the consumption of fixed capital) or the return (net operating surplus) to be zero. By convention in the SNA, it is assumed that there is no return to assets used by government for non-market production, so there is no net operating surplus for this sort of production. This is equivalent to assuming, a social discount rate of zero for non-market producers.

Box 7.1 Terminology for the use of capital

Gross operating surplus	= benefit from the asset
	= economic rent
	= value of capital service flows
Net operating surplus	= return to capital
	= effect on the value of the NPV of time passing
	= gross operating surplus *less* consumption of fixed capital
Consumption of fixed capital	= decline in the value of asset between two points in time
	= gross operating surplus *less* net operating surplus
	= gross operating surplus *less* the effect of time passing
	= value of capital service flows *less* return to capital
Return to capital	= economic rent *less* consumption of fixed capital
	= value of capital service flows *less* consumption of fixed capital

7.165. If an asset is such that no amount of use in a year leads to a decline in its value, there is no consumption of fixed capital and the entire value of the capital service flows represents a return to the capital and thus income. In statistical terms this implies that gross operating surplus and net operating surplus are the same. This used to be held to be the case for such structures as roads, but the 1993 SNA reviewed this practice and suggested that even here there was likely to be some decline in value over time. It is because there is no deduction for the consumption of fixed capital for natural assets in the SNA that all operating surplus earned by them is treated as income. The implications of assuming no decline in the value is that natural growth must always keep pace with harvesting or that there be sufficient abundance of the item that it is free and there is no cost to using up this “capital”.

7.166. The identification of how far an asset generates income and how far it is used up in production is crucial for the good measurement of income. Revenue which results from liquidating assets should not be treated as income, which is why the SNA insists that in principle all income measures in the national accounts should be measured net of consumption of fixed capital (even if this is not always possible in practice for all countries). An insistence on correctly identifying the two elements coming from the use of natural capital is one important reason for moving into the area of integrated environmental and economic accounting.

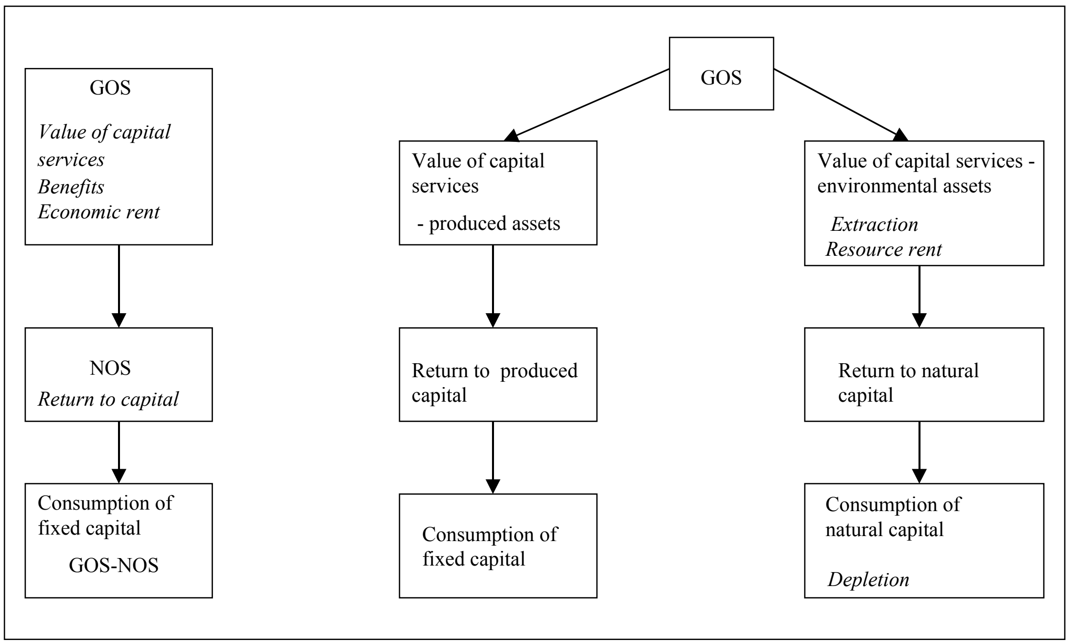
Separating produced and non-produced assets

7.167. If a firm uses both produced and non-produced assets, it is possible in principle to separate gross operating surplus into the capital service flows rendered by the produced capital and those rendered by the non-produced capital. Likewise, it is possible in principle to separate net operating surplus into a return on the produced assets and a return on the non-produced assets. The value of the capital service flows rendered by the natural resources, or their share in gross operating surplus, is the value of the ***extraction***, harvest or abstraction of natural resources. It is also referred to as the ***resource rent***. The term equivalent to consumption of fixed capital is called ***depletion***.

7.168. The word “depletion” is commonly used with different meanings. It is sometimes used to denote the total quantity of extractions of natural resources times the realised price per unit. It is sometimes used to represent the net effect of extractions, once the return to natural resources has been taken into account. In this text, the word “extractions” (sometimes “harvest”, sometimes both) is used in the first sense. Depletion is used, as in the SNA, in the second sense to mean the change in value of the stock of the resource due to extraction. It is thus the counterpart for non-produced assets to the notion of consumption of fixed capital for produced assets.

7.169. Figure 7.1 shows diagrammatically the relationship between the different concepts with the alternative terminology which may be used. The left part of the diagram relates to the case where all the assets are treated together and the right part to that where a separation is made between produced and environmental assets.

Figure 7.1 The decline in the value of fixed capital and the income it generates



3 Valuation of non-produced assets

7.170. When there are no direct market prices for non-produced assets, it is necessary to estimate the value using net present value techniques applied to the resource rent. Once the resource rent for an asset has been determined, three further pieces of information are necessary to determine the net present value (that is, the value of the stock level) of the asset.

For how many more years into the future will the asset generate economic rent?

What will be the pattern of decline (if any) in the economic rent?

What is the appropriate value of the discount rate that must be applied to earnings in future years?

7.171. For the whole of this section, it is assumed there is no change in prices during the year. The effect of price changes within the accounting period is discussed in Section E where the elements of the asset account relating to "other changes" are discussed.

Estimating resource rent

7.172. There are three possible ways of estimating resource rent. The first is based on actual transactions and may be called the appropriation method. The other two methods depend on estimating resource rent by partitioning the information on economic rent for all the assets for a firm into that part pertaining to its produced assets and that relevant to the non-produced assets.

7.173. There are two basic ways to approach the problem. Both start with the assumption that there is information available on the gross operating surplus and net capital stock of a firm or industry. The first method uses the perpetual inventory method (PIM) of determining capital stock to identify the consumption of fixed capital. Deducting this from gross operating surplus gives net operating surplus. From this an estimate of the return to produced capital is deducted and what is left must be the rent on the non-produced assets. In terms of Figure 7.1 this is equivalent to working up diagonally from bottom left to top right. The second method uses the theory of capital service flows to determine how much of the gross operating surplus represents the capital services rendered by the stock of produced capital. What is left when this is deducted from gross operating surplus is then resource rent attributable to the non-produced assets in use. In terms of Figure 7.1 this is equivalent to working across the first row and from the point of view of calculating resource rent the lower two rows can be ignored.

The appropriation method

7.174. In many countries, governments are the primary owners of the nation's natural resources. As landlords, governments could in theory collect the entire rent derived from extraction of the resources they own. Resource rent is normally collected by governments through fees, taxes and royalties levied on companies that carry out extraction. One approach to estimating the economic rent attributable to a resource is to equate it with the fees, taxes and royalties collected from the companies involved in the resource extraction. However, in practice, fees, taxes and royalties tend to understate resource rent as they may be set by governments with other priorities in mind; for instance, implicit price subsidies to extractors, and encouraging employment in the industry. Also, the rate of payments to government may not move in line with market prices for the extracted product though one would expect the true economic rent to do so. When these data are not separately identifiable, or suitable, resource rent must be imputed using various indirect methods. However, if the two sets of data are available, publishing a comparison of the values may be useful for economic policy analysis.

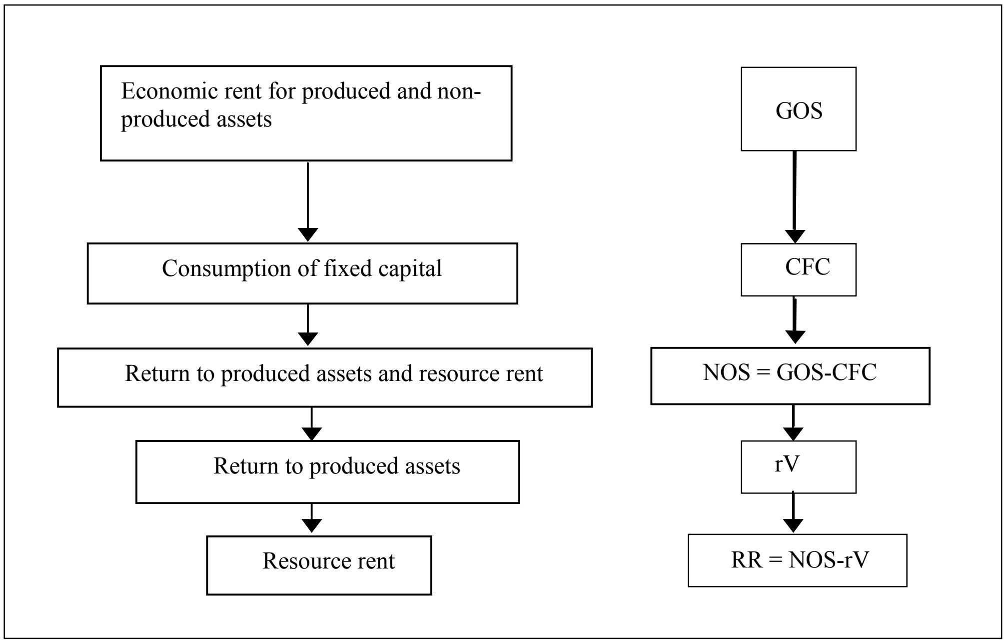
Resource rent derived from PIM calculations

7.175. Many countries use a perpetual inventory model (PIM) to determine measures of capital stock. This method starts by determining the value of an asset which is n years old by making assumptions about the rate of decline in its value over the n years since it was purchased. The decline in this value since the previous year is set equal to the consumption of fixed capital. Net operating surplus is calculated by deducting the consumption of fixed capital from gross operating surplus (from the production account) and the return to fixed capital is calculated using the value of capital stock determined by the PIM. The resource rent earned by the unit, industry or the whole economy is derived at the end of this sequence of calculations.

7.176. The process to be followed is shown schematically in Figure 7.2. The left hand part of the diagram shows the sequence followed in terms of economic concepts, the right hand part in algebraic terms.

7.177. Taking the economic rent for all assets, the gross operating surplus (GOS) and deducting the consumption of fixed capital (CFC) gives the return to produced assets and resource rent or net operating surplus (NOS). The return to produced capital is taken to be the discount rate (r) multiplied by the value of the produced capital stock at the start of the year (V). Deducting this from the net operating surplus gives the resource rent (RR).

Figure 7.2 Resource rent derived from PIM calculations



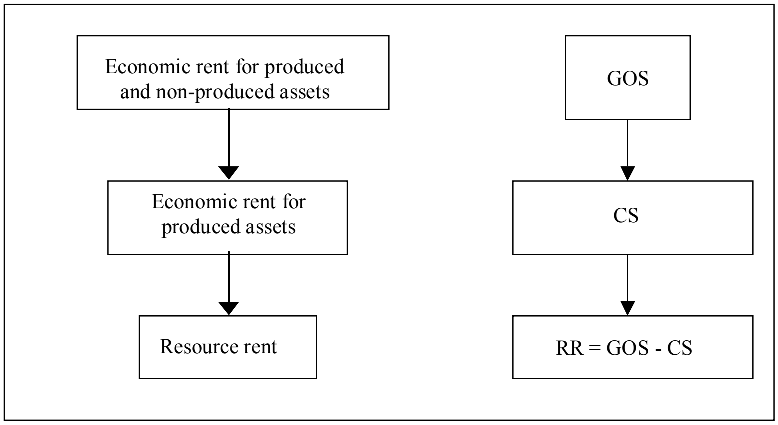
Resource rent derived from capital service flow calculations

7.178. An increasing number of OECD countries are making estimates of capital stocks using the capital service flow method which is an alternative way of applying PIM. This methodology starts by considering and modelling the decline in the service provided by the asset over its life rather than the decline in price. (A light bulb for example may shed the same light throughout its life even though its value declines as it ages because the length of time for which it is expected to function declines.) Such measures of capital service flows are used in productivity studies as well as in the calculation of net income flows. The value of the capital service flows (CS) estimated from the stock of capital is deducted from the total economic rent (GOS) as recorded in the production account. The result gives the resource rent (RR) directly. This is shown schematically in Figure 7.3 with two parts as in Figure 7.2.

7.179. For every pattern of a decline in the service flows provided by an asset there is one and only one matching pattern of a decline in the asset's price[2]. In theory, therefore, both methods should give exactly the same resource rent. In practice, however, the match between the decline in efficiency and that in price is not always obvious and studies have shown that the capital service flow estimates may be more robust to variations in assumptions than the PIM estimates. More details of producing estimates of capital stocks can be found in a recently published OECD manual on the capital services approach to stock measurement (OECD 2001a).

[2] This assumes for simplicity that there is no relative inflation in the price of the asset.

Figure 7.3 Resource rent derived from capital service flow calculations



Negative resource rent

7.180. Calculating resource rent as the residual between revenue and costs (operating plus capital) can give very erratic results which may sometimes be negative. One reason is that for many basic commodities the price is set on the world market and thus reflects global supply and demand while the local costs remain fairly constant from one year to the next. If the return to the fixed capital is determined based on a long run average, then this will give a stable measure of the return to produced capital but a very volatile measure of the resource rent. This issue is discussed further in Born (1995).

7.181. As noted above, and especially when negative resource rents result, it is important to investigate and eliminate as far as possible any fluctuations in the estimates for resource rent caused by errors in methodology or underlying assumptions. Sometimes, though, it will be correct that the resulting series is erratic and may even be negative on occasion. This is likely to be the case when it is not possible to make major changes to the rate of extraction for an industry even when the world price drops because of the need to keep machinery operating or when the extractors think the fall in price is temporary and will recover shortly. It is even the case that an enterprise can only afford to extract some deposits in some circumstances; for example, coal in much of Europe if it is subsidised. In such a case, the economic rent of the coal deposit is clearly zero and the value is also zero. It is only in such cases where there are strong social pressures to continue an uneconomic activity, though, that exploitation of uneconomic deposits is likely to persist over a period of time.

Zero resource rent

7.182. It should be noted also that if a stock of natural resources is so abundant that no amount of extraction has an effect on the prospective life-time of the remaining deposit there is no scarcity of the resource and thus its depletion and the value of the stock are also both zero. The whole of the economic rent, or gross operating surplus, represents a return to the capital and thus income. This is the rationale which underlay the accounting for environmental assets in the 1968 SNA; that is, that there was no shortage of resources and thus it was not necessary to attribute a value to them. It is the realisation that the current extraction procedures may lead to a shortage of some resources in the near future which leads to the conclusion that it is deficient not to realise this in terms of the impact on a nation's wealth and its assessment of its current income. This argument is reinforced by the fact that even a resource which is abundant at the global level may not be so plentiful for an individual country or region.

Determining the life length of the resource

7.183. In determining the period over which future extractions or harvests can be made, it is indispensable to have physical information available about the existing level of stock, the volume extracted every year and the rate of renewal (if any). The life length of the resource may then be calculated simply as the existing stock level divided by the excess of expected extractions over expected renewals. It is wise to use expected extractions and renewals to allow for exceptional events (say forest fires expected to occur about every five years on average) and to prevent an erratic pattern of life lengths emerging as the life length is recalculated year after year based on new information.

7.184. In the case of renewable resources (which is to say, in practice, biological resources) it is unambiguous that the rate of renewal needs to be included in the calculation of life length.

7.185. If a non-renewable resource is known exhaustively, it is clear there is no renewal to be taken into account. (An early study of such a case concerned a phosphate atoll. The total size of the phosphate deposit was known very accurately and it was known with equal certainty that there was no prospect of the deposit being renewed by natural causes on any human time-scale.) Life length can be determined straightforwardly from known reserves and expected extraction rates in such a case. The case of other mineral and energy deposits is less clear and the subject of some controversy. The practical problems pertaining to different possible assumptions are discussed at length in the first part of Section E below.

Determining the pattern of resource rents

7.186. The demand for and price of the non-produced asset may alter depending on the development of technological alternatives and changing tastes. In the absence of such changes, though, the only factor affecting the pattern of economic rent is the human decision about how much to extract.

7.187. Economic texts show different patterns of extraction as illustrations of how extractors might choose to maintain their revenue, their income or use some other elegant mathematical formula to determine an extraction rate for their resources. In practice, the statistician should base the expected pattern of extraction on past behaviour, informed by expert information if such is available. In the absence of any other information, it is probably safest to assume that extraction will continue at the same rate as in the past since this is the level for which an appropriate level of fixed capital has been acquired.

Determining the discount rate

7.188. As discussed above, resource assets for which returns are either delayed (growing timber) or spread over a lengthy period of time (mineral deposits) can be valued by discounting the expected future income to a present value. Doing so first requires the choice of a discount rate, a choice that is often the subject of considerable debate.

7.189. The discount rate (that is, the rate used to discount future income) expresses a time preference; the preference of an asset's owner for income today rather than in the future and also the owner's attitude towards risk. These factors will vary depending on the ownership of the asset. In general, individuals and businesses will have higher rates of time preference than governments. That is, individuals and businesses will tend to demand a quicker return from ownership of a resource asset than will governments. Higher rates of time preference translate into higher discount rates. Higher degrees of risk aversion will also lead to higher discount rates.

7.190. Some commentators argue that "social" discount rates should be used to derive the net present value of non-produced assets. The rationale is that these rates take into account inter-generational issues which suggest the discount rate (time preference) should be closer to zero.

Determining the rate of return

7.191. As discussed above, the return to an asset is that part of value added, specifically part of net operating surplus, which can be attributed to the use of the given asset in production. The rate of return is a ratio, usually shown as a percentage, which relates this income flow to the value of the stock which generates it. The simplest way of calculating such a rate is therefore to divide the return to the asset by its capital value.

7.192. This simple ratio, however, assumes that the value of capital stock covers all the assets used in production or, put another way, that there is no income arising from assets which have not been included in the measures of capital stock. If there are such assets, then the rate of return will be overstated because returns to unidentified assets will be attributed to those which have been identified. Obviously the issue of greatest interest in this handbook is the identification of the value of natural assets used in production but it is worth remarking that there are serious concerns about other types of assets which may be captured either poorly or not at all. One example of these is so-called intangible assets such as those associated with trade marks and brand names. Another concerns the role of education and training in enhancing human capital.

7.193. The means of identifying the part of operating surplus attributable to these sorts of assets is to use an exogenous rate of return for the identified assets and attribute the rest of the operating surplus as the return to the unidentified assets. This is the basis of two of the three means of estimating resource rent described above. Sometimes, however, an exogenous rate of return will be applied even when it is thought that all assets have been identified and correctly valued to determine “normal profits” for the enterprise in question. Any difference from net operating surplus as calculated in the production account is described as “pure profit” or “pure loss”, depending on sign. It is usually assumed that a pure profit exists only when there is some distortion on the market; for example, when a new product is first launched and can command a premium on its price.

7.194. There are at least three views about how to determine an exogenous rate of return. The first is that it is determined by the net operating surplus generated from the capital stock of the particular industry in question. Secondly, the return to produced capital could be seen as covering the cost of financing the acquisition of the produced capital stock. Alternatively, it can be interpreted as the opportunity cost of the investment in the produced capital assets. This opportunity cost could be estimated as the average real rate of return on investment elsewhere in the economy.

7.195. In the first approach, the concept of a “normal” rate of return is often used to apply to the value of fixed capital stock. This “normal” rate is sometimes determined by reference to the ratio between net operating surplus (rate of return) and capital stock in an industry assumed to have similar performance characteristics but without the presence of a natural resource.

7.196. The second approach assumes the interest rate on bonds issued by resource companies or the return on shares in resource industries is appropriate for use as the rate of return. The financing cost approach has the advantage that the returns are directly related to the risks associated with the operation of the capital (in the case of the bond price). However, returns on shares reflect both returns on capital and the resource, as well as being influenced by external factors in the market. Therefore, while the use of the interest rate on bonds seems appropriate as a proxy for estimating returns on capital, the use of return on shares does not.

7.197. The third approach relies solely on the opportunity cost of capital elsewhere in the economy. An interest rate based on long-term government bond rates is taken as the value of the rate of return for use in estimating the return to produced capital in the accounts. The disadvantage with the use of the long-term government bond rate as an appropriate "return to capital" is that it is a "riskless" rate. The rate does not include a premium to cover the risk and uncertainty involved in extractive industry operations.

7.198. The first and second approaches attempt to approximate the internal rate of return, whereas the third is clearly an external rate which it is supposed should hold more generally. The rate of return on corporate bonds could be used to derive returns on capital in the particular industry under consideration. Where there are few corporate bonds issued in the country compiling asset values, then either of the other approaches may be adopted, provided an allowance is made to counter the deficiencies in the approaches.

The relationship between the discount rate and rate of return

7.199. In an enterprise where all the assets are identified and measured accurately, and where conditions of perfect competition prevail, the discount rate and the rate of return should be equal. If the discount rate is higher than the rate of return to capital, the entrepreneur would be advised to lend money rather than to invest in more equipment. If the rate of return is higher than the discount rate, there will be a shortage of funds to lend and the discount rate should rise to attract more funds. Ultimately both rates depend on the opportunity cost of capital and the time preference of the asset owners for money now or in the future.

7.200. As noted above, however, there are several reasons why this equality may not hold. When the extractor and the owner are two different units with different time preferences and attitudes towards risk a difference between the two rates can be justified. However, wide and persistent differences between the two rates should be examined for plausible explanations. It is important for the statistician to try to ensure that errors of measurement are eliminated as far as possible and to this end, alternative estimates of resource rent and the calculation of "pure profits" may be helpful in establishing confidence in the estimates to be used in calculations depending on resource rent.

Nominal and real rates

7.201. Net present value calculations express future incomes in terms of the prices at a given point in time. If the time series of rents to be discounted and added is expressed in constant prices, the discount rate or rate of return should be a real rate (that is, one where the general level of inflation has been removed). If the time series of rents is expressed in prices with a built-in level of inflation, then the rates used must also allow for this inflation so that the process of discounting removes the effect of inflation as well as bringing the valuation back to one at the date of interest.

7.202. Usually, the models underlying both the PIM and the capital service flows approach are calculated in constant prices, in which case the discount rate should be in real terms (that is, adjusted for the general rate of inflation). However, if future rents are estimated allowing for price inflation, then the same level of price inflation should be allowed for in the discount rate used. Ambiguities arise if different rates of inflation are allowed in the different elements in the calculations.

4 Estimating the value of the stock level of the resource

7.203. Once estimates for the life length of the asset, the resource rent over this period and a discount rate have been determined, the value of the stock level of the resource can be estimated as the net present value of the pattern of resource rents.

7.204. Using the approach above, gross or net operating surplus can be divided into one part attributable to produced capital and one part to resource rent. When making projections into the future is concerned, the relative life lengths of the two sets of assets must be considered. If they are identical, the value of the stock of the resource may be written as either the net present value of the series of (GOS_t-CS_t) or (NOS_t-rV_t). There is yet a third way of writing this. The net present value of (GOS_t-CS_t) may be written as the net present value of *GOS* less the net present value of C*S*. By definition, the net present value of *CS* is the value of the produced capital stock*, V,* so the value of the stock level of the resource may be written as any of:

NPV(GOS_t - CS_t);

NPV(NOS_t - rV_t);

NPV(GOS_t) – *V*.

7.205. In all these equations the calculation is over the life length common to both sets of assets. If the natural resource has a life length greater than the produced capital in place to extract it, while the NPV formula needs to be applied to the whole of the life of the natural resource, the available series for capital services rendered by the produced assets and the return to these will exist only for a shorter period corresponding to the life of the produced capital. In this case, projections of capital services arising from additional produced capital and the return to it, or the present value of future capital formation must be made and incorporated in the appropriate equation.

The net price or Hotelling alternative

7.206. An alternative sometimes offered to the net present value method described above is the net price method based on the Hotelling model. This model assumes that under certain market conditions non-renewable resource rent will rise at a rate equal to the rate of discount (or interest rate) as the resource becomes scarce[3]. Under these circumstances, the value of the resource stock can be calculated simply as the current rent per unit of resource times the size of the stock (Landefeld and Hines, 1985). Because rent rises over time at a rate that is exactly sufficient to offset the discount rate, there is no need to discount future resource income.

7.207. Implicit in the calculation is that the net price of the resource rises in line with the rate of discount. The evidence to support this approach is mixed. Further, a question may be asked about whether an estimate based on the assumption of future price increases is consistent with normal SNA valuations for balance sheets when the prices of the balance sheet date are used for valuation throughout.

5 Summary of methods to value natural resource stocks

7.208. Box 7.2 gives a summary of the factors discussed in this section which determine the value given to natural resource stocks. The following section considers how these general considerations apply in the case of particular assets.

[3]The Hotelling model is generally assumed not to apply to renewable resources, which, if sustainably managed, do not become scarce. Renewable resources that are not sustainably managed, but depleted instead, can in theory be valued using the Hotelling model.

Box 7.2 Summary of methods to value resource stocks

Data needs for estimating ***stock values***:

Resource rent
Stock of the resource
Life-length or rate of extraction of the resource
Decision on how to record renewals/discoveries
Discount rate for future income

Data for estimating ***resource rent***

1. Appropriation method
   - direct observation
2. PIM based method
   - stock of produced capital (estimated from price decline)
   - net operating surplus
   - rate of return to produced capital
3. Capital service based method
   - stock of produced capital (estimated from efficiency decline)
   - gross operating surplus
   - capital services rendered by produced capital

Simple definitions of key terms

Appropriation	Observed payment of (part of) resource rent to the owner of the resource.
Capital services	A measure in volume terms of the services rendered by an asset in an accounting period.
Capital services method	A means of estimating the total volume of services rendered by all assets formed by aggregating the capital services of a group of assets
Consumption of fixed capital	The decline in the value of an asset (other than the effect of price changes) due to its use in production during the accounting period.
Discount rate	The annual percentage by which future income is discounted to give an equivalent value in the present period.
Economic rent	The income generated by an asset when used in a production process.
Gross operating surplus	The difference between the value of an enterprise's output less all costs of production including compensation of employees and any taxes on production. Conceptually equal to the sum of the economic rent of all assets used.
Life-length	The period of time for which an asset is expected to remain of use. For natural resources this is often calculated as the stock divided by the average annual (net) extraction rate.
Net operating surplus	Gross operating surplus less consumption of fixed capital
PIM (perpetual inventory method)	A method to determine the level of the stock of one or several assets by cumulating acquisitions and deducting disposals and the decline in value due to the use of the asset in production.
Rate of return	Measures the "profitability" of an asset. Often calculated by dividing the operating surplus by the capital stock.
Resource rent	The economic rent of a natural resource.
Stock of an asset	The level of the resource available. Can be measured in both physical and monetary terms.

E Asset accounts in monetary terms

7.209. In this section, there is discussion of the valuation of stock level of a number of individual natural resources as well as the means of valuing additions to and deductions from stock levels. There are separate sub-sections for mineral and energy resources; biological resources, both cultivated and non-cultivated; and land and soil. There is some mention of the problems of valuing water and ecosystems, though at the present time it is unlikely that comprehensive asset accounts in monetary terms can be established for these assets.

7.210. There is also a sub-section discussing the problems associated with establishing values for the other changes in assets, especially the effect of price changes.

1 Mineral and energy resources

7.211. Valuation of mineral and energy resources, frequently equated with subsoil deposits, is complicated by the means of recording associated investment in produced assets. The special cases of the measurement of mineral exploration and the relationship to the valuation of new discoveries are discussed at length in Chapter 8. The issue of decommissioning large extractive structures such as oil rigs is also relevant. This was discussed in Chapter 6 and is referred to again in Chapter 8. In the present section, it is simply assumed that these problems have been resolved and all that remains is to estimate the value of the subsoil deposit itself.

7.212. Sales of subsoil deposits do sometimes take place, but infrequently, and the information on market prices for them may thus be very limited. The extent of information available may depend on institutional arrangements. For countries where the subsoil deposits are held privately there is likely to be more information on sales than in countries where all subsoil deposits are owned by the government. In practice, therefore, the value of the stock level of mineral and energy resources will often be estimated by means of the net present value techniques described in the preceding section. Estimates are needed for the unit resource rent to use, the physical level of stocks, the rate of extraction and the discount rate to use.

7.213. As explained in the previous section, the value of a stock of a natural resource can be calculated as the net present value of the stream of future resource rents the resource will yield until it is exhausted. This resource value (RV) can be written as a function of the resource rent (RR), the years the resource is expected to last until exhaustion (n) and a discount rate (r). For minerals and subsoil deposits, if no better information is available, it is often assumed that the rate of extraction will be constant from year to year. In such a case, the value of the resource rent will stay constant in constant price terms and the value (also in constant price terms) can be written as:

$$\mathrm{RV} = \mathrm{RR}\sum_{k=1}^{n}\frac{1}{(1+r)^k} = \mathrm{RR}\left[\frac{(1+r)^n - 1}{r(1+r)^n}\right]$$

If the level of the stock of the resource in physical terms is S and the annual rate of extraction in the same units is E, then the life length of the deposit, n is simply:

n = S/E

Similarly, the unit resource rent rr can be written as:

rr = RR/E

Thus, the value of the stock of the resource depends on the physical stock level (S), the annual extraction (E), the unit resource rent (rr) and the discount rate (r). Each of these is discussed in more detail below.

Stock level

7.214. Originally, in calculating life length of oil reserves, it was assumed that since the reserves are not renewable on a human timescale, the appropriate estimate of life length is simply proven reserves over current extraction rate. On this basis, several European countries have had ten years worth of oil stocks for over twenty years. Calculating the value of the stock on this basis and speaking of running down the nation's wealth over a ten year period is then misleading.

7.215. Estimates of the physical stocks of subsoil resources, especially of oil and gas, are usually categorised by the degree of certainty with which they are known and their economic viability given present prices and extraction technologies. Deposits which are well described and viable are often described as "proven" and those where there is less certainty as "probable". These terms are not exact and are subject to variation from one country to another. Further discussion of the measures of physical stocks is given in Chapter 8. For the purposes of the present chapter, it is sufficient to use the categories of proven and probable as just described.

7.216. The SNA specifies the coverage of subsoil resources to be valued in the balance sheet as proven reserves only. A number of countries work, even in the SNA context, with "proven" plus "probable" reserves rather than "proven" only. This is sometimes because the information on the two classifications is not available separately and sometimes simply to have a more realistic assessment of "established" reserves. One possibility is that probable reserves should be added to proven reserves with a weighting factor reflecting the probability of their being converted to proven and even to extend the same procedure to possible reserves (with a lower probability factor). Though theoretically appealing, this process is likely to encounter data problems in implementation. The simple use of proven plus probable seems a preferable, generally applicable recommendation for the SEEA.

7.217. In principle, the coverage of the reserves in the physical and in the monetary asset accounts should be the same if the two accounts are to be used in combination. In the SEEA, both proven and probable reserves are included as assets but, as just noted, countries following the SNA strictly will cover only proven reserves. In such a case, it would be helpful if the valuations in the SEEA accounts were separated by type of reserves so that the degree of overlap with the SNA was obvious.

Resource rent

7.218. Historically the unit resource rent for subsoil assets varies from year to year. Since it is calculated in effect as a residual, if the world price of oil rises faster or more slowly than the costs of extraction, other things being equal the resource rent will fluctuate in the same direction. In making projections about the level of unit resource rent over a future period, it is usually assumed that it will remain constant in constant price terms. The question which remains is whether to use the unit resource rent observed in the most recent period, whether to use an average over a number of recent years, or to make projections building in assumptions about the likely evolution of relative prices over the period in question. This issue is discussed further in the section on prices below.

Extraction rate

7.219. Independently of assumptions about the unit resource rent, an assumption must be made about the pattern of extraction to be followed over the future. The assumption most often used is that it will stay constant in physical terms, but there is no reason why this should necessarily be so. As resources approach extinction, there may be a decline in output as some deposits are completely exhausted if there are no new deposits to take their place. Alternatively an enterprise could adjust the rate of extraction to give the same total income every year, or could reduce the amount extracted as the resource diminishes assuming that the price would increase at the same time. There may be information available from government or from enterprises on projected levels of extraction which could be used. However, these often tend to be based on conservative projections of the likely level of new discoveries and reappraisals which is why the published figures on the expected life length of resources are regularly exceeded in practice. For simplicity, and in the absence of more precise information, the assumption made here is that the rate of extraction is kept constant in physical terms.

Life length

7.220. At any point in time, the life length of the reserve is equal to the stock at that point divided by the average extraction rate. In the course of a year, the life length will diminish by one due to extractions and will change by D/E where D is the level of new discoveries and reappraisals and E the average extraction rate. If D is positive the life length increases; if on balance there are more negative reappraisals than upwards reappraisals and new discoveries, then the life length is further reduced in the course of the year. The life length at the end of the year, n_t, can thus be expressed as the life length at the beginning of the year, n_{t-1}, less one due to extractions plus D/E. Thus both extraction and discoveries affect the life length at the end of the period but not the life length at the start of the period. To convert from the start period life length, therefore, it would be necessary to make a projection of the likely level of discoveries as well as assuming that the life length is diminished by one year due to extractions.

7.221. Obviously the extent of the stock used to calculate life length must be consistent with the extent to be valued. If a value is to be placed on proven reserves only, then the life length will be appreciably shorter, and the value of the stock lower, than if proven and probable reserves are to be used together. Given that extractions are always made from proven reserves, one way of looking at this is to say that the proven reserves give a life of, say, n_1 years, the probable reserves extend this from year n_1+1 to n_2 and possible reserves (if counted) extend the life further from year n_2+1 to n_3. Given the way in which the discounting factor increases, this automatically means that the further distant the prospect of extraction, the less the reserves of equal size contribute to the present monetary value. This does not necessarily imply that the newly discovered reserves are extracted last, simply that some of the combined existing and newly discovered reserves will be extracted in these later years.

The valuation of discoveries

7.222. The value of discoveries is the amount by which the NPV of the whole deposit increases as a result of new finds and upwards reappraisals. The additions should be added to any existing volume estimates of proven plus probable reserves, with the same rate of extraction and same discount rate as for the initial volume. The value of discoveries is then the difference between the NPV of the enlarged volume and the volume before the new discoveries. If the life length of the reserves before the discovery was n years and after discovery is n+t years, then the increase in value is the NPV of extraction in years n+1 to n+t. The addition to value of the discoveries is much less than the value of a similar quantity of resources at the time of extraction, and very much lower than the market price for the extracted resource. Further note that the value of the discoveries also depend on the level of existing proven reserves. If these are high, the value of the discoveries is lower than the value of the same volume when existing proven reserves are lower or zero, reflecting the relative scarcity of reserves at these two points.

7.223. If the size of the discoveries is so large that the average level of extraction permanently increases, then there will be consequent changes to the value of the total resource stock on this account.

Valuation related to parameter changes

7.224. Because the value of the reserve stock depends on the stock level, the extraction rate and the unit resource rent it is possible to consider the effect on the value of changes in the stock level due to extraction, due to changes in the extraction rate, due to discoveries and to changes in the unit rent. Suppose that in addition to the value at the end of the year, RV_t, values under three other conditions are considered, denoted by subscripts 1, 2 and 3 and the variables relating to the previous year have subscript (t-1). The difference between the end of year point t and condition 1 is the level of discoveries, D_t. Between conditions 1 and 2 the difference is the extraction E_t. Between conditions 2 and 3 it is the extraction rate which changes to E_t from E_{t-1}. Between condition 3 and t-1, the start of the year or, equivalently the end of the previous year, it is the unit resource rent rr_t which has changed from rr_{t-1}. These are shown schematically in Table 7.8. This scheme simplifies the timing of events by assuming that the unit resource rent and the rate of extraction change at the start of the year and that discoveries and rent are recorded at the end of the year.

Table 7.8 Parameters for valuation under different assumptions

Value	Subscript	Unit resource rent	Extraction rate	Stock level	Life-length
RV_t	t	rr_t	E_t	$S_t = S_{t-1}-E_t+D_t$	$n_t = S_t/E_t = (S_{t-1}-E_t+D_t)/E_t$
RV_1	1	rr_t	E_t	$S_{t-1}-E_t$	$n_1 = (S_{t-1}-E_t)/E_t = n_2-1$
RV_2	2	rr_t	E_t	S_{t-1}	$n_2 = S_{t-1}/E_t$
RV_3	3	rr_t	E_{t-1}	S_{t-1}	$n_3 = n_{t-1} = S_{t-1}/E_{t-1}$
RV_{t-1}	t-1	rr_{t-1}	E_{t-1}	S_{t-1}	$n_{t-1} = S_{t-1}/E_{t-1}$

7.225. The change in the value of the stock over the whole year is RV_t-RV_{t-1}. This can be decomposed into a number of stages in each of which only one of the parameters changes, thus:

$$RV_t - RV_{t-1} = (RV_t - RV_1) + (RV_1 - RV_2) + (RV_2 - RV_3) + (RV_3 - RV_{t-1})$$

7.226. Box 7.3 shows how each of the expressions affects the total value of the stock of the asset. Putting all these together, the total change in the value of the stock of the resource between the start and end of the year can be decomposed as shown into five elements:

- the effect of discoveries and reappraisals;
- the effect of extraction;
- the return to the natural resource (the effect on the NPV of time passing);
- the effect of changing extraction rate; and
- the effect of changing resource rent.

Of these the first one and the last two may be zero but the other two will always co-exist and always exist as long as any extraction takes place.

7.227. Note that this decomposition is dependent on the order in which the effect of the changes in parameters is evaluated. A different ordering will give somewhat different results.

Box 7.3 Derivations of the decomposition of change in stock valuation

Discoveries and reappraisals (RV_t-RV_1)

Supposing the discoveries are positive, then the new life length n_t is greater than n_1 and this expression can be written as:

$$RV_t - RV_1 = rr_t E_t \sum_{k=1}^{n_t} \frac{1}{(1+r)^k} - rr_t E_t \sum_{k=1}^{n_1} \frac{1}{(1+r)^k}$$

$$= rr_t E_t \sum_{k=n_1+1}^{n_t} \frac{1}{(1+r)^k}$$

$$= \frac{rr_t E_t}{(1+r)^{n_1}} \sum_{k=1}^{n_t - n_1} \frac{1}{(1+r)^k}$$

If there are net negative reappraisals, then n_t is less than n_1 and the expression becomes:

$$RV_t - RV_1 = \frac{-rr_t E_t}{(1+r)^{n_t}} \sum_{k=1}^{n_1 - n_t} \frac{1}{(1+r)^k}$$

If there are no discoveries in the year, n_t is exactly equal to n_1 and the term for RV_t -RV_1 is exactly zero.

Extraction (RV_2-RV_1)

The value of the stock after deducting E_t from the previous stock level, can be written as:

$$RV_2 = rr_t E_t \left[\sum_{k=1}^{n_2} \frac{1}{(1+r)^k} \right] = \frac{rr_t E_t}{1+r} + \frac{rr_t E_t}{1+r} \left[\sum_{k=1}^{n_2 - 1} \frac{1}{(1+r)^k} \right]$$

$$= \frac{rr_t E_t + RV_1}{(1+r)}$$

and so:

$$RV_1 - RV_2 = -rr_t E_t + rRV_2$$

Thus the change in value due to extractions in a year can be expressed as the sum of a decrease equal to the value of the resource rent and an increase equal to the return on the value at the start of the year. This is a more formal derivation of the equation described in Figure 7.1.

Changes in the extraction rate (RV_2-RV_3)

Changing the extraction rate changes the expected life length which is similar to the impact of discoveries and reappraisals, but with the unit resource rent unchanged the total stock value alters:

$$RV_2 - RV_3 = rr_t E_t \sum_{k=1}^{n_2} \frac{1}{(1+r)^k} - rr_t E_{t-1} \sum_{k=1}^{n_3} \frac{1}{(1+r)^k}$$

$$= rr_t E_t \left[\sum_{k=1}^{n_2} \frac{1}{(1+r)^k} - \frac{E_{t-1}}{E_t} \sum_{k=1}^{n_3} \frac{1}{(1+r)^k} \right]$$

Change in the unit resource rent (RV_3-RV_{t-1})

The last term represents the change in value due to a change in resource rent:

$$RV_3 - RV_{t-1} = rr_t E_{t-1} \sum_{k=1}^{n_{t-1}} \frac{1}{(1+r)^k} - rr_{t-1} E_{t-1} \sum_{k=1}^{n_{t-1}} \frac{1}{(1+r)^k}$$

$$= E_{t-1} \sum_{k=1}^{n_{t-1}} \frac{1}{(1+r)^k} \left[rr_t - rr_{t-1} \right]$$

7.228. Table 7.9 gives an example of such a decomposition for Norway for 1995. The life length for the resource at the beginning of the year was 25 years.

Table 7.9 Decomposition of changes in oil reserves

	Volume (million tonnes)	Value (billion Norwegian kroner)
Opening stocks	3 531	418
Discoveries and reappraisals	116	8
Extraction (resource rent)	-141	-26
Return to natural capital		16
Change in the rate of extraction		13
Change in the unit resource rent		-18
Closing stocks	3 506	411

Source: Statistics Norway.

Aggregation of the same resource over different deposits

7.229. In the discussion so far, it has been implicitly assumed that the mineral and energy resources constitute a single deposit so that any extractions and discoveries affect the life length of all reserves available to a country. In practice, of course, this is not the case and some oil fields will be exhausted in a relatively short time frame and extractors will then move to another. The question arises, therefore, of whether it is legitimate to calculate the value of all resources as if they were in a single deposit or whether they should be calculated field by field.

7.230. Many reappraisals apply to established fields where extraction is already in progress. New upward revisions in quantities will extend the life of the wells and by analogy of the "first in, first out" model of depletion of inventories, the addition to value will reflect the previous and new life lengths. As long as the initial calculations are correct, then the adjustments for changes in the life length will also be realistic.

7.231. A somewhat different situation holds for a completely new discovery. If a new field is discovered with an expected life length of, say, twenty years, equal by itself to the existing reserves of a country, it is not realistic to automatically assume that this new field will be extracted in years twenty-one to forty. On the other hand, nor is it realistic to automatically assume it will be extracted in years one to twenty and thus double the total extractions in these years. It always takes some little while to prepare for extraction so there is a built-in delay initially. Further, in cases where there is such a large new discovery, the impact on the rate of extraction of pre-existing reserves should be taken into account explicitly. For these reasons it is desirable if at all possible to make projections of the impacts of new discoveries and reappraisals separately.

Disaggregation of different resources occurring in the same deposit

7.232. For some subsoil resources, a single deposit may yield several products. An oil well often contains gas also. Silver, lead and zinc frequently occur together and can only be extracted together. In this case the resource rent used in the calculation of the value of the resources needs to be divided by commodity. However, in practice, data are available by establishment only. In such cases, a separation of the unit costs of extraction for each product is not possible except by using some rule of thumb.

7.233. One possibility is to allocate total extraction costs in proportion to each product's contribution to net revenue from the mine. If no extraction cost data at all are available, then extraction costs may be estimated by pro-rating total operating expenses between extraction and non-extraction costs. This may be done by asking a sample of mining companies what they expect the breakdown between operating and extraction costs to be. Once this is done, net revenue data is then used as an indicator to derive extraction costs by commodity. As a final option (if the above solutions are not possible), costs could be estimated by commodity by assuming a ratio of extraction cost/price for each commodity.

7.234. Sometimes production processes, such as extraction and refining or mining and raw metal processing, are integrated. In such cases, it is difficult to identify separately the extraction costs from all the other costs. In the case of integrated production processes, the extraction activity is likely to be treated as an ancillary activity. In this case, the value of the extracted products used internally is not a part of the reported value of production. The costs for the extraction activities are included in the total cost of the enterprise, but the part of the total cost that is related to the extraction is not separately specified. If detailed data are available from the enterprise, it may be possible to assess incomes and costs associated with the extraction activity. Alternatively, it may be necessary to impute the resource rent from the combined activities of the enterprise, assuming that all profits above the “normal” return to capital are due to the use of the subsoil assets.

2 Biological resources

7.235. Biological resources are divided into cultivated and non-cultivated.

Cultivated biological resources

7.236. Cultivated biological resources are valued according to standard SNA rules which means that observed prices are the preferred method of valuation. For these resources, observed prices are generally available.

7.237. For beef cattle or crops, all the costs incurred in cultivation are recorded as production and capital formation (specifically, increases in inventories) until the time of slaughter or harvest when decreases in inventories are recorded. The rationale for this treatment is that rearing plants and animals is a production process with a long production period. All costs are cumulated as a form of capital cost until the moment when these can be recovered via the sale of the crop or animal.

7.238. In the case of a dairy cow or rubber tree, for example, the market price is assumed to be equal to the discounted present value of the future yield of milk or rubber over the life of the cow or tree. Production and fixed capital formation is recorded in the early years of the life of the cow or tree as it reaches maturity and consumption of fixed capital as it declines from its peak of maturity. These effects are reflected in the prices for animals and plantations of different ages.

7.239. The value of the stock of cultivated biological resources is relatively simple to calculate as the observed market price per unit times the volume of the stock, allowance being made for the fact that prices for assets of different ages carry different prices. Only for plantations yielding repeat products over a period of time is it likely that NPV techniques for valuation will be necessary.

Non-cultivated biological resources

7.240. For non-cultivated biological resources, the basis of valuation is the resource rent only. The resource rent is derived by deducting all costs of harvesting the resource from the market price received for it. The value of the stock is then derived by NPV techniques using information about the total physical quantity, its expected life length given natural growth rates and the rate of harvesting.

7.241. In principle, additions to stock levels should be recorded for natural growth (less natural wastage) and deductions for the harvesting which takes place for human consumption. In some cases, though, it may not be possible to record these separately but only the net change in stock levels.

Wooded land and timber resources

7.242. In the asset classification of the SEEA and the 1993 SNA, forest land and standing timber are classified as two separate assets. Land is a non-produced asset, while standing timber is a produced asset if the forest is cultivated and a non-produced asset if it is non-cultivated.

7.243. In principle, the value of timber and the value of forest land should be separated. In practice it is often difficult to separate the two elements since forested land may not be available for other purposes, whether by reason of location, soil type, or administrative restrictions. When looking at a forest as an indefinite "going concern" the value to be given to it clearly covers both the land and the standing timber. This composite asset is called a "forest estate" here to distinguish it from forested land, forests and standing timber. It should also be taken to include any forest-related environmental assets included in the area concerned.

7.244. A range of methods has been developed and tested to value forest estates as well as land and standing timber separately. Eurostat has published a manual presenting a framework for integrated environmental and economic accounts for forests (Eurostat, 1999) as well as a report on valuations performed testing this framework (Eurostat, 2000b). The United Nations Food and Agriculture Organisation is in the process of compiling a handbook devoted entirely to the compilation of forest accounts.

Forest estates

7.245. A simple method for valuing forest estates is to calculate the average price of one hectare of forest and to apply it to the whole forest area. Average prices may be calculated from a register of transactions or a fiscal database. Data on transactions exist in many countries but the number of transactions per year is often very low. Many transactions that do take place may be influenced by hunting rights and questions of inheritance as much as by pure forestry motivations. Sales following the reclassification of forest land (for example, to permit road building) may also influence recorded prices. The use of transaction data as a source may thus not be wholly suitable without further examination.

7.246. As forests are often not homogeneous, if the data are available it is preferable to classify forests according to their characteristics and then to calculate a price for each category and apply this price to the corresponding stock. Relevant classification criteria are the productivity of the land, species and age structure of the standing timber, the existence of hunting rights and so on.

7.247. Starting from a sample of recorded transactions, the value of forest estates can also be estimated as a function of these characteristics using a hedonic pricing model. This method can be used to value forest land and standing timber separately by associating the characteristic used to one or the other underlying asset.

7.248. Another method that can be used to value forest estates is the net present value of the future forest resource rent. The resource rent is calculated as the value of output in the forestry industry minus all costs of production. The production costs include a return to produced fixed assets engaged in production (roads, buildings, equipment, etc.) and compensation to self-employed persons. If the current level of harvesting is assumed to be sustainable, and prices and costs are assumed to be constant, the value of the forest may be calculated as the present value of a constant, perpetual stream of resource rent generated by the harvesting.

7.249. Comparing the results of the transactions-based method and the net present value method can give insights into the validity of the assumptions used in the estimates, such as the discount rate used and the biases in observed transactions prices.

Forested land

7.250. In some countries transaction prices of bare forest land are available and can be used to value the whole forest area in a similar way to that described for forest estates. If this is not the case, it might be possible to estimate land values based on transactions in forest estates using hedonic pricing techniques as described above.

7.251. The price of bare forest land may also be approximated by the price of comparable land; for example, starting from prices of marginal agricultural land. Other alternatives are to estimate the price of land as a share of the price of forest estates or to use recommended (administrative) values.

7.252. Another possibility is to apply two different valuations to the standing timber on the forested land. The first values the standing timber at a moment in time, assuming that no regeneration will take place as trees mature and die or are felled; in other words, harvesting of timber is restricted to the current rotation cycle of the forest. This puts a value on the existing standing timber. The second valuation is on the basis that harvesting can be sustained indefinitely, so that the value of the asset can be calculated as the discounted present value of an indefinite annual stream of rent generated from harvesting the timber stock. As explained above, this gives a valuation of the timber and land combined as a forest estate. The differences between these two estimates can then be taken as an estimate of the forested land excluding the current standing timber.

Valuation methods for timber

7.253. The theoretical value of standing timber is equal to the discounted future stumpage price for mature timber after deducting the costs of bringing the timber to maturity. The stumpage price is the price paid by the feller to the owner of the forest for standing timber. The costs include thinning (net of any receipts), other forest management costs and rent on the forest land. For non-cultivated forests the management costs are very low or even zero.

7.254. Applying the ***present value*** method as described in Section D to forests is relatively complicated and requires a lot of data on the age structure and growth rate of the forest, on forest management costs and on the rent on land. Therefore, simplified methods are often applied. They differ mainly in the complexity of the modelling of revenue and production costs, the data they require and the way the rate of discount is determined. Two such valuation methods are the ***stumpage value*** method and ***consumption value*** method.

Simplified present value methods

7.255. In many applications the value of the standing timber is based on the receipts from felling of mature timber only while costs are neglected.

7.256. On the basis of a forest inventory, the standing timber is distributed by age classes (for example by twenty year classes). Estimates are made of the harvesting age and volume of standing timber per hectare at the harvesting age. These volumes are multiplied by the stumpage price to estimate future receipts, and discounted to estimate a value per hectare for each age class. These values are multiplied by the total area of each age class and added to give the value of the total stock of standing timber.

7.257. Because yields, prices and harvesting ages differ by species, this method should be applied to each main species separately. Since it neglects intermediate costs and receipts, as well as the rent on land, the method introduces a bias (of unknown size) in relation to the theoretically correct value. It is most reliable when the costs are relatively small in relation to value; this may be true for many cost elements. In particular, the actual rent on land may be very low or even zero in some areas.

7.258. In a more realistic variant, an average management cost is introduced. This may be calculated by dividing actual forestry costs by the forest area based on information from forestry experts or based on analysis of the accounts of forest companies.

The stumpage value method

7.259. The method described above can be simplified further by assuming that the rate of discount is equal to the natural growth rate of the forest. This offsets the need for discounting, so the value of the stock is obtained by multiplying the current volumes of standing timber by the stumpage prices (still neglecting costs)[4]. This is known as the stumpage value method or net price method.

7.260. In the simplest variant, an average stumpage price is calculated and applied to the whole stock of standing timber. Physical data for the total stock are generally available from forestry statistics and national forest inventories and only an average stumpage price has to be calculated.

7.261. If stumpage prices are not directly available, they may be calculated by deducting the logging, transporting and stacking costs from the "roadside pick-up" prices (also called wood in the rough or raw wood prices). The roadside pick-up price is the price of timber already felled, transported to the roadside and stacked, and volumes and values will often be available in industrial statistics. The average stumpage price is then calculated by dividing the stumpage value by the volume of the removals expressed in cubic metres of standing timber (this may require a conversion of the volume of wood in the rough into its standing timber equivalent). More detailed variants apply several average stumpage prices per species to the volume of standing timber per species.

7.262. The average stumpage price is dependent on the age structure of the removals, because stumpage prices are higher per cubic metre for mature trees than for younger trees. This means that the value of standing timber can change because of changes in the age structure of removals. The age structure may change over time because of over-exploitation, or when much of the forest results from afforestation programmes (and is young on average).

7.263. When the stumpage value method is used, some potential problems should be kept in mind. For physical data, the volumes should be accurately measured with the correct units. In general, coefficients are used for the conversion between a cubic metre of standing timber (measured following the prescriptions of, say, the *Temperate and Boreal Forest Resource Accounts 2000* (United Nations Economic Commission for Europe and Food and Agriculture Organisation of the United Nations, 2000) and a cubic metre of wood in the rough. These coefficients depend upon the type of wood in the rough (logs, pulp wood, fuel wood) and the way it is measured (with or without bark).

[4] This is reminiscent of the Hotelling method but here the discounting is offset by physical growth not by price increases.

7.264. Physical and monetary data should be consistent. A main problem is fuel wood. Fuel wood for own final use is within the production boundary of the 1993 SNA (valued at basic prices), but it is often not included in the output of the logging industry, whereas it may be included in forestry statistics in physical terms. In most cases the consumption of fuel wood is estimated as a balancing item, comparing two successive forest inventories.

The consumption value method

7.265. The consumption value method is a variant of the stumpage value method. The difference is that in the consumption value method, different stumpage prices are used not only for different species, but also for different age or diameter classes. These prices are applied to the stock of timber, which is generally known by species and age or diameter classes through forest inventories. The consumption value method measures the value of the timber as if it were all cut now; hence its name.

7.266. When stumpage prices by species and by age or diameter are available, they can be applied directly. If they are not available, the standing timber stock, described by species, diameter or age classes, etc., has to be converted into assortments of wood in the rough using specialised forest algorithms. The potential total production of wood in the rough is calculated by assortment and wood in the rough prices are applied. The logging costs are then deducted in order to arrive at a stumpage value. In the most detailed methods, logging costs are calculated by wood assortment or logging conditions (slope, access, etc.). In general, however, an average logging cost by cubic metre of wood is used.

Valuing standing timber - conclusions

7.267. A summary of the alternative valuation methods discussed is given in Box 7.4. The basic difference between the stumpage value method and the consumption value method is that the former uses the structure of the fellings for weighting the stumpage prices, whereas the latter uses the structure of the stock. These two structures may differ considerably and may also change over time. The two methods are special forms of the net present value method (with implicit discounting) and it can be argued that they are in line with SNA principles. However, it is difficult to compare their results analytically with the results of the net present value method. Which of the methods gives more accurate results has to be judged on the basis of the characteristics of the forest to be valued, including the conditions of exploitation. The choice depends upon the current structure of the stock and the fellings and their assumed evolution in the future. The net present value method is best when the forest is managed optimally according to the principles of forestry economics and for large-scale afforestation, where the structure of the stock and fellings will change over time. The stumpage value method gives good results when the current felling structure can be assumed to continue in the future. For old growth and overly-mature forest, the consumption value method is a good method.

7.268. An advantage of the stumpage value method is that it can be used to value all the items in the physical timber account in a simple way; not only stocks, but also removals, natural growth and other changes as well. This is not the case for the other methods discussed here.

Box 7.4 Summary of valuation methods for timber

This box provides formulae for the valuation of standing timber according to the methods described in this section. In each case the value is a product of the area of the forest (A) with the quantity of the timber in terms of cubic metres per hectare (Q) and the average stumpage price per cubic metre (p).

Stumpage value method

This is the simplest formulation; no discrimination is made for the age of the timber at the valuation date.

Using the stumpage value method the value of standing timber, S, is given by:

$$S = ApQ$$

Consumption value method

The consumption value method requires data for different age classes from 1 to n. The area, quantity and price for timber of age t are shown by a subscript t.

Using the consumption value method the value of the stock of standing timber, S, is given by:

$$S = \sum_{t=1}^{n} A_t p_t Q_t$$

Simple net present value method

In the simple version of the net present value method only receipts from harvesting mature timber are included; other receipts (from thinning) and costs are ignored. It is assumed the receipts are only realised when the timber reaches maturity at age T. At this point the price realised and quantity to be harvested have subscripts T. To reach the net present value, discounting using a discount rate of r for each of the (T-t) years until harvest must be applied.

Using the net present value method the value of standing timber, S, is given by:

$$S = \sum_{t=1}^{n} \frac{A_t p_T Q_T}{(1+r)^{T-t}}$$

Allowing for management costs

Suppose information on the management costs per hectare is available. This might be in the form of a simple average, c, for the whole forest or more refined information showing the costs for trees of a given age, c_t, might be available.

The total costs under the stumpage value method will be Ac. Under the consumption value method they will be $\Sigma A_t c_t$. Under the net present value method they will be: $\sum_{t=1}^{n} \frac{A_t c_T}{(1+r)^{T-t}}$

Each of these, if available, needs to be deducted from the formulae for S given above.

If estimates of the revenue from thinnings are available, additions to the value of the standing timber can be made to each of the formulae in a similar way:

$$S = \sum_{t=1}^{n} \frac{A_t (p_T Q_T + s_T)}{(1+r)^{T-t}}$$

7.269. Table 7.10 shows test results from Germany, Austria and France for the three valuation methods for standing timber mentioned above. The net present value method gives higher values than the stumpage and consumption value methods in all three countries. The differences between the consumption value and stumpage value in Germany and France reflect differences between the structure of removals and the structure of the stocks.

Table 7.10 Germany, Austria and France: Standing timber values

ECU/m^3

	Germany 1995	Austria 1995	France 1991	France 1994	France 1996
Consumption	19.7	19.8	32.1		35.3
Stumpage	31.1	22.0	20.8 – 26.8	23.8 – 29.7	
Net present value	(53.0)*	26.5 –28.1	39.5		

* Indication
Source: Eurostat, 2000b.

3 Fish

7.270. Fish farmed in an aquaculture establishment are produced assets. These assets are privately owned and can be traded in the market. In most cases market prices are easily obtainable and can be used to estimate the value of live fish owned by the establishment.

7.271. Monetary valuation of wild fish stocks is more complicated. One possibility is to value the fish stock via the value of fishing licences and quotas where realistic market values are available. The other is to base the value on the net present value of the resource rent of the fish stocks. If there is a perfectly functioning market for fishing licences and if these licences cover the whole stock, these two valuations should give the same result. Because of market imperfections and uncertainties in the statistical assumptions required for net present value calculations, this is unlikely to be exactly so in practice. This topic is discussed as well in Chapter 8.

An appropriation method for valuing fish stocks

7.272. When fishing rights, instanced by the existence of licences and quotas, are freely traded, it might be possible to estimate the value of the natural resource from the market prices of these entitlements. In many cases, where the government hands the access rights to fishermen, trading in these access rights is prohibited and therefore there is no directly observable market valuation. In some cases fishing rights may be tied to some asset (often a fishing vessel and, in some cases, land) which is freely traded. In these cases, it may be possible to infer market valuation of the access rights by comparing the prices of the associated assets when fishing rights are attached to them and prices of similar assets that do not have any such rights.

7.273. Two forms of quotas are common. An Individual Transferable Quota (ITQ) provides entitlement to an absolute level of catch. An Individual Transferable Share Quota (ITSQ) provides entitlement to a fixed share of a total which may itself be variable from year to year in accordance with, for example, international agreements. The value of the quota represents the NPV of the owner's expected income using the quota over its period of validity. If the fishery is managed with such quotas and the quotas are valid in perpetuity, the value of all quotas, at the market price, should be equal to the value of the use of the fish stock. If the quotas are valid for a single year only, the total should give an approximation to the resource rent in that year.

7.274. However, in most of those cases where ITQs and ITSQs are used to manage fisheries, the market in these quotas is far from perfect and so these access rights do not fully reflect the value of the resource. Fishing licences and quotas are often introduced when considerable excess capacity exists in the fishing industry. Unless those setting the total level of the quotas do so based on knowledge of the maximum catch consistent with preserving stocks, the earnings from the catch will not correspond to the concept of income which maintains the capital intact. A total permissible catch which is higher than this level will mean that some of the fishermen's earnings should be regarded as depletion of the fish stocks and not income.

Valuation based on the net present value of future rents

7.275. The operating surplus for ocean fishing of wild fish stocks can be used as a basis for the calculation of economic rent of the resource. As in the similar case for subsoil deposits, the total amount of gross operating surplus must be partitioned between that part representing the economic rent of the ship, nets and other equipment used and the part representing the resource rent of the fish.

7.276. There are a number of complications particular to the fishing industry which must also be taken into account. The first is that artisanal fishing is very common, especially in developing countries. Here the production account yields an item called "mixed income" as the balancing item rather than operating surplus. This is because it represents a return not only to the produced capital used and the natural fish stocks but also an element of remuneration to the self-employed fisherman. When this is the sort of data available, an adjustment to remove this element of labour remuneration must also be made.

7.277. Because fisheries frequently target more than one species, it is very difficult to obtain data on the cost of fishing for each species. The joint-production character of the production process creates special complications for the estimation of the cost of fishing for each species.

7.278. As well as permitting fishing in excess of the sustainable level of catch, governments may sometimes subsidise fishing so that fishing continues even when the resource rent is negative.

7.279. Just as the question of the sustainable level of catch affects calculations of resource rent using an appropriation method, so it affects the direct estimation of resource rents. If the fish stock is to be preserved in perpetuity, harvest should not exceed the renewal rate of a stable fish population. When this is the case, the economic rent of the fish and the return to the fish are identical, there being no depletion of the stock. Over-fishing results in increased gross operating surplus in the short term, but the deduction for the change in the value of the total stock reduces the income element below the level of income in the stable case. Even when the harvest in a year does not exceed the nature renewal of that year, the situation may still not be sustainable because of over fishing in the past and the need to rebuild an age structure of fish capable of self-perpetuation. An improved calculation of the partitioning of the operating surplus between a depletion and an income element should take into account estimates of the maximum sustainable yield of fish by species and area.

7.280. Not only is this a complication for the estimation of the appropriate income element in the years actually observed, it can be even more acute when making projections of the resource rent for future years. It is important to note that biological systems are often quite complicated and the knowledge of these systems, and their productive possibilities, is usually partial.

Conflicting policy goals

7.281. One factor leading to unrealistic levels of fishing quotas is the desire of governments to preserve fishing communities. Considerations of employment issues, regional issues and sometimes the protection of a certain way of life enter frequently into decisions on fisheries management. There is thus a conflict here between social, economic and environmental goals. Subsidies which are socially beneficial but environmentally harmful are one instance of what can result in such situations. There is some further discussion on this in Chapter 8.

7.282. One source of conflict is between short term and long term objectives and the recording of ownership of the stocks. This issue is discussed in Chapter 10.

7.283. As explained in Chapter 5, resource management accounts are not yet well developed, but it is clear that costs incurred by, say, government in order to preserve and enhance fish stocks could be taken into account when undertaking a full accounting for the costs and benefits of fishing. This is referred to again in Chapter 10.

4 Land

Valuation of the stock

7.284. At first sight, valuation of land by means of observed market prices would seem straightforward; in practice, a number of complications arise.

7.285. The first problem is that although there is a market in land, relatively little land changes hands in any year and so a comprehensive set of prices to cover all land types in all locations is seldom if ever available. Even when prices are recorded, they may be subject to many of the distortions described earlier in connection with valuing forested land. Further, some land will never be exchanged on the market. This may include designated public areas, land under traditional patterns of common ownership and remote and inhospitable land.

7.286. The second problem is that land is almost never sold as a separate asset. Often land under buildings will be sold with the buildings in a single transaction and partition of the value into an element for the land only may be approximate at best and very frequently such a partition may not in fact be made.

7.287. Sales involving land may also cover other aspects than the initial purpose of the land, such as building land or agricultural land. A building plot with a spectacular view will fetch a higher price than an equivalent area in a very similar location but without the view. Thus amenity benefit is merged with the direct use benefit. Similarly, some ecosystem aspects may be incorporated in the value ascribed to land.

Additions to the value of land

7.288. Whenever land is actually sold there are transaction costs involved. Typically these are those of the lawyers registering the change of ownership of the land and the estate agents who bring the buyer and seller together. There may also be taxes payable in connection with the land purchase. The SNA refers to these expenses as the "costs of ownership transfer". These costs are not recoverable by the new owner; any further sale will cover the underlying value of the land itself plus a new set of costs of ownership transfer. As a transaction, the costs to the purchaser of the land are treated as fixed capital formation and they are written off over time by means of consumption of fixed capital.

7.289. Major land improvement schemes are also recorded as capital formation and, when appropriate, consumption of fixed capital is applied over a period of time following the date of the improvement In the SNA balance sheet, though, both the value of the costs of ownership transfer and of land improvement are incorporated with the value of land as a non-produced asset. As a result, an asset account for land compiled according to the SNA rules on recording of the costs of ownership transfer is rather complex. The annex to Chapter X of the 1993 SNA discusses some of these aspects in detail.

7.290. From the point of view of environmental accounting, these complications may not present useful extra information. Globally, an asset account for land in physical terms is very simple. There may be marginal changes in land area during a year due to erosion or land reclamation but in general terms, the volume of land in terms of physical extent does not change. What is of interest, though, is the use to which land is put and the type of land cover which supports (or not) other forms of life and which regenerates the atmosphere. These issues are the topic of more extensive discussion in Chapter 8.

Degradation of land and soil

7.291. The only instance of land being used actively rather than passively is to support biological resources, whether cultivated or non-cultivated. In fact the characteristics which lead to biological growth are contained in the soil and thus the valuation and changes in valuation of land may equally be attributed to soil in this case.

7.292. Where land is used sustainably, the soil has an infinite life and therefore no adjustment for depletion is required; the whole value of the resource rent arising from biological growth should rightly be considered as income. However, where land is being degraded due to economic activity, a depletion adjustment to income is applicable.

7.293. The degradation of land/soil can be defined as the decline in the biological productivity or usefulness of land and soil resources for their current predominant intended use caused through the use of the land by humans (Gretton and Salma, 1996). Implicit in the concept of land degradation is the notion that agricultural land use removes something from the soil. In the absence of natural regeneration or land management, the productivity of the land is then reduced.

7.294. Land degradation can involve the changing mineralisation of soil as occurs through irrigation, altered soil acidity and heavy metal contamination. It can also involve changes in soil structures and erosion that occurs with soil structure decline, surface scalding, water and wind erosion and mass movement of slopes. Degradation of land resources can also involve changes in biological conditions due to factors such as woody shrub infestation, disappearance of perennial bush, clearing of native vegetation, invasion by feral animals and other pest species and pollution from farm residues and farm wastes. Offset against these are improvements in land quality from soil conservation, afforestation and other changes in agricultural practices.

7.295. In the context of economic assets used here, land degradation represents the decline in the capital value of land over time caused by economic activity (after deducting price rises due to inflation). This decline in value represents the fall in future productive capacity of the land. As such, it stops well short of a full measure of the cost of land degradation to environmental systems more generally as it does not include impacts such as the deterioration of river systems.

7.296. Degradation of land or soil leads to a decline in production and hence a decline in the resource rent earned by the land compared to the resource rent which would have accrued if there had been no decline. To calculate the decline of the value of the land it is necessary to compute the net present value of future land rent that is foregone due to degradation attributed to the year in question. The impact of degradation, the decline in the value of the land should be shown as depletion of natural resources even though it is due to qualitative changes in the soil and not quantitative changes in the land itself.

7.297. Some estimates of the value of lost agricultural production in Australia exist. A few estimates have been cited in the literature but the accuracy of the available estimates and the methodology for deriving these is not very well known. Nevertheless, the relative magnitudes of the estimates in the following examples are illuminating.

7.298. Gretton and Salma (1996) reported a number of studies estimating losses due to loss of agricultural production in Australia. The Australian Department of Environment, Sports and Territories estimated a loss of around 5 per cent of the value of agricultural production in 1994-95. Similarly, the study quoted a figure for the year 1994-95 from the Prime Ministerial statement on the production equivalent of degradation that was around 6 per cent of agricultural production in Australia. The Cooperative Research Centre for Soil and Land Management (1999) estimated the costs (on-farm costs and off-farm indirect impacts on other parts of the economy) of adverse impacts of sodic, acidic and saline soils to the Australian economy. This loss was approximately double the results reported for the period five years earlier, of which about 90 per cent was attributable to on-farm cost or crop yield losses. A report commissioned by the National Farmer's Federation and the Australian Conservation Foundation estimated that the annual cost of degradation in rural landscapes was of the same order and could treble by 2020 if no action is taken (Virtual Consulting Group and Griffin nrm Pty Ltd., 2000).

7.299. When farming practices, such as allowing the land to lie fallow for a period, lead to an improvement in soil quality and the expectations of higher resource rent in future, this should be recorded as land improvement within the SEEA.

5 Valuation of water resources

Valuation of water

7.300. Very large quantities of water flow through an economy, some as natural resources, some as ecosystem inputs, some as products and some as residuals as described in Chapter 3 and further elaborated in Chapter 8. It may not be feasible to try to compile a complete water account including opening and closing balance sheets, partly because the level of the water stocks may be unknown and secondly, even if known, valuation may be very difficult.

7.301. Until the present, water has often been made available free as a public service or for a flat charge because it has been seen to be freely available and not subject to scarcity. The costs, therefore, have tended to be related to the cost of transporting water by pipe to designated outlets rather than to the volume of water consumed. There are indications that this is changing in many parts of the world and this change may accelerate as demand for water increases with increasing populations and increasing prosperity.

7.302. Water valuation is crucial for water management decisions, in particular for those related to the allocation of water to different uses in the presence of increasing demands for freshwater and limited supply. Decision makers in many nations face many questions. How much water should be allocated to agriculture for irrigated food production? How much should go to cities for final consumers and to industries? How much is needed for hydropower generation and in-stream uses? How much groundwater should be pumped now and how much should be saved for future needs? How much groundwater should be extracted versus how much surface water? How much should the beneficiaries of water pay for water supply?

7.303. There are two main ways in which water can be valued. The first and uncontroversial measure is that of the direct market price. The second is an appropriation method. In addition, other less satisfactory methods are sometimes used.

Market prices

7.304. The privatisation of formerly public utilities has led to more direct charging. Sometimes this is still on the basis of a flat fee per dwelling; more often there is a move to charge by volume consumed. Even when charges are levied per litre consumed the rates charged may vary considerably from one kind of user to another. For example, one form of subsidising agriculture may be to offer bulk water supplies at very advantageous rates. This may lead to excessive overuse with consequent shortages for other consumers. For the purposes of sound management of the resource, monetary accounts should be drawn up to show the different classes of consumer linked to the different rates charged.

Appropriation method

7.305. Another form of pricing of growing application is the issuing of water rights. These may offer a short term rental of a water source or perpetual water rights. Short-term rentals grant rights for a limited period of time, say for one irrigation cycle or a season. The prices observed in this situation are short run and may often reflect other factors in addition to the marginal value of water. The prices paid for the rights can be taken as the value of the water available in the period covered by the rights and a value for the total stock of water estimated using net present value techniques applied to future rights issues. Prices paid for perpetual water rights represent an immediate estimate of the stock of water to which the rights give access without the need for net present value calculations. There is however an element of speculation involved in determining these prices and with an underdeveloped market in such rights, care should be used in using these prices.

Other methods

7.306. In principle, it would be possible to calculate a resource rent for water used for irrigation by looking at the rent for similar unirrigated land and attributing the increase for the irrigated land to the water used. In practice, however, it is unlikely that the same crop will be grown extensively on near-identical land with and without irrigation so this is not likely to be a very practical means of valuation.

7.307. The valuation technique of last resort, which is least satisfactory from a theoretical point of view but perhaps most common in practice, is to set the value of water equal to the cost of making it available. This is to confuse the price of the water with the cost of the means of delivery, as noted above, and is likely to prove increasingly unsatisfactory as pressure on water supplies increase.

6 Ecosystems

7.308. Few attempts have been made to establish asset accounts for ecosystems. Many of the reasons are practical: determining a suitable unit of account, deciding how to deal with the "collective" nature of a complete ecosystem, delineating the borderline of the ecosystem of interest and defining the extent of possible duplication when an entity interacts in more than one ecosystem.

7.309. However, there is no reason in principle why accounts should not be drawn up for at least some aspects of ecosystems. For example, physical and monetary estimates could be provided for each of the services offered by forests. This would entail calculating, for example, the amount of carbon dioxide absorbed by a country's forests in a given period and estimating the value of this service to the population. The same would have to be done for all other services offered by the forest. Of course, it may not be possible to derive the same sort of physical and monetary estimates for each service. For some it may be necessary to use some of the techniques discussed in Chapter 9 to impute a value of services. For example, the amenity service of the environment may be reasonably measured in monetary terms via a willingness to pay survey or in terms of admission fees to a national park whereas the parameters of the physical amenities may relate to number and types of species present, distance to main conurbations, sporting facilities and so on. In contrast, the monetary value of habitat might be very difficult to estimate, while the physical extent of habitat (at least for a particular species) might be rather easily measured.

7.310. When it is not possible or not desirable to provide individual estimates for each service of an ecosystem, it may only be possible to present a single set of statistics that incorporates all the services offered by the system. In the forest example, this might consist of a physical estimate of the extent of the forest and a corresponding monetary estimate of the value of forests to the population (aside from the value of the timber they contain, which is classified as a natural resource asset). The deficiencies of such a solution should however be clearly recognised. Natural resources can be measured in physical terms and valued, albeit with some practical problems. On the basis of this, analyses can be made to show whether these assets are being used by the economy in a sustainable way or not. Ecosystems are by their nature less amenable to "economic" measurement and valuation and thus it is extremely difficult (or may even be misleading) to make judgements on the ecological sustainability of a course of action based on economic accounts. In order to have a more rounded and complete view of ecological sustainability, indicators reflecting ecological conditions must be used to complement the SEEA accounts.

7 Other changes in assets

7.311. The SEEA asset account contains three groups of items between the opening and closing balance sheets: those for additions to stock levels, those for deductions from stock levels and other changes in stock levels. This last heading contains four items: the effects of catastrophic losses, unforeseen obsolescence and environmental degradation of produced assets, changes in ownership and valuation changes. The basis of valuing the entries under catastrophic losses and uncompensated seizures, and changes in ownership are exactly as described above for additions to and deductions from the stock levels of the asset in question. The item relating to produced assets is not relevant for environmental assets. The principles underlying the entries for valuation changes are different and are discussed below.

Valuation changes

7.312. The entries for valuation changes relate to changes in value which take place solely because of changing prices. These may be price changes which affect all items in the economy similarly and correspond to the change in the general level of inflation or they may arise from differential movements in prices. Changes in prices affect all assets, but the effects are likely to be greatest for mineral and energy supplies where the price of the commodity is governed by world prices. Similarly large fluctuations may also affect agricultural commodities held in store from one year to another, though these should be treated in the accounts as products and not as non-produced assets.

7.313. The change in the value of the stock level due to the change in the resource rent from one year to the next gives some indication of the extent of holding gains or losses experienced because of changing prices. The figures for rr_t and rr_{t-1}, like all the symbols representing flows, relate to the value during a year and are thus normally assumed to be expressed at the average prices of the year concerned. The values of the stocks to enter into balance sheets, however, should be expressed in the prices of the date to which each balance sheet relates. Thus in principle two adjustments are necessary in respect of each flow variable, one to adjust back from average year prices to start year prices and another to adjust forward to end year prices. In a period of rising prices, the full value of holding gains in a year consists of the effect of the rise in price between resource rent at the start and end of the year for all stocks held throughout the period, plus the increase from the start of the year until the time when the resource is extracted or disposed off plus the increase between the price at the time of discovery, reappraisal or acquisition and the price at the end of the year. If prices fall, holding losses are calculated in a similar manner but working back to the previous higher price instead of forward to the next higher price.

7.314. For natural resources and produced fixed capital, the largest element in valuation change is likely to be in respect of the stocks held throughout the period, though for items where prices are volatile during the course of a year the other effects may be significant also. Because resource rent is calculated as a residual, it may show a change even when the world commodity price does not change because of changes in other costs associated with exploitation and extraction of the resource.

7.315. As noted, the valuation to be placed on an entry in the balance sheet should be based on the prices prevailing at the date for which the balance sheet is compiled. If the market is working as expected, allowance for relative future price changes will be reflected in the current market prices and thus, in principle, no extra allowance is to be made for expectations in the change in relative price of the commodity over its future life length. In any case, no allowance should be made for expected increases in the general price level. For this reason, the discount rate to be used in an NPV calculation should be expressed in an unvarying price level also. Sometimes, though, calculations will be based on future resource rent with built-in projections of price changes (usually increases). When this is so, then the discount rate should also reflect changes in price. Ambiguities arise though when the general price level built into a nominal discount rate increases at a different rate from the price increase projected for the resource.

7.316. For some analyses, alternative estimates of stocks of assets may be useful. If world commodity prices are fluctuating, there may be estimates made of the stocks of resources based on long term trend prices rather than the prices at the date of the balance sheet. Stock levels expressed in the prices as of the balance sheet date may be less relevant for corporate decision makers (extractors) involved in long-term projects. Investment decisions for assets where the returns are either delayed or spread over a lengthy period are a medium to long-term proposition. Further, in the case of subsoil asset extraction, mining leases often specify fixed production rates and extractors negotiate fixed prices for their commodities some years in advance. For this reason, the use of moving averages of prices, production, and discount rates covering five years or more is likely to yield more stable and reliable estimates.

F Integrating asset accounts with the flow accounts

1 Asset accounts vs. accumulation accounts

Reclassifying capital formation

7.317. Section E of Chapter 6 showed how the full set of SNA flow accounts can be portrayed in a matrix format and then how alternative variations can be introduced to highlight areas of special interest or to introduce alternative and additional classifications. The purpose of the present section is to show how the matrix shown in Table 6.5 can be expanded to incorporate asset accounts for all SEEA assets. Such an expanded matrix is shown in Table 7.11.

Table 7.11 Accounting matrix including asset accounts

			National economy										National asset accounts			
			Goods and services (products)	Use of products	Generation of primary income	Use of assets	Distribution of primary income account	Secondary distribution of income account	Use of income account	Capital account	Financial account	Rest of the World economy	Produced assets and land	Natural resources	Ecosystems	Rest of the world environment
			1	2a	2b	2c	3	4	5	6b	7	8	6a	9a	9b	10
													Opening stock levels	Opening stock levles	Opening stock levels	
National economy	Goods and services (products)	1		Intermediate consumption					Final consumption			Exports	Capital formation by asset		Residuals from consumption	Residuals from consumption
National economy	Use of products	2a	Output												Residuals from production	Residuals from production
National economy	Generation of primary income	2b		Gross value added												
National economy	Use of assets	2c			Consumption of fixed capital								Consumption of fixed capital		Residuals from capital formation	Residuals from capital formation
National economy	Distribution of primary income account	3			Net value added		Property income					Primary income flows from the ROW				
National economy	Secondary distribution of income account	4					Net balance of primary income	Current transfers				Current transfers from the ROW				
National economy	Use of income account	5						Net disposable income								
National economy	Produced assets and land	6a				*				Net capital formation by sector			Acquisitions less disposals of non-produced assets			
National economy	Capital account	6b							Net saving	Capital transfers		Capital transfers from the ROW				
National economy	Financial account	7								Net lending or borrowing	Acquisitions less disposals of financial assets					
	Rest of the World economy	8	Imports				Primary income flows to the ROW	Current transfers to the ROW		Capital transfers to the ROW	Net lending to or borrowing from the ROW				Residuals generated by non-residents	
	Natural resources	9a		Natural resource input to production					Natural resource inputs to consumption			Natural resource inputs to ROW economy		Natural resources drawn from the environment		
	Ecosystems	9b		Ecosystem inputs to production					Ecosystem inputs to consumption			Ecosystem inputs to ROW economy			Ecosystem inputs drawm from the environment	
	Residuals			Residuals re-absorbed by production						Residuals going to landfill					*Less* cross boundary residual outflows	
	Rest of the world environment	10		Environmental inputs to production					Environmental inputs to consumption						Cross-boundary residual inflows	
	Other changes in assets	11											Reclassification to the economy from the environment Other changes	Additions to and deductions from stock levels Reclassification from the environment to the economy Other changes	Other changes	
													Closing stock levels	Closing stock levels	Closing stock levels	

7.318. As noted in the introduction to this chapter, the asset account is seldom used in a purely SNA context. This is because an asset account refers to a particular type of asset, regardless of the ownership of the asset. Within the SNA accounts, the articulation of the accumulation accounts is done according to ownership rather than by asset. In the case of some environmental assets, such as subsoil deposits or fish stocks, there may be only a single owner and so there is a one to one match between the type of asset and the owner. For others, the ownership may be quite diverse. Land is one such case. It is also the case that ownership of produced assets is spread across sectors and industries. Aggregating these assets by type rather than by ownership permits a comparison of the returns to different sorts of assets, independent of the structure of ownership.

7.319. The first task is to introduce a supplementary pair of rows and columns into the matrix relating to capital. Row and column 6 of Table 6.5 are partitioned to show first the classification by type of asset and then the classification by sector as in the SNA capital account. Row and column 6a in Table 7.11 allow for a cross-classification between products acquired as capital formation and type of asset and row and column 6b a further cross-classification between type of asset and ownership. The entry which appeared in Table 6.8 which would appear in the shaded cell at the intersection of row 1 and column 6b now appears in row 1 column 6a.

7.320. Although the fact that rows and columns 6a and 6b show a reclassification of the same concepts is fundamental, it is convenient to portray column 6a next to columns 9 and 10 where the other asset classifications are shown. Column 6b is left within the boundary of the flows showing how capital formation is financed by the owners of the assets.

7.321. Capital formation is now shown as acquisition of products according to the type of asset in the row for goods and services and the column for types of asset (row 1, column 6a). The cross-classification between products and type of asset is fairly simple since only a limited number of goods and services are acquired as assets and the mapping between the classifications is straightforward.

Bringing in transactions in land and existing produced assets

7.322. Land is a non-produced asset but one which has always been included within the SNA asset boundary. Enhancements to the value of land brought about by land improvement or just the costs of ownership transfer are included under capital formation as explained in Section E. Purchases and sales of land cancel out across the whole economy since only residents may acquire land, but when a sectoral disaggregation of total capital acquisitions and disposals is shown, these purchases need to be shown separately. In fact, existing produced assets may be bought and sold also. From the point of view of total capital formation they can be largely ignored since only transactions with the rest of the world affect the total economy level but again in a sectoral decomposition they should be shown.

7.323. As well as reclassifying the acquisition of new assets by type to sector, therefore, it is convenient to incorporate transactions in existing assets and non-produced assets such as land at this point. This is the starting point for the entry in the row for type of asset (6a) and the column for the capital account (column 6b).

Consumption of fixed capital

7.324. An entry for the consumption of fixed capital was introduced in Table 6.8. It was noted above that the consumption of fixed capital is used to compute net domestic product from gross domestic product as well as net operating surplus from gross operating surplus. In fact this distinction between gross and net applies to all the balancing items in the SNA. When analysing capital in detail, it is useful to elaborate the treatment of consumption of fixed capital further. In Table 7.11 the production account is subdivided into three elements.

The first of these corresponds to the provision of and use of products. The second shows the generation of primary income and the third the use of assets. Consumption of fixed capital then appears in the row for the use of assets (row 2c) and the column for primary income (column 2b) leaving net value added as the balancing item that links the generation of income account and the distribution of primary income account. These entries appear shaded in the upper left part of Table 7.11.

7.325. There are two possible ways of showing how the consumption of fixed capital affects other entries. One would be to enter it in the row for asset types (row 6a) and the column for use of assets (column 2c). This cell is shown shaded and marked by an asterisk in Table 7.11. An alternative is to enter it in the symmetrically opposite cell (row 2c, column 6a) with a negative sign instead of a positive one and this is in fact what has been done in the table. This form of recording achieves a number of desirable consequences. The first is that it can be deducted from gross capital formation as part of the asset account in column 6a. The second is that the entry in row 6a for capital formation can now be shown in net terms. If, instead, consumption of fixed capital was placed in the cell with the asterisk neither of these consequences would follow and further manipulation of the table would be necessary to achieve these ends.

2 Completing the asset accounts

7.326. The entries for other changes in assets are added in row 11 in Table 7.11. The opening and closing stock levels are inserted above row 1 and below row 11 respectively. Column 6a augmented in this way gives an asset account for produced assets and the non-produced assets captured in the SNA.

7.327. By partitioning the row and column for the national environment to show natural resources and ecosystems separately, we can assemble assets accounts for these two groups of assets in a similar manner. The only other entries which need to be added are the entries where the new rows and columns intersect. Here we use the same device as that used for the consumption of fixed capital. The entry at the (9a, 9a) diagonal is the negative amount offsetting the other entries in row 9a. It shows the total amount of natural resources drawn into the economy from the national environment. It is a negative entry in the asset account, as desired. For the natural resource column only, there is a possible entry in row 11 to show additions to and deductions from stocks of natural resources such as those due to discoveries and depletion of subsoil deposits.

7.328. Entries for opening and closing stock levels of ecosystems are shown to denote the conceptual possibility of compiling an asset account for them, even if this is difficult in practice. For some assets, such as water, for example, it may make little sense to try to develop a figure for total stock levels. Nonetheless, the other entries in the column are relevant and can be shown in a manner similar to that for those assets where stock levels are measurable.

3 Examples based on the SEEAland data set

7.329. This section gives examples showing how the techniques described earlier in the chapter can be applied to the data for natural resources in the SEEAland data set.

Example of asset accounts for oil and gas

7.330. Compiling the asset account in physical terms is fairly straightforward. Table 7.12 shows the account based on the SEEAland data set. The inputs of oil and gas are consistent with those shown in all the hybrid accounting matrices.

Table 7.12 Physical asset account for oil and gas

Million tonnes

	Gas		Oil	
	Previous year	Current year	Previous year	Current year
Opening stock	1 215	1 200	570	550
Additions and discoveries	10	7	10	22
Extraction	- 25	- 27	- 30	- 38
Closing stock	1 200	1 180	550	534

Source: SEEAland data set.

7.331. The starting point to compile the asset account in monetary terms is to estimate values for the resource rent for oil and gas. This is shown in Table 7.13 using both approaches described in Section D. Both start from a figure of gross operating surplus. The first deducts first the value of consumption of fixed capital and then the return to fixed capital. The other simply deducts the value of the capital services rendered by fixed capital to give the value of the resource rent.

Table 7.13 Calculation of resource rent for oil and gas

Billion currency units

Gross operating surplus	104.1
Consumption of fixed capital	
- mineral exploration	4.1
- other fixed capital	20.8
Net operating surplus	79.2
Return to fixed capital	
- mineral exploration	3.3
- other fixed capital	17.6
Resource rent	58.3
Gross operating surplus	104.1
Capital services	
- mineral exploration	7.4
- other fixed capital	38.4
Resource rent	58.3

Source: SEEAland data set.

7.332. Based on this information, net present value techniques are used to determine the value of the stock levels. The life length of the deposits is assumed to be 44 years for gas and 14 years for oil. These are made without allowing for the impact of new discoveries on the life length. A discount rate of 4 per cent and a rate of return of 8 per cent have been used. As well as calculating the value of the opening and closing stocks, this information has been used to calculate the decomposition of the change between the two stock levels. This is shown in Table 7.14.

Table 7.14 Monetary asset account for oil and gas

Billion currency units

	Gas	Oil
Opening stock (= closing stock of previous year)	175.6	523.2
Changes due to:		
Extraction (resource rent)	-9.3	-49.0
Return to natural capital (Revaluation due to time passing)	7.7	21.2
Discoveries and reappraisals	0.4	16.2
Changes in extraction path	9.3	34.7
Change in the unit resource rents (Nominal holding gains/losses)	6.5	-27.5
Closing stocks	190.2	518.8

Source: SEEAland data set.

Example of asset accounts for the timber resources of forests

7.333. In these examples, both cultivated and non-cultivated forests are assumed to be managed sustainably with no depletion taking place. Table 7.15 shows the physical asset account for non-cultivated forests.

Table 7.15 Physical asset account for timber in non-cultivated forests

Million tonnes

Gross increase in timber	45 060
Residuals from felling	580
Other natural deductions	1 480
Increase in standing timber	43 000
Timber felled	9 000
Net increase in standing timber	34 000

Source: SEEAland data set.

7.334. It is assumed that some forestry activity is performed by self-employed workers, so the national accounts first produce a figure for mixed income rather than gross operating surplus. From this an estimate of the compensation of labour must be made to derive a figure equivalent to gross operating surplus. Thereafter the calculation is similar to that described earlier. The calculation is shown in Table 7.16.

Table 7.16 Calculation of resource rent for timber in non-cultivated forests

Million currency units

Mixed income	649
Compensation of labour	100
Gross operating surplus	549
Consumption of fixed capital	174
Net operating surplus	375
Return to fixed capital	133
Resource rent	242
Gross operating surplus	549
Capital service of fixed capital	307
Resource rent	242

Source: SEEAland data set.

7.335. The monetary asset accounts for forestry in Table 7.17 show an account for cultivated forests, one for non-cultivated forests as well as one for the fixed capital used in both forms of forestry. In this case the discount rate is assumed to be 3 per cent and the return to capital 4 per cent.

Table 7.17 Monetary asset accounts for forestry

Millions of currency units

	Cultivated forests	Uncultivated forests	Fixed capital
Opening stocks	9000	8068	7245
Gross fixed capital formation			269
Consumption of fixed capital			378
Change in inventories, work in progress	-120		
Change in inventories, other			0
Harvest of natural biological resources (timber)		242	
Natural growth of non-produced biological assets		242	
Other changes in assets			
Reclassification			
Price changes			
Catastrophic losses			
Closing stocks	8880	8068	7136

Source: SEEAland data set.

Example of asset accounts for fish

7.336. In Table 7.18 and Table 7.19, three hypotheses about the levels of wild fish stocks are examined. In all of them it is assumed the catch in each year is 2 million tonnes. Associated with this usable catch there is an amount of 500 thousand tonnes wasted. In addition, 1 million tonnes a year are attributable to natural death.

7.337. Three separate assumptions are made about the level of stocks. In case 1, it is assumed that the level of stocks is unknown but increasing so that the level of catch is sustainable without depletion. In case 2 the initial stock is 14 million tonnes and grows at 10 per cent per year. Because depletion is consistently higher than natural growth, the stock is exhausted within ten years. In the third case, the stock level is unknown but a figure for net growth is known.

7.338. Table 7.18 shows the calculation of resource rent on the two alternative bases as shown for oil and gas. In the case of capture fishery, it is assumed some of this is performed by artisanal fishermen so the national accounts first produce a figure for mixed income rather than gross operating surplus. From this an estimate of the compensation of labour must be made to derive a figure equivalent to gross operating surplus. Thereafter the calculation is similar to that described earlier.

Table 7.18 Calculation of resource rent for capture fisheries

Millions of currency units

Mixed income	2 318
Compensation of labour	750
Gross operating surplus	1 568
Consumption of fixed capital	970
Net operating surplus	598
Return to fixed capital	516
Resource rent	82
Gross operating surplus	1 568
Capital service - fixed capital	1 486
Resource rent	82

Source: SEEAland data set.

7.339. Table 7.19 shows an asset account for fisheries. It gives information on the farmed fish in aquaculture as well as the fixed capital used in that industry. It also shows the fixed capital used in capture fisheries as well as the estimates of fish stocks, and changes in them, under the three cases described above. Even though the physical size of the stock is unknown in case 1, it is possible to place a monetary value on the sock on the basis of the resource rent derived each year and the assumption that the stock is non-declining. In all cases, the discount rate and rate of return are both assumed to be 4 per cent.

Table 7.19 Monetary asset accounts for fisheries

Millions of currency units

	Aquaculture		Capture fishery			
	Fixed capital	Farmed fish	Fixed capital	Wild fish Case 1	Wild fish case 2	Wild fish case 3
Opening stocks	3 200	650	12 900	2 050	610	Unknown
Gross fixed capital formation	304		1 087			
Consumption of fixed capital	240		970			
Change in inventories, work in progress (farmed fish)		311				
Change in inventories, other						
Harvest of non-cultivated biological resources (catch)				82	82	82
Returns to natural resources					24	
Natural growth of non-cultivated biological assets				82		21
Other changes in assets						
Reclassification						
Price changes						
Catastrophic losses						
Closing stocks, biological assets	3 264	961	13 017	2 050	552	Unknown

Source: SEEAland data set.

Chapter 8 Specific resource accounts

A Chapter overview

8.1. This chapter describes resource accounts for each of the main categories of environmental assets. It discusses in turn mineral and energy resources, water resources, biological resources as exemplified by forest and aquatic resources, and land and ecosystems. This order is that of the SEEA classification of environmental assets and should not be interpreted as indicating any sense of priority among the areas. However, there are cases where considerations of different assets overlap. For example, discussion of all aspects of forest resources inevitably involves some discussion on land.

1 Chapter objectives

8.2. The chapter sets out to show how many of the techniques described in previous chapters can be brought together to give a rounded picture of different aspects of a single asset or related group of assets. The types of accounts presented have different emphases for different resources. In part this reflects the different characteristics of the resources considered. In part it is intended to illustrate the flexibility offered by the SEEA to provide an interface between environmental accounting and environmental statistics more generally. The examples presented should be regarded as illustrative; though some accounts fit a given sort of resource more readily than others, there is no intention to tie one particular form of analysis rigidly to only one type of resource.

8.3. This chapter does not introduce any new techniques *per se*. The idea of supply and use balances in physical terms is taken from Chapter 3 and the juxtaposition with monetary data from Chapter 4. Expenditure related to environmental protection is treated as described in Chapter 5 and the issue of environmental permits and licences as in Chapter 6. Questions relating to monetary valuation of assets are addressed in Chapter 7 along with the construction of asset accounts. Any implications for macro-economic aggregates of flows of the assets are explored in Chapter 10. More policy applications appear in Chapter 11. The effect of environmental degradation, especially in the case of water, is the subject of Chapter 9.

8.4. This chapter has multiple objectives depending upon the resource in question. For some resources (e.g., minerals) the objective is to provide additional, detailed treatment on specific questions that have not been dealt with elsewhere in the handbook. For other resources (e.g., land and water) that are not dealt with extensively elsewhere in the handbook, the objective is to give a more or less complete exposition of the accounting.

2 Mineral and energy resources

8.5. The discussion on mineral and energy (or subsoil) resources in this chapter complements that given in Chapter 7 where the question of placing a valuation on them was discussed at length. The focus of attention here is twofold. The first concerns measurement of the resources in physical terms and the second the interaction of the valuation to be placed on the resource with the valuation placed on the economic activities which permit its extraction for absorption into the economy.

8.6. Physical asset accounts for subsoil resources seem relatively straightforward, though care is needed to define how sound is the knowledge of the extent of such resources. Subsoil resources are not renewable on a human time scale and so it seems at first sight that any use of them must be non-sustainable. The extent to which they are being used non-sustainably, however, may be modified in the light of new knowledge on the extent of resources available.

8.7. Subsoil resources are the only natural resource where the only living species they directly interact with is mankind and that interaction takes place entirely in the market place. Exploring the complex of monetary activities related to the extraction activity and the dividing line between valuation of a production activity and of the deposit itself is a matter of discussion in Section B. Closely related is the question of who can claim to own the resource and who bears the cost of the rundown in the stock of it.

3 Water resources

8.8. Section C on water brings together SEEA considerations of the flows of water as a natural resource, an economic product and a residual. The hydrological cycle of water shows how it is drawn from liquid water bodies into the atmosphere as vapour (evapotranspiration) and then returned to earth in the form of precipitation. The concern in the SEEA is mainly with the stages which intervene between precipitation and evapotranspiration.

8.9. Considerable use is made of water by some industries for their own purposes, particularly agriculture for irrigation and energy for cooling or hydro-power. Some water is “displaced” by industry but not otherwise used, for example water pumped out of mine shafts. Water industries abstract water from the environment, distribute it to others, often recover it as “dirty” water for treatment for either recycling or return to the environment. The section elaborates accounts where all these phenomena are shown with their interconnections.

8.10. To date water seldom has a monetary value placed on it, so as yet there are no comprehensive monetary accounts for water but the monetary implications of water management are examined in the section along with the issue of water rights.

4 Forests, wooded land and forest products

8.11. Section D presents accounts for wooded land, timber and forest products. Timber reserves are one category of biological resources. While it is useful and practicable to construct accounts for timber, it is more informative to look at the total value of forested land, paying attention to the timber, the land on which it grows and other forms of ecosystems supported by the forests. All of these are considered in this section.

8.12. Most timber comes from forested land but some wooded land lies outside forested areas. Specific accounts are usually compiled in respect of forests but include the consequences for forested land and forest products also. Timber from other wooded land may or may not be included according to circumstance. Forests exist as both produced assets (cultivated or plantation forests) and as non-produced assets (non-cultivated or natural forests). These may resemble one another very closely so that it is not always easy to distinguish one from the other. It is important to develop accounts which make the distinction apparent and may allow for cases where an alternative view is possible about whether the extent of human intervention is sufficient to be classified as "cultivation" or not.

8.13. Physical accounts for forests make this distinction and also usually spell out the types of tree species involved, whether broad-leaved trees yielding hardwood or conifers yielding softwood. Other aspects of forests are also regularly documented in physical accounts; for example, the age structure of the forest which determines the time to maturity of the standing timber. In addition, information pertaining to other aspects of forests (such as by-products in the form of wild animals and fruit, and the change in biodiversity) is often presented in connection with timber-related accounts for forests. Forests also provide environmental services including carbon sequestration.

8.14. Because of climatic variation from one year to another, year-to-year movements in forest growth may disguise long term trends. It may therefore be preferable to make calculations over a multi-year period or using moving averages to assess whether there is an imbalance between growth and harvest. Indeed, forest censuses are usually conducted over a multi-year period and typically avoid this problem except for the impact of major catastrophes.

5 Aquatic resources

8.15. The accounts for aquatic resources are presented in Section E. Like forests, fish exist both in cultivated and non-cultivated forms. By convention, only aquaculture (fish farming) is treated as giving rise to cultivated fish and other aquatic resources. All other aquatic resources are treated as non-cultivated, including those where freedom of movement in the open sea is inhibited by human controls (fish ranching).

8.16. It is difficult to establish the total stock of fish of various species exactly and various indirect measurement techniques must be used to establish the physical stocks of fish by species. Such measurements may have to extend to species which are not used by humans but which are vital to the ecological chain to which species of interest belong.

8.17. Valuation of commercially exploited wild fish depends on the value of the landed catch. For these species, therefore, there is little difficulty in theory in obtaining a valuation, although in practice all of the necessary data may be difficult to obtain. For those which are simply part of the aquatic ecosystem, valuation is more problematic and not necessarily particularly useful. As with forests, an assessment of physical sustainability may be rather different from economic sustainability.

8.18. An important issue for aquatic resources is the issuing of fishing licences and quotas. These are an important economic instrument in the preservation of sustainable levels of fish stocks and they are discussed at some length in this section. Also discussed is the question of the impact of fishing by non-residents in territorial waters.

6 Land and ecosystem accounts

8.19. Land and ecosystem accounts are presented in Section F. Land is an asset which is unlike any other natural resource in that it may change in quality due to human intervention but effectively cannot be either created or destroyed by man (ignoring the activities of reclaiming land from the sea and the impact of possible rising sea levels due to global warming). Nor can land be imported or exported. There are, however, implications for the use of land due to the patterns of exports where other countries demand products either embedded in the land (minerals say) or biological products dependent on the land.

8.20. Data on land use and land cover typically relate to the nature of the use being made of land, changes in this use and changes in the quality of land which may affect its suitability for various purposes. This is an area where the classifications to be used may well vary quite considerably from one country to another depending on the geographical structure of the country and the context of policy interest.

B Subsoil resources

1 Introduction

8.21. As noted in the introduction, subsoil (that is, mineral and energy) resources are inanimate and affect other environmental assets only indirectly in so far as activities associated with mineral extraction disturb the natural environment. In narrow terms, the problems of accounting for subsoil assets are confined to (i) knowing how to measure the level of stocks in physical terms and (ii) how to place a value on these. More broadly, though, there is interest in the impact of owning and using minerals on the economy; that is, the activities of the related producing industries of mineral exploration and mineral extraction. Further, there is the question of who benefits from the ownership of the resources. Each of these issues is taken up in the sub-sections which follow.

8.22. The issues surrounding the definition of what exactly constitutes a subsoil deposit affect decisions made in respect of other assets, in physical as well as monetary terms. Because there are different, valid opinions about how some problematical issues should be resolved, in places a number of options available to the implementer are listed. These are presented in this chapter, as in Chapter 7, in boxes for easy reference.

2 Asset accounts in physical terms

8.23. For some subsoil deposits, a fairly exhaustive knowledge of the size of the deposit, or at least the knowledge that it will last for a very long time, exists even before extraction starts. For others knowledge of the size of the deposit changes as extraction proceeds. This is particularly so in the case of oil and gas.

8.24. It is common practice for an oil company to decide to start extraction as soon as it is known that reserves are sufficient to guarantee profitable extraction for a given number of years. This period of time varies from country to country depending on such issues as government undertakings to permit foreign companies to operate and a judgement about the degree of political stability which would underwrite this commitment. Reserves of "proven" oil vary from about 10 years in many OECD countries up to 40 years in some developing countries.

Categories of oil stocks

8.25. Reserves of oil are grouped into different categories depending on the certainty of knowledge concerning them. Different categories are used in different parts of the world but three terms in common use are "proven", "probable" and "possible" reserves. "Proven" reserves are those where it is known that it is both technically feasible and economically viable to extract the oil. "Probable" covers reserves which are known to exist but where some doubt exists over whether they are technically or economically viable. "Possible" covers reserves where there is considerable doubt over the technical and or financial viability of extraction. In addition, two other classes of reserves are sometimes referred to. "Potential" reserves are known to exist but thought to be not technically or economically feasible to extract. "Speculative" reserves cover estimates of oil which have not been positively identified but which, based on previous geological experience, it is reasonable to expect to discover in the future. For the United Kingdom, the probabilities of viable extraction attached to the classes of proven, probable, possible and potential reserves are over 90 per cent, between 90 and 50 per cent, between 50 and 10 per cent and under 10 per cent respectively. The size of the reserves typically decreases as the certainty of their viability increases. It is quite common for the stocks of oil according to these categories to be shown in a McKelvey box (McKelvey, 1972).

8.26. Table 8.1 shows an example of this box for the oil reserves of the United Kingdom at the end of 1999. The most certain reserves are in the top left cell. Moving to the right across the columns or lower down the rows indicates a decrease in the economic or technical feasibility of extracting the reserves. The associated uncertainty is indicated by the fact that the two lowest categories are given as ranges rather than point estimates.

Table 8.1 McKelvey box for the UK continental shelf oil reserves, 31 December 1999

Million tonnes

	Discovered reserves				Undiscovered reserves
	Proven Over 90%	Probable 50-90%	Possible 10-50%	Potential additional Less than 10%	Hypothetical or speculative
Economic	665	455	545	85 - 370	250 – 2600
Marginally economic					
Sub-economic					

Source: United Kingdom Office for National Statistics, 2001.

8.27. Other criteria may also be used in classifying reserves. In the case of oil, this may relate to the sulphur content or specific gravity. For other minerals it may be the mineral content of the lode.

8.28. The SNA only records assets with monetary values and formally includes only proven subsoil reserves in its list of assets. The SEEA includes proven, probable and possible reserves in its physical accounts. Some countries may also have estimates of “speculative” (sometimes called “hypothetical”) reserves which may also be included.

8.29. In some places subsoil asset stocks are not available classified into proven and probable but only together in a single class called “established”. In these cases, this is the category included in the SNA since it is all that is available. In some other countries, it is also felt that the restriction to proven reserves is too conservative and proven and probable reserves are combined, even in the SNA context and even when the two categories are available separately.

Discoveries and reappraisals

8.30. As extraction proceeds and more is learnt about the characteristics of a particular oil well, the amount of reserves it represents will be adjusted in the light of new knowledge. If the field is bigger than expected or if it proves technically easier to extract than previously thought or if the world price of oil increases so that a greater quantity of oil can be extracted at a profit, then there will be an upwards reappraisal of the previously classified stock level. This may revise the total level of reserves or simply move some possible reserves to probable and some probable to proven. Equally, downwards revisions are also possible, both in absolute size and from one classification to a less certain one.

8.31. A completely new discovery is likely to be recorded as either probable or possible since extensive investigation is necessary to confirm the viability required of proven reserves. No oil is extracted before it has been proven (with the possible exception of very small amounts as part of the proving process) so it is possible to think of oil reserves moving through the categories from least certain to proven before extraction.

8.32. While there are some reasons why it may be desirable to separate reappraisals from new discoveries (which are discussed below), often the necessary information is not made available by oil companies. In such a case the word "discoveries" is often used to cover both reappraisals and new discoveries. In the case where there are no new discoveries and reappraisals have been downwards, this will lead to a seemingly counter-intuitive negative entry in "discoveries" when the two are combined. In general, if there are negative entries for discoveries it is probable that they are really a combination of both discoveries and reappraisals. It is suggested the term "discoveries and reappraisals" should be used in full when the two items are not available separately to avoid such apparent anomalies.

Extractions

8.33. The other change in the physical levels of oil (and other non-gaseous subsoil) reserves during a year is due to the extractions carried out in the period. For gas, the situation is rather more complicated. Gas is often found with oil and it is the pressure exerted by the gas which causes the oil (and some gas) to gush up the well. Some of the gas may be flared rather than being put to direct use. Some, especially after extraction has been continuing for some time, may be re-injected to increase the pressure on the remaining oil and so allow more oil to be expelled. In such cases, if the gas associated with the oil is being accounted for, an allowance must be made for the decrease in the amount of gas available for other uses due to flaring and re-injection.

Units

8.34. Physical accounts may be compiled in any satisfactory unit, as long as all the elements of the account can be measured in the same unit. For oil, both cubic metres and tonnes are frequently used, as well as barrels which is the unit often used in a connection with international oil prices. Conversion rates from one unit to another are not always constant. Allowance has to be made for the quality of the oil in terms of its specific gravity. For gas, allowance for the fact that the volume of gas expands as the temperature rises has also to be made. One way to overcome these variations in compiling energy balances where data for several energy types are combined is to use a unit referred to as "tonnes of oil equivalent" (toe) which is standardised to allow for variations such as these. This quantity of energy is, within a few per cent, equal to the net heat content of 1 tonne of crude oil.[1] Joules are also used to combine accounts for different energy sources.

Accounts

8.35. Putting together the considerations above on the classification of oil reserves and the nature of the physical changes that may occur within a year, it would be possible to draw up a theoretical asset account as in Table 8.2. This is very data-demanding and in practice some simplification will probably be required. Equally, however, some extra information may sometimes be available (for example, the extent of proven reserves currently being exploited) and in such cases an extension of the table may be feasible and desirable. Another possibility is that if adjustments to standard units such as tonnes taking account of quality issues have not been done, it may be desirable to add extra detail to the table showing the effect of different quality levels. In practice, "other reserves" are often expressed as a range between upper and lower bounds. It is then to be

[1] The toe is unit of account adopted by the International Energy Agency (IEA) and is equivalent to 10^7 kilocalories or 41.868 gigajoules.

decided whether to use a mid-point, apply a probability to the bounds or simply take the lower bound in calculating total reserves.

Table 8.2 Asset account for oil reserves

	Proven	Probable	Possible	Other	Total reserves
Opening stock					
Reappraisals due to					
- new information					
- new technology					
- price changes					
New discoveries					
Extractions					
Closing stocks					

Uses of physical asset accounts

8.36. The most immediate and obvious use of physical accounts is to compile an indicator which shows whether the stock levels of a given resource are declining and, if so, how quickly. This may be done in terms of the absolute levels or in terms of year-to-year changes. Though mineral and energy resources can never be used in a wholly sustainable way, because they are not renewable on a human time scale, proven reserves may appear to be sustainable if the rate of discoveries and reappraisals keep pace with extractions. Even when this is not so, if the rate of depletion of a deposit decreases from one year to the next, it may indicate that the resource is being used more sparingly than in the past. For some deposits this may be because of the possibility of recovering material from recycling or may be due to technological developments increasing the efficiency of use of the material. All of these are useful indicators for those interested in the degree of sustainability of a nation's resources.

3 Asset accounts in monetary terms

8.37. In order to compile a table corresponding to Table 8.2 in monetary terms, it is necessary to be able to place a monetary value of each of the entries there. The means of doing so were discussed at length in Chapter 7 (in the first sub-section of Section E).

8.38. Market prices for mineral deposits may or, more probably, may not exist. When market prices do not exist, a valuation by means of establishing the net present value of future resource rents must be used. There are three steps to establishing this net present value (NPV). The first is to estimate the level of the resource rent in the current period. This then needs to be projected into the future. Thirdly the set of future resource rents must be discounted to a value in the present period.

8.39. Resource rent is determined by one of two routes. The gross operating surplus of the mineral extractor covers the benefits derived from both the produced assets in use and the natural resource. One way to derive the resource rent is to estimate the capital services rendered by the produced assets, deduct this amount from the gross operating surplus so leave a figure for the resource rent directly. The other is to deduct an amount estimated as the return on produced assets from net operating surplus to derive the resource rent. These two routes should theoretically give the same result but may not in practice.

8.40. Projecting the resource rent into the future depends on a number of parameters. How long will the mine remain in operation? How is this affected if the rate of extraction alters? What effect do new discoveries have on the expected life length of the mine? What happens to the projections if the unit resource rent varies? There are different possible answers to most of these questions and to the way each parameter affects the total.

8.41. The third step in the calculation of the NPV is the choice of a discount factor and here too there is scope for different opinions.

8.42. All these choices and their consequences are discussed at length in Chapter 7. Box 7.2 gives a summary of the methods used to value resource stocks in general and Box 7.3 looks at the effects on mineral reserves of the parameters listed here in the second step of the valuation process.

4 Mineral exploration and mineral extraction

8.43. However the resource rent is determined, information about the level of produced assets used in the extracting industry must be available. For this reason, the treatment of decommissioning costs and mineral exploration are intrinsic to the valuation of the resource being extracted.

Decommissioning costs

8.44. In simple accounting terms, the difference between treating an expense as intermediate consumption and as fixed capital is a question of when the cost is charged against operating surplus. In the case of intermediate consumption, gross value added is reduced directly and on a one-time basis. For capital formation, the expense is spread over a period of years and affects net value added.

8.45. At the end of production, it is difficult to treat the whole of large decommissioning costs as intermediate consumption when there may be little if any remaining output or value added. Equally if they were to be treated as fixed capital, there may be no future value added against which to charge consumption of this fixed capital. From this stems the recommendation elaborated in Chapter 6 that the costs should be anticipated in terms of consumption of fixed capital so that over the whole time period the sum of consumption of fixed capital offsets the sum of the original capital formation and the cost of decommissioning (again for simplicity ignoring the effects of changes in both absolute and relative prices).

Mineral exploration

8.46. It is seldom the case that a mineral deposit is found and extraction can begin without considerable preliminary activities of prospecting for the mineral and then preparing to extract it. During the 1970s there was extensive activity exploring for oil in the North Sea. Under the provisions of the 1968 SNA, all the associated expense was treated as intermediate consumption. Because this activity took place before extraction began, there was no production of oil against which to set these costs and so the exploration firms were shown as operating at a loss. This was seen to be undesirable and unrealistic. Companies undertaking such activities, unless they are working on contract to another firm, do not expect to cover their costs as they proceed but to cover them in the long run from the proceeds of the discoveries. These proceeds, in fact, must cover the costs of both successful and unsuccessful exploration. In commercial accounts these exploration costs are usually treated as a form of capital formation and in recognition of the fact that the benefits of exploration are delayed, the 1993 SNA introduced a new category of intangible fixed capital, called “mineral exploration” (AN.1121) This is defined as follows:

> The value of expenditures on exploration for petroleum and natural gas and for non-petroleum deposits. These expenditures include pre-licence costs, licence and acquisition costs, appraisal costs and the costs of actual test drilling and boring, as well as the costs of aerial and other surveys, transportation costs, etc., incurred to make it possible to carry out the tests.

8.47. The SNA goes on to recommend that the value of the expenditures be recorded at cost and consumption of fixed capital on this amount be calculated over a period "using average service lives similar to those used by mining or oil corporations in their own accounts". (1993 SNA paragraph 10.91)

The cost of mineral exploration

8.48. This recommendation of the SNA on valuation could be seen to be misleading. The guidance to value output at cost is most often used in connection with production on own account where there is no comparable market activity and valuation at the sum of actual costs incurred is recommended as a minimum valuation to place on the activity. Not all mineral exploration is carried out on own account. A reading of the SNA recommendation, consistent with the general advice on valuation, would be that mineral exploration is to be valued at the market price of such exploration where possible and at cost only when such an alternative is not possible. There is then a question about whether a typical mark-up should be added to actual costs in the case of own-account exploration.

The value of mineral exploration and the value of the mineral resource

8.49. There is an implication for the valuation of the mineral resource of treating mineral exploration as capital expenditure rather than intermediate consumption. Unless an independent means of valuing the resource is available, it must be determined by means of resource rent calculations. The inclusion of mineral exploration as a form of fixed capital contributes to the allowance for consumption of fixed capital which must be deducted from gross operating surplus to reach resource rent. Resource rent is thus lower when mineral exploration is treated as capital expenditure than when it was treated as intermediate consumption. As seen from the simplistic example above, net operating surplus is higher in the years where exploration only and no extraction took place. This is offset by lower net operating surplus once extraction starts and the cost of mineral exploration is treated as a charge on the resulting value added.

8.50. We can therefore see that the value of mineral exploration and that of the resource discovered are inextricably linked. The higher the cost of exploration, the lower the value of the deposit and vice versa. Equally the pattern of the consumption of fixed capital on the mineral exploration affects the balance of value between the two assets. The implications for the accounting system, both SNA and SEEA, are quite important since the mineral exploration is a produced asset and the mineral resource is a non-produced asset.

8.51. Consider two means of exploring for minerals which are identical in all respects except that the first is undertaken by a contractor and the second is done on own account. Following the recommendations above, the contractor earns, and charges for, some operating surplus. The value of mineral exploration is higher and the value of the mineral resource is lower than if the exploration were done on own account. It is not that there would be no operating surplus in respect of the own account exploration but rather that it would not be separated from other operating surplus earned by the extractor. However, it would add to the resource rent and thus to the value of the reserve. If we allow own account exploration to include a margin for operating surplus we effectively alter the balance in the accounts between produced and non-produced assets. Clearly it would be possible to think of a level of operating surplus which would mean the resource rent fell to zero. In such a case there would be a zero value for the mineral deposit but a (relatively) high value for the mineral exploration.

What is mineral exploration?

8.52. The recognition of this dilemma calls into question the assumption about the nature of the produced asset we call mineral exploration. The definition from the SNA quoted above is less a description of the nature of the asset than a prescription for the means of valuing it. However, it is the assumption that the asset represents knowledge about the mineral deposit which leads to it being classed as an intangible produced asset rather than a tangible one. Much of the rationalisation for the approach adopted in the SNA is the similarity between mineral exploration and research and development.

8.53. An alternative view is that it is artificial to try to treat knowledge about the resource separately from the resource itself since clearly both are exploited simultaneously.

8.54. This view is consistent with a consideration of the economic rent of subsoil deposits which runs as follows. Initially, there is a basic value of an unknown deposit. The activity of exploration, of identifying a deposit and documenting its characteristics enhances the value of the resource, so that the economic rent of the deposit now covers both its initial value plus the costs of the exploration activity. The net operating surplus of the exploration activity covers the return to the produced capital uses plus the NPV of the deposit prior to exploration. This view treats the mineral deposit in a manner similar to a cultivated biological asset. It is a natural process which initially gives rise to the asset, but to make it accessible to the economy there are not just extraction costs but essential preliminary costs also. These costs should be recorded as fixed capital formation, parallel to land improvement and may be called “enhancements to the value of subsoil resources”. In the balance sheets, this enhancement to the subsoil resource is aggregated with it and shown as a produced asset called, for example, a “developed natural resource” which includes the contribution of productive activities to the value of the resource. In this case there would be no separate asset of “mineral exploration” recorded. This treatment is advanced in *Nature's Numbers*, a recent report of the U.S. National Research Council on environmental accounting (Nordhaus and Kokkelenberg, 1999), but is not as yet favoured by the majority of national accountants.

Is there double counting between mineral exploration and mineral resources?

8.55. It is sometimes asserted that the decision to introduce mineral exploration as an asset additional to the non-produced mineral resources leads to a double counting of assets. As shown above, this is not so if the value of the deposit is calculated in such a way that the value of the mineral exploration is excluded from the resource rent forming the basis of the valuation of the deposit. However, the possibility of making an estimate of the deposit other than by means of the resource rent exists. Where markets in mineral deposits exist, direct observation may be possible. If a market exists for discovered fields, the market price should reflect the value of the combined asset of mineral exploration and mineral resource, and would be higher than the NPV of the resource rent for the mineral resource.

8.56. Another means of estimating the value of the deposit is to base this on the payments due from the extractor to the owner where these two are different. Whether a valuation based on such payments will be consistent with a valuation based on resource rent will depend on at least two factors. The first is whether the level of future payments agreed between the owner and extractor changes in response to factors affecting future resource rents; for example, the levels of future discoveries, changes in the commodity price of the mineral relative to the overall level of prices and changes in technology which affect both the cost of extraction and demand for the mineral. The second is that the agreement may not have been predicated on the assumption that the owner wished to recoup all of the resource rent. If the agreement is more in the nature of a production sharing arrangement, so that the owner shares in the potential benefits of the sort of changes just mentioned, the extractor may be allowed to retain a share of the resource rent as his share of the joint exercise.

8.57. Whatever the reason, if there are independent measures of the value of the mineral deposit, then there is no certainty that the sum of the mineral exploration and the resource will together exactly match the total return expected from the extraction process. While it is not a question of exact double-counting there is a real probability that there will be either under- or over-counting of the total level of assets.

Options for recording the values of mineral exploration and mineral deposits

8.58. There are three possible ways of recording costs associated with mineral exploration and the value of the relevant mineral deposit. These are shown in Box 8.1. Options 1 and 2, but not option 3, are consistent with the SNA. Options 2 and 3, but not option 1, are consistent with the principle of valuing assets according to a concept of the capital services these assets will yield in production.

Box 8.1 Options for recording mineral exploration and mineral deposits

Option 1 is to record values for both the mineral exploration and the mineral deposit from independent sources, neither depending on a calculation of the resource rent of the deposit. There is no guarantee in this case that the sum of the assets will exactly match the net present value of the stream of resource rents; the total maybe either greater or smaller than this depending on the assumption underlying the valuation of the deposit.

Option 2 is to record the value of mineral exploration based on either market prices or costs (depending on whether it is carried out by a contractor or on own account) and to base the value of the mineral deposit on the net present value of the resource rent calculated to exclude the value of mineral exploration.

Option 3 leads to identical values as option 2 but treats the sum of the two values as attributed to a "developed natural asset" which would be recorded as a tangible produced asset. This is in contrast to the SNA where mineral exploration is classified as an intangible produced asset and the mineral resource as a tangible non-produced asset. There is no impact on the asset account or on the balance sheet of this change (except for headings used) but there are changes implied for the flow accounts as explored in Chapter 10.

5 Balance sheet entries for the assets associated with mineral exploitation

8.59. The SEEA makes extensive use of the asset account. For any asset, the asset account shows the whole range of impacts on the asset between the opening and closing balance sheet. In the SNA, attention focuses on balance sheet rather than asset accounts. When the owner of an asset is the unit which uses it in production, there is no difficulty in assimilating the asset accounts for all the assets owned and used by the producer into a single balance sheet. However, further consideration is needed when the unit which uses the asset is not the (sole) owner of the asset. This is very frequently the case in respect of mineral deposits especially in countries where government has ownership of the asset on behalf of the nation at large.

Ownership in the SNA

8.60. The SNA does not discuss how to determine the ownership of non-produced assets and thus in which balance sheet to place them. By implication of the lack of any alternative advice, the guidance must be assumed to be that the assets should be recorded in the balance sheets of the legal owners.

8.61. Suppose that government is the legal owner of oil reserves with an agreement that a particular unit may extract them. Then in the SNA the value of the oil reserves appears in the balance sheet of the government. Attributing the ownership of the mineral exploration may be less easy. If the extractor has carried out the exploration either on own account or *via* a contractor, then clearly the entries for this asset will be in the balance sheet of the extractor.

8.62. However, as noted above, there may not be an extractor during some early periods of exploration. This may be carried out at the behest of the owner of the putative discoveries even though the owner has no productive activity related to either exploration or extraction. Nevertheless, the appropriate recording must be to record the mineral exploration as an asset of the owner. Knowledge of whether a mineral deposit exists and the extent of it is the basis on which the owner can enter into an agreement with an extractor at a later stage. When such an agreement is made and the extractor starts production, he acquires this knowledge so the asset must be transferred to his balance sheet and is written off by the extractor over time as part of the costs of production. In fact, the payments by the extractor to the owner must be enough to reimburse the owner for the costs he incurred to acquire the knowledge about the deposit as well as representing a return to the deposit itself.

8.63. If the terms of the agreement between the owner and the extractor are such that the extractor can expect to retain some of the resource rent of the asset, it would seem appropriate even in the SNA to record the value of the mineral deposit as divided between the owner and the extractor according to the proportions each is expected to receive. This might mean that an independent estimate of the owner's valuation of the deposit is made and the extractor is credited with the difference (if positive) between a value based on the resource rent calculations and that amount due to the owner. This should be seen as a variation of option 2 in Box 8.2.

Ownership in the SEEA

8.64. Here also we enter into a number of options. The first is to follow the SNA recommendations as described above. The second is to say that the agreement with the extractor in effect gives him ownership not only of the knowledge about the deposit but actually of the asset itself. It is, after all, the extractor who will make decisions about how much to extract and for how long. In return the extractor enters into a financial arrangement with the owner with a financial claim then appearing in the owner's balance sheet instead of the deposit and the extractor showing the deposit as an asset and the financial liability offsetting it. This line of reasoning is similar to that used in the SNA for financial leasing. (Details of financial leasing are given in 1993 SNA paragraph 6.118).

8.65. Though this solution is attractive in a number of ways, the implication is that the level of the financial claim and liability alter from year to year as does the value of the deposit, as new discoveries are made and changes to the pattern of production are introduced by the extractor. Financial claims are usually clearly specified in advance and not subject to such sorts of alterations.

Box 8.2 Options for recording the ownership of mineral-related assets

Option 1 shows mineral exploration in the balance sheet of the extractor and the value of the deposit in the balance sheet of the legal owner. If the agreement between the owner and the extractor allows for the extractor to retain some of the resource rent coming from the asset, the ownership of the asset should be partitioned consistently.

Option 2 shows both the mineral exploration and deposit as being in the *de facto* ownership of the extractor. In addition the extractor has a financial liability towards the owner corresponding to his share of the resource rent. This amount is also shown as a financial claim in the balance sheet of the owner.

C Water resources

1 Introduction

8.66. Water has a number of particular characteristics which call for rather special treatment in a resource account. Because water is literally a vital resource since it is fundamental to any form of life, it forms one of the ecosystem inputs recorded in the SEEA. Because it is used by many industrial processes, and by consumption, it also constitutes a natural resource. In some of these cases, and perhaps increasingly so in future, water is paid for and represents a product. Lastly used or dirty water is discharged back to the environment as a residual. Water is the only environmental asset which can be classified into each of these four sorts of flows.

8.67. Further, measuring water, even in physical terms, is not easy. Water travels under the influence of solar radiation and gravity and it is in continuous movement and transformation. Because it is difficult to measure a stock level of something always in motion and not always in the same physical state, it is common to take some sort of flow measure as a proxy for a stock measure.

8.68. More important than sheer volume may be measures of water quality, but these too are fraught with definitional problems. Water not fit for human consumption may be perfectly satisfactory for some other uses. The point at which water is treated as a residual does not depend entirely on its quality but also on the infrastructure for handling it. As important as quality is, it cannot be used to discriminate between different possibilities for recording flows.

8.69. Even when water is crucial to economic activity, it is seldom priced in the market. Nevertheless, information concerning the monetary aspects of water is important and is presented in Section 4.

Water accounting – general principles

8.70. Water resource accounts comprise stock and flow accounts in physical terms as well as quality accounts. Because of the nature of water, a set of physical flows accounts is often the starting point in the compilation of water accounts. Stock accounts are also very important for groundwater, lakes and reservoirs. Accounts are calculated for a given geographical territory, which can be a country, a region or a river basin (catchment area) or any relevant area of interest. Here the focus is on water accounts at the national level in line with the other parts of the SEEA.

8.71. The accounts offer an integrated view of water supply and uses by industry and by purpose. They include measures of water pollution, protection and management and describe water quality in physical and monetary terms. The accounts help to understand the interaction between human activity and the environment. They help to identify water availability for various uses, stresses on water, and qualitative and quantitative water scarcity.

8.72. In Section 2 the basic concepts of hydrology are introduced and the interaction between the hydrological system and the economy is described. The asset classification of water resources is then discussed in detail and physical flow accounts for supply and use tables for water flows and accounts for water stocks are presented. Numerical examples are included as well as a more theoretical framework.

8.73. Several case studies have been undertaken at the national and/or regional level. Examples include studies for France, Spain, Denmark, Finland, the Netherlands, Chile, Moldova, Australia, Namibia, Korea, Canada, and the Philippines. Despite limited experience in water accounting and some formal differences that exist in the presentation of the accounts, important similarities can be noted. These similarities result from the use of a systematic way of organising data on water resources, water supply and water use in a manner consistent with the concepts, definitions, and classifications of the SNA while respecting the fundamental concepts of hydrology.

8.74. The water accounts presented in this section include both physical flow accounts and asset accounts. The physical flow accounts are constructed in accordance with the accounting rules outlined in Chapter 3. They are restricted to measurement of the water flows between the economy and the environment that lie within the scope of physical accounting presented in Figure 3.3. Specifically, they exclude flows of water that occur exclusively within the environment. The asset accounts for water are compiled in accordance with the accounting rules outlined in Chapter 7. They are restricted to measurement of the opening and closing stocks of water within the national environment and of the flows associated with the natural and economic processes that account for the difference between the opening and closing stocks.

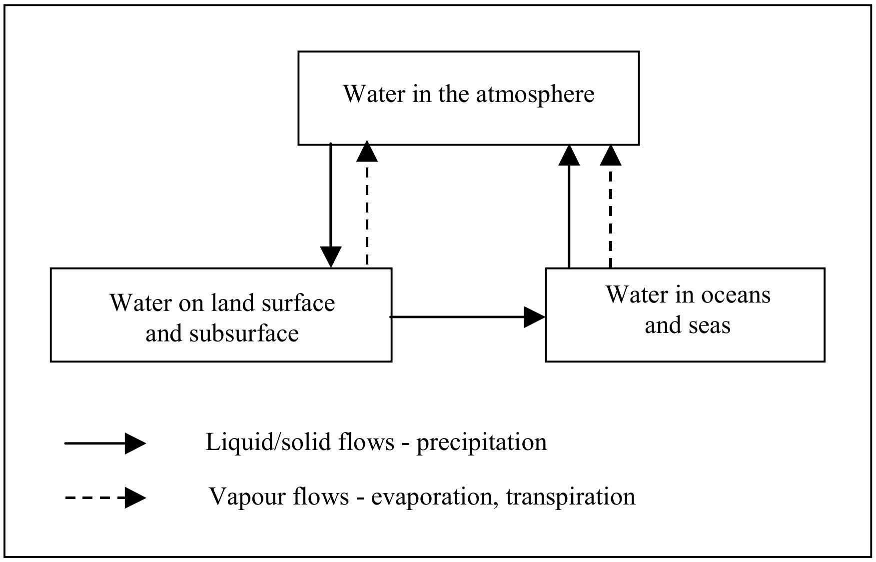
2 The hydrological system

8.75. When compiling water accounts, it is important to understand the hydrological cycle and to describe what the hydrological system means within a territory of reference. The hydrological or water cycle is defined as:

> "…the succession of stages through which water passes from the atmosphere to the earth and back to the atmosphere: evaporation from the land or sea or inland water, condensation from clouds, precipitation, accumulation in the soil or in bodies of water, and re-evaporation" (United Nations Education, Scientific and Cultural Organization and World Meteorological Organization, 1992).

The hydrological system portrays a system of repositories of water in the territory of reference and the transfers between them. The simplest description of the hydrological system uses three repositories: water in the atmosphere, water in the oceans and seas and water on the land surface and subsurface. Figure 8.1 shows the main components of the system and the transfers between them. The principal transfers to the atmosphere are represented by evaporation and transpiration, and the principal transfers from the atmosphere by precipitation.

Figure 8.1 Elements of the global hydrological system



8.76. Here we focus only on the part of the global hydrological system which deals with water on land surface and subsurface in the territory of reference, the inland water system. This sub-system can be further disaggregated into various components such as lakes, reservoirs, groundwater, rivers, permanent snow fields, ice, and water in soil.

8.77. The natural input of water to the inland water system is precipitation. Part of this precipitation evaporates back into the atmosphere immediately; part drains into surface water (lakes, rivers, reservoirs) to ultimately end up in the sea; part infiltrates soil and becomes soil moisture and then groundwater. A portion of the groundwater gradually works its way back into surface water (and becomes the main source of dependable river flow) and or to the sea. Plants and vegetation absorb a part of the soil moisture through their roots and release most of it into the atmosphere in the process of transpiration. Permanent snow fields and ice represent a large store of water in its solid form. They contribute to the flow of surface and subsurface water during snow melt seasons. In addition to these movements of water, there are also natural inflows into and out of the territory of reference from and to other territories and to the sea through rivers and groundwater. This natural system is modified through human activities such as direct abstraction, returns of water and induced evapotranspiration.

Asset Classification

8.78. The asset classification of water resources in the SEEA reflects those components of the hydrological system that are available for water abstraction and provide direct inputs into the economy. The stock classification can be described as follows:

EA.13 Water Resources
- EA.131 Surface water
  - EA.1311 Artificial reservoirs
  - EA.1312 Lakes
  - EA.1313 Rivers
- EA.132 Groundwater

8.79. ***Surface water*** comprises all water which flows over or is stored on the ground surface (United Nations Education, Scientific and Cultural Organization and World Meteorological Organization, 1992). Depending on data availability and national priorities, the classification could be further disaggregated. Reservoirs can be classified according to the type of use; for example, for human, agricultural, electric power generation or mixed uses. Rivers can be classified on the basis of the regularity of the runoff as perennial (where water flows continuously throughout the river) or ephemeral (where water flows only in direct response to precipitation or to the flow of an intermittent spring). Namibia (Lange, 1997), Moldova (Tafi and Weber, 2000) and France (Margat, 1992) have used such a breakdown.

8.80. ***Groundwater*** comprises all water which collects in porous layers of underground formations known as aquifers. Aquifers may be unconfined, that is have a water table and an unsaturated zone or may be confined when they are between two layers of impervious or almost impervious formations. Unconfined aquifers are recharged during the water cycle by the percolation of rain or melted snow and thus hold renewable groundwater. The water in confined aquifers has accumulated over a geological time span and, because of its location, cannot be recharged at all or only over a long time span. Such water resources are non-renewable or fossil water. (Water in lakes may also be considered non-renewable when the replenishment rate is a small proportion of the total volume of water.)

8.81. The other components of the hydrological system such as soil water, glaciers, permanent snow fields, ice, and marine water are not part of the classification of stocks either because water cannot be abstracted (soil water) or because water abstraction does not have an effect on the size of the stocks (glaciers, marine water, etc.). However, it is important to understand the role of these components in the hydrological cycle and to account for them when compiling the accounts. If detailed information on stocks of soil water, permanent snow fields and ice is available, it can be included in a special column in the asset accounts. Several countries including France, Moldova, Spain, and Chile have compiled accounts for soil water, permanent snow fields and ice. This information is particularly relevant in the case of seasonal accounts when water stored in soil and permanent snow fields in one period is an essential resource for the following one.

8.82. The 1993 SNA asset classification includes only a small portion of the total water resources. Only "aquifers and other groundwater resources to the extent that their scarcity leads to the enforcement of ownership and/or use rights, market valuation and some measure of economic control" are within the SNA asset boundary. In addition, the SNA asset category "land" includes any associated surface water.

8.83. The SEEA extends this boundary to include all water resources that provide both direct use and non-use benefits. This implies that the SEEA asset category "water resources" (EA.13) includes all the water resources which can be extracted in the current period (direct use benefits) or might be of use in the future (option benefits). In practice, data are more likely to be available in cases where water is scarce and where the services to production and consumption provided by water bodies are threatened or actually diminished.

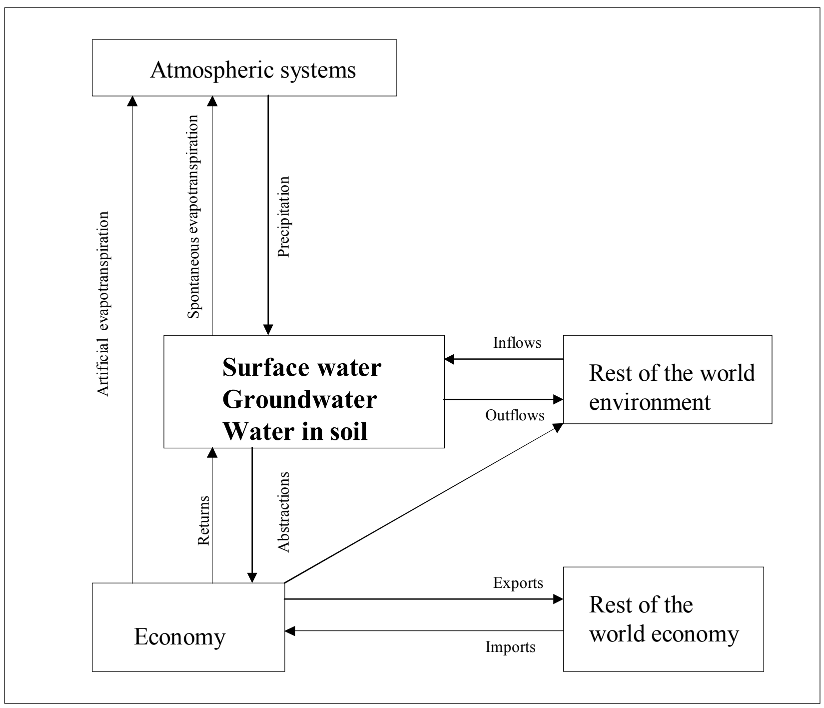
8.84. The SEEA also considers water resources in terms of the area covered by surface water. The area of surface water is included in the "land and surface water" (EA.2) category of the asset classification. Aquatic ecosystems are included in the "ecosystem" category (EA.3) of the classification. Measurements relating to the area of surface water are included under land cover in the section on land accounts below.

Physical flow accounts for water

8.85. Figure 8.2 shows the interaction between the hydrological system and the economy. This expands on the system described in Chapter 3 with particular reference to water and an elaboration of the national environment to show water in the atmosphere separately from surface and subsurface water. The principal flows between these two sections of the environment are precipitation and evapotranspiration as shown in Figure 8.1.

8.86. The exchanges of water between the environment and the economy include direct abstraction, irrigation and returns of water to ground, surface water, the sea and brackish water. The passive uses of water by the economy which do not involve direct abstraction, such as recreation or transportation, are not considered here. The storage and release of water in dams are not considered to take place within the economy but within the hydrological system. This is because it is difficult to make a distinction between the direct economic use of the water and what is required for regulating the discharge of the rivers for, say, flood prevention or to support runoff in summer.

Figure 8.2 Schematic representation of the interaction between the hydrological system and the economy.



Source: Based on Tafi and Weber, 2000.

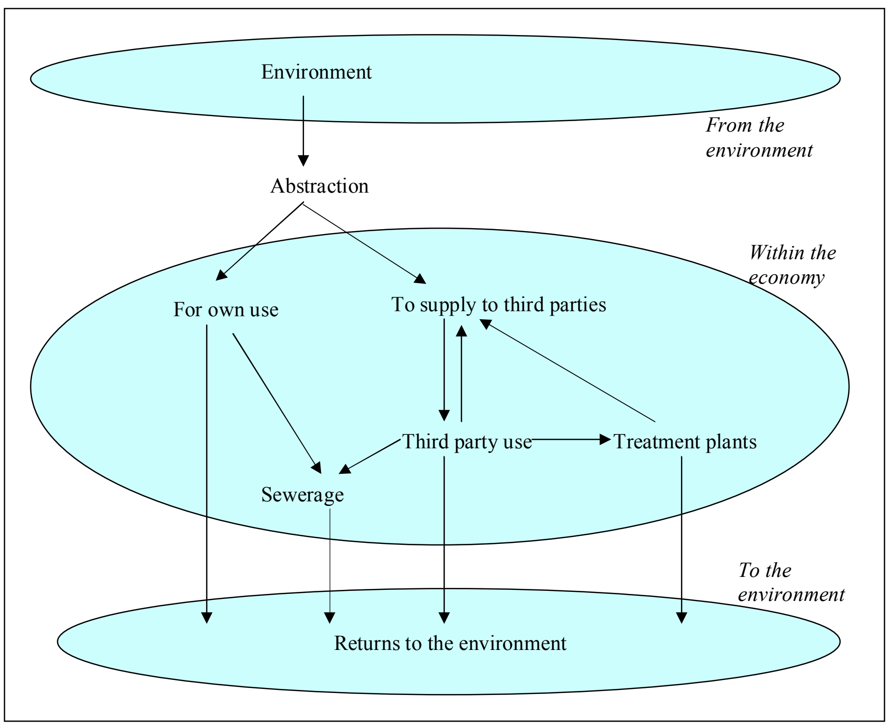
8.87. The economy returns water to the hydrological system through various flows including returns of wastewater to aquifers, rivers, lakes and oceans; returns to soil and water bodies from irrigation activities; and losses in transportation (supply and sewerage pipes, etc.). These return flows are an input to the hydrological system and become a resource (even if often of lower quality) for subsequent uses. Imports/exports of water to and from the economy are considered as direct inflows/outflows of water through pipes from and to the economies of other territories.

Water accounts - physical flows

8.88. Physical water accounts describe the whole system of flows of water in physical terms between the environment and the economy and within the economy. In describing these flows, it is important to recall the difference between ecosystem inputs, natural resources, products and residuals discussed in Chapter 3. Water as an ecosystem input or a natural resource belongs to the environmental sphere; once it is abstracted and processed by an industry, it is considered a product and it enters the economic sphere. This product can be delivered to either other industries or final consumers. When water is no longer useful in its current state, it is considered to be a residual. Some flows of residuals are recorded within the economy (for example, the routing to water treatment plants) but ultimately all residuals are returned to the environment. Figure 8.3 gives a diagrammatic view of the various stages of supply to be captured in the flow accounts.

8.89. There is an issue about how extensive the coverage of water abstracted for own use should be. One option is to say that in the main these abstractions simply move the water from one place to another without it really entering the economy and, therefore, they should be considered as "hidden" flows, as with mining spoil. Pumping water out of mines, for example, would fall under this heading. The other option is to consider that these flows do enter the economy, in which case the return of the water to the environment would then be recorded as a residual flow. Depending on the situation in a particular country, water used for hydropower generation can be considered as water extracted and returned to the hydrological system and thus entering the economy as a product; similarly with water extracted by agriculture for irrigation.

Figure 8.3 Schematic water flows



8.90. One reason for classifying own account abstractions as products is the increasing implementation of rights to abstract water. When these rights acquire a monetary value, it is difficult not to consider the abstractions as products. For consistency, therefore, all abstractions are considered here as products, whether for own use or supply to a third party.

8.91. Flows of water from the environment to the economy, within the economy, and from the economy back to the environment can be described in a supply and use table. Supply and use tables are constructed such that the basic identity "supply equals use" is satisfied for flows from the environment, within the economy and return to the environment, separately.

8.92. In the case of water as a natural resource, the environment supplies all the water that is directly abstracted by the economy. Once abstracted, water is either used by the extractor or is supplied to third parties by (mainly) water companies. Once used, water may be sent to plants which treat and recycle water to third parties or discharge it to the environment. Alternatively, waste water may be sent to the industry "sewage and refuse disposal, etc." (ISIC 90), which first absorbs some residuals (contaminants) and then discharges the waste water as a (possibly cleaner) residual to the environment. At every stage in the process, there may be returns of residuals to the environment. These may be deliberate discharges or inadvertent leakages and losses in transport.

8.93. The main industries dealing with water as their principal activity are shown in Box 8.3. Note, though, that this is not the same as a list of industries who are the main abstractors from the environment.

Box 8.3 Description of the main agents which supply and handle water

ISIC 41 Collection, purification and distribution of water

- Includes activities that produce water as the principal product of interest
- Includes desalting of sea water to produce water as the principal product of interest
- Excludes irrigation system operation, which is included in ISIC 1.40, and treatment of wastewater in order to prevent pollution, which is included in ISIC 90

ISIC 1.40 Agriculture and animal husbandry service activities, except veterinary activities

- Includes operation of irrigation system for agricultural purposes.

The operation of irrigation systems is a specific service providing water to farmers, especially through a network of open-air canals. It should be noted that irrigation water could also be provided by ISIC 41 through normal pipes (as drinking or non-drinking water).

ISIC 90 Sewage and refusal disposal, sanitation and similar activities

- Includes activities of sewage and refusal disposal and other processes of sewage disposal and maintenance of sewers and drains.

Supply table

8.94. Table 8.3 shows a numeric example[2] of the supply of water. It consists of three parts. The first part shows flows from the environment to the economy in total only. The second part shows flows of water (a product) and waste water (a residual) within the economy. These flows are attributed to industries, final consumers and the rest of the world. The third part shows the eventual return of waste water to the environment and the agent responsible for the return.

8.95. All abstraction of water is shown as coming from the environment to the economy. It can and should be disaggregated between whether it is ground, surface or other water (for example from the sea or brackish water); for some countries further detail may be useful.

8.96. Much water is abstracted for the use of the abstracters. This is especially so of the electricity generation and agriculture industries. Water which after abstraction is distributed to third parties becomes distributed water. It is possible to draw up a two way matrix showing which industry supplies and which uses distributed water.

[2] The tables in this sub-section are based very loosely on an actual country example. They are internally consistent but have not been made explicitly consistent with other tables in the SEEAland data set.

8.97. In addition to the industries shown in Box 8.3, some industries may supply water which has already been used in the production process to other industries needing lower-quality water in their production process. When data are available, the supply can therefore be further disaggregated depending on the type of water (water as waste water, treated water, etc.). The supply of water is measured after deducting losses during transportation (distribution) which are considered as returns to the environment from the water distributors.

8.98. The entries in the third part of the table include all the flows of water from the economy to the environment. Residuals flowing to the environment come from different industries in different ways. The returns of water from agriculture include the runoff of that part of water used for irrigation which is not absorbed and returns to surface, ground and other water. Water used for cooling or hydroelectricity generation is returned to the environment directly after use. Water treatment plants recycle some water as a product but discharge some to the environment. This can be further disaggregated into treated and untreated waste water.

Table 8.3 Water supply table

Million cubic metres

		Agriculture	Fisheries	Energy	Mining	Manufacturing	Distribution/ irrigation water	Distribution/ mains water	Sewerage	Government	Households	Rest of the world	Environment	Total
From the environment	S1 Total abstractions												3 316.2	3 316.2
	From Surface water												2 551.7	2 551.7
	From Groundwater												764.5	764.5
	From other water													
	For own use												*1 763.6*	*1 763.6*
	For delivery												*1 552.6*	*1 552.6*
Within the economy	S2 Total supply of distributed water	2.2		1.0		139.3	530.0	653.0		135.3	372.0	5.0		1 837.8
	Water supplied to users	2.2		1.0		6.2	530.0	653.0				5.0		1 197.4
	Of which recycled water			*1.0*		*5.7*						*5.0*		*11.7*
	Waste water to sewerage					133.1				135.3	372.0			640.4
To the environment	S3 Total residuals	152.1	46.0	1 448.6	4.6	17.0	167.1	204.8	640.4	11.5	12.0			2 704.1
	To inland water													
	Returns from irrigation	96.8												96.8
	Treated wastewater		8.0			11.1			613.7		6.0			638.8
	Untreated wastewater	20.0	30.0			5.0				9.3	6.0			70.3
	Cooling water			448.2										448.2
	Water used for hydroelectricity			1 000.0										1 000.0
	Water lost in transport	33.5	8.0	0.4		0.9	167.1	204.8	26.7					441.4
	Other returns of water	1.8			4.6					2.2				8.6
	To the sea													
Consumption		524.1		32.8	0.3	3.2				0.4	56.3			617.1
Total supply		678.4	46.0	1 482.4	4.9	159.5	697.1	857.8	640.4	147.2	440.3	5.0	3 316.2	8 475.2

Source: Constructed water example.

8.99. The total supply of water from the rest of the world represents imports of water. Analogously in the use table, the total use of water by the rest of the world would represent the exports of water, though it happens that in this example there are no exports of water.

8.100. Table 8.3 shows about three quarters of water abstractions are from surface water and about one quarter from ground water. Just over half of the abstractions are for own use and just less than half are for distribution to others. The residuals from agriculture comprise waste water from animal farming and that part of irrigation water which filters through to ground water instead of being taken up by plants. The evapotranspiration of irrigation water by soil and vegetation and absorption by other users is called "consumption".

Water flows within the economy

8.101. In order to see who is supplying water to whom, a matrix of flows of water within the economy can be compiled as shown in Table 8.4. In this particular case, the main redistribution is of irrigation water to agriculture and of drinking water to households as well as supply of waste water for treatment to the sewerage industry. The row total in this table shows the total supply of water and is equal to the row for total supply of water in Table 8.3.

8.102. If abstractions for own use were considered as a product, then these amounts would feature in the diagonal elements of Table 8.4. The small entry for agriculture shown here represents supply from one unit to another within the industry, not strictly own use by the unit making the abstraction.

Table 8.4 Matrix of flows within the economy

Million cubic metres

Origin \ Destination	Agriculture	Fisheries	Energy	Mining	Manufacturing	Distribution/ irrigation water	Distribution/ mains water	Sewerage	Government	Households	Rest of the world	Total supply of distributed water
Agriculture	2.2											2.2
Fisheries												
Energy							1.0					1.0
Mining												
Manufacturing					5.2		1.0	133.1				139.3
Distribution/irrigation water	530.0											530.0
Distribution/mains water			9.8		113.1		4.7		110.4	415.0		653.0
Sewerage												
Government								135.3				135.3
Households								372.0				372.0
Rest of the World							5.0					5.0
Total use of distributed water	532.2		9.8		118.3		11.7	640.4	110.4	415.0		1 837.8

Source: Constructed water example.

Use table

8.103. Table 8.5 is the counterpart to Table 8.3 and shows the use of water. In this table the abstractors of water are shown by industry and sector. Usually the largest abstractors will include agriculture and electricity generation, who abstract for own use, as well as the water supply industries who abstract in order to deliver to third parties. As before, disaggregation between surface, ground and other water is desirable.

8.104. The total use of distributed water within the economy is equal to the total supply of distributed water. Total water use can be determined by adding abstractions for own use to the amount received from distributors as products. It is helpful to analyse these total uses by purpose. For example, the use of water by agriculture could be further classified as water for irrigation, for animal husbandry, sanitary purposes and for other purposes. The use of water could be also disaggregated by purpose according to data availability and specific country needs. In Denmark, for example, the use of water is distinguished for potable water supply, industrial cooling, use in production processes and other uses. This decomposition may not be relevant to all industries so a number of more detailed satellite accounts could be constructed to the extent that there is demand for them and sufficient data are available (Bie and Simonsen, 1999). The Australian Bureau of Statistics (2000) distinguishes the use of water according to whether it is reused in the production process, after having been treated to some extent, or whether it is directly supplied through mains. Namibia and Botswana classify water use according to whether it is provided by town systems or rural systems.

8.105. Due to the particular characteristics of water use for hydroelectricity and cooling in conventional or nuclear power plants (including the use of sea water for this purpose), the use of water in the generation of electricity can be accounted for separately. In the present example, about half of total abstractions are used in the generation of electricity. Of the remainder, the major use is for irrigation, either through own-account abstractions or via the distribution of irrigation water to other users.

Table 8.5 Water use table

Million cubic metres

		Agriculture	Fisheries	Energy	Mining	Manufacturing	Distribution/irrigation water	Distribution/mains water	Sewerage	Government	Households	Rest of the World & Sea	Environment	Total
From the environment	U1 Total abstractions	146.2	46.0	1 472.6	4.9	41.2	697.1	846.1		36.8	25.3			3 316.2
	From Surface water	95.9	46.0	1 470.5		20.2	597.1	322.0						2 551.7
	From Groundwater	50.3		2.1	4.9	21.0	100.0	524.1		36.8	25.3			764.5
	From other water													
	For own use	*144.0*	*46.0*	*1 471.6*	*4.9*	*35.0*				*36.8*	*25.3*			*1 763.6*
	For delivery	*2.2*		*1.0*		*6.2*	*697.1*	*846.1*						*1 552.6*
Within the economy	U2 Total use of distributed water	532.2		9.8		118.3		11.7	640.4	110.4	415.0			1 837.8
	Water received by users	532.2		9.8		118.3		11.7		110.4	415.0			1 197.4
	Of which recycled water							*11.7*						11.7
	Waste water collected by sewerage								640.4					640.4
To the environment	U3 Total residuals												2 704.1	2 704.1
	To inland water													
	Returns from irrigation												96.8	96.8
	Discharge wastewater after treatment												638.8	638.8
	Discharge of untreated wastewater												70.3	70.3
	Cooling water												448.2	448.2
	Water used for hydroelectricity												1 000.0	1 000.0
	Water lost in transport												441.4	441.4
	Other returns of water												8.6	8.6
	To the sea													
Consumption													617.1	617.1
Total use		678.4	46.0	1 482.4	4.9	159.5	697.1	857.8	640.4	147.2	440.3		3 321.2	8 475.2

Source: Constructed water example.

8.106. The supply and use tables can be combined into a single table as in Table 8.6. There are three ways in which water becomes available for use within the economy. It can be abstracted for own use, it can be abstracted for delivery to others and it can come from recycling or imports from another economy. For each of these sources, there may be losses before reaching the intended user, though in Table 8.6 losses are only shown for the first two sources.

8.107. Water reaching the user may be returned to a recycling plant, exported, discharged directly to the environment or discharged to the environment *via* the sewerage industry. Water that is not returned to water bodies because it is absorbed by plants (irrigation water), domestic animals, humans or in industrial processes appears as consumption, the balancing item in the table. This item may also include a small amount of water accumulated in inventories of products such as beverages.

8.108. Box 8.4 shows how the entries from the supply and use tables can be reconciled in this single table showing the main stages of water flows through the economy.

Table 8.6 Main stages of water flows through the economy

Million cubic metres

	Agriculture	Fisheries	Energy	Mining	Manufacturing	Distribution/irrigation water	Distribution/mains water	Sewerage	Government	Households	Rest of the World & Sea	Total
Total abstractions	146.2	46.0	1 472.6	4.9	41.2	697.1	846.1		36.8	25.3		3 316.2
For own use	144.0	46.0	1 471.6	4.9	35.0				36.8	25.3		1 763.6
Leakages during use	33.5	8.0	0.4		0.9							42.8
Available for own use	110.5	38.0	1 471.2	4.9	34.1				36.8	25.3		1 720.8
For delivery	2.2		1.0		6.2	697.1	846.1					1 552.6
Leakages during distribution						167.1	204.8					371.9
Recycled water and imports							11.7				5.0	16.7
Water supplied to users	2.2		1.0		6.2	530.0	653.0				5.0	1 197.4
Water received by users	532.2		9.8		118.3		11.7		110.4	415.0		1 197.4
Water available for use	642.7	38.0	1 481.0	4.9	152.4		11.7		147.2	440.3		2 918.2
Recycled water							11.7					
Waste water to sewerage					133.1				135.3	372.0		640.4
Returns from irrigation	96.8											96.8
Treated wastewater		8.0			11.1					6.0		25.1
Untreated wastewater	20.0	30.0			5.0				9.3	6.0		70.3
Cooling water			448.2									448.2
Water used for hydroelectricity			1 000.0									1 000.0
Other returns of water	1.8			4.6					2.2			8.6
Consumption	524.1		32.8	0.3	3.2				0.4	56.3		617.1

Source: Constructed water example.

Asset accounts for water

8.109. Asset accounts for water describe how the stocks of water at the beginning of the accounting period are affected by flows of water between the environment and the economy and transfers of water internal to the hydrological system to reach the stocks of water at the end of the accounting period.

8.110. Before embarking on the compilation of asset accounts for water, the definition of water stock has to be clarified. For groundwater, reservoirs and lakes it is conceptually simple to measure stocks. For rivers, the stock of water is not well defined due to the "flowing" nature of the resource. Here to maintain consistency with the other water resources, the stock of water in a river is measured as the volume of the riverbed. This is the definition that has been used by Spain, France, Chile and Moldova. However the volume of a riverbed is not always a good measure of water stocks, especially for ephemeral rivers. An alternative solution is to consider annual runoff into the river or the mean annual runoff in a country subject to very large annual variation.

8.111. Annual runoff is the total volume of water that flows during a year, usually referring to the outflow of a drainage area or river basin. For perennial rivers, runoff is measured at the lowest point downstream, sometimes close to the estuary. Hence it includes all flows which have taken place upstream. For rivers crossing national borders, runoff up to the point of entry into the country should be deducted.

8.112. Mean annual runoff is defined as the average net annual rainfall under natural conditions. The result depends on the runoff regimes for each river basin. When flow increases downstream and the flow is greatest at the mouth of the river basin, the mean annual runoff is defined as applied to the river basin. When the flow in rivers decreases downstream, often with little or no outflow from the river basin, the mean annual runoff is defined as the combined mean annual runoffs of each of the major catchment areas in the river basin, calculated at the point where the flow is greatest and excluding runoff from upstream basins (Australian Bureau of Statistics, 2000; Australian Water Resources Council, 1987)

Box 8.4 Reconciliation of entries in tables Table 8.3, Table 8.5 and Table 8.6

Row	Title	Relation to other rows	Relation to other tables
1	Total abstractions		Use table - total abstractions
2	For own use		Use table - abstractions for own use
3	Leakages during use		Supply table - water lost in transport except for losses by distribution
4	Available for own use	Row 2 - row 3	
5	For delivery	Row 1 - row 2	
6	Leakages during distribution		Supply table - water lost in transport by distribution
7	Recycled water and imports		Matrix of flows within the economy
8	Water supplied to users	Row 5 - row 6 + row 7	Supply table - water supplied to users
9	Water received by users		Use table - water received by users
10	Water available for use	Row 9 + row 4	
11	Recycled water	Row 7 (excluding imports)	
12	Waste water to sewerage		Supply table - water water to sewerage
13	Returns from irrigation		Supply table - returns from irrigation
14	Treated wastewater		Supply table - treated waste water
15	Untreated wastewater		Supply table - untreated wastewater
16	Cooling water		Supply table - cooling water
17	Water used for hydroelectricity		Supply table - water used for hydroelectricity
18	Other returns of water		Supply table - other returns of water
19	Consumption	Row 10 - rows 11 to 18	Supply table consumption

8.113. Using average flows over a period of time as a proxy for stock figures presents problems in the asset accounts, as some of the flows in the table may be already included depending on where the river flow is measured. In such a case, the flows in the asset account should be modified accordingly to avoid double counting.

8.114. Table 8.7 represents an asset account for surface water and groundwater resources. As explained above, the classification of water resources does not include water in soil and vegetation, permanent snow fields and ice. In this case, the accounts measure the precipitation which reaches surface and ground water. The runoff to surface water and infiltration to ground water are therefore net of evapotranspiration.

8.115. The opening and closing stocks represent the quantity of water, in cubic metres, at the beginning and end of the accounting period. The changes in stocks during the accounting period can be caused by human activities (abstraction and return of water to the environment) and by natural process (precipitation, evapotranspiration, natural inflows and outflows to other rivers, etc.). In Table 8.7 only evapotranspiration from surface water bodies is shown since the precipitation is recorded net of the evapotranspiration that occurs before water reaches the surface water. The detailed description of the table entries is as follows:

> ***Abstraction*** shows the total volume of inland water abstracted in a year (Since in the constructed example there is no abstraction from other sources, abstraction equals to the total U1 in Table 8.5).
>
> ***Residuals*** represent the total volume of water in the accounting period returned to the environment (i.e. inland water). They are equal to the part of S3 in Table 8.3 which is returned to inland water. In the constructed example the returns to the sea are zero, thus the residuals in Table 8.7 are exactly equal to

S3 in Table 8.3. They can be disaggregated by major activity as shown. If data are available, the returns of water could also be disaggregated by type of water returned.

Table 8.7 An asset account for inland water

Million cubic metres

		EA.131 Surface water			EA.132 Ground-water	Total
		EA.1311 Reservoirs	EA.1312 Lakes	EA.1313 Rivers		
Opening Stocks		1 500	2 700	300	150 000	154 500
Abstraction (-)		1 580		972	765	3 316
Residuals (+)	Returns from irrigation			47	50	97
	Wastewater			441	268	709
	Lost water in transport			141	300	441
	Others			1 457		1 457
Net precipitation (+)			100	2 175		2 275
Inflows (+)				9 000	1 100	10 100
Net natural transfers (+/-)		1 650	110	-1 715	- 45	0
Evaporation from water bodies (-)		170	216	133		519
Outflows (-)	To other country			2 300	380	2 680
	To the sea			8 000	1 000	9 000
Other Volume changes	Due to natural disaster					
	Discovery (+)					
	Others					
Closing Stocks		1 400	2 694	300	149 229	153 623

Source: Constructed water example.

Precipitation consists of all precipitation. When the category "water in soil" is not included in the table, the figures for precipitation are net of evapotranspiration. Hydrologists call this "efficient precipitation". It represents the part of the total annual precipitation that reaches the lakes, rivers, reservoirs and groundwater whether directly, via runoff or by infiltration.

Inflows represent the total volume of water in the accounting period that enters the territory of reference. For a river that enters the territory of reference, the inflow is the total quantity at its entry point. If a river borders two countries without finally entering either of them, each country could claim a percentage of the flow to be attributed to their territory. If no formal convention exists, a practical solution is to attribute 50 per cent of the flow to each country. In the situation in which rivers cross borders several times it is necessary to take account of outflows at exit as well as inflows on entry.

Net natural transfers for a water resource are defined as the difference between the inflows to one type of water resource from all the others and the outflows from the same water resource to all the others. A separate matrix showing these transfers can be compiled as indicated in Table 8.8.

Evapotranspiration is the total volume of evapotranspiration from the ground, wetlands and natural water bodies and transpiration of plants where the soil is at its natural water content. This is a hydrological concept. It excludes the evapotranspiration generated by all human intervention except for non-irrigated agriculture and forestry.

Outflows represent the volume of water that leaves the territory of reference during the accounting period. This flow could be disaggregated depending whether the flow is to other territories or to the sea.

Other changes in volume include all the changes in the stocks of water that are not specified elsewhere in the table. This item can either be estimated or calculated directly.

8.116. Some countries may not have information on each flow separately. Some of the flows can be combined according to data availability. Table 8.7 allows for the calculation of indicators such as total renewable water resources, total actual renewable water resources, total non-renewable water, and dependable water.

Total natural renewable water resources is the sum of the average annual flow of rivers and recharge of ground water generated from endogenous precipitation and the natural flow originating outside the country (Food and Agriculture Organisation of the United Nations, 2000).

Total actual renewable water resources is the sum of the internal renewable water resources and natural incoming flow originating outside the country, taking into account the quantity of flow reserved to upstream and downstream countries through formal or informal agreements (Food and Agriculture Organisation of the United Nations, 2000).

Dependable water is defined as the portion of the surface water resource that can be depended upon for annual water development during a period of time. The period of time varies according to national situation, but it is usually 19 out of 20 (or 9 out of 10) consecutive years.

Total non-renewable water is the volume of water which is not renewable by endogenous processes during the hydrological cycle. It includes fossil groundwater generated in geological times as well as a large part of water in lakes whose replenishment rate is very small.

8.117. Table 8.8 gives a rather simplistic numeric example of transfers between water resources. These are natural flows and are determined by processes of infiltration from surface water to groundwater, processes of groundwater discharge to surface water, and so on.

Table 8.8 Transfers between water resources

Million cubic metres

Origin:	Destination:	EA.131 Surface water: Reservoirs	EA.131 Surface water: Lakes	EA.131 Surface water: Rivers	EA.132 Ground-water	Total Outflows
EA.131	Reservoirs					0
	Lakes					0
	Rivers	1 650	110		220	1 980
EA.132 Groundwater				265		265
Total inflows		1 650	110	265	220	2 245
Net natural transfers		1 650	110	-1 715	- 45	0

Source: Constructed water example.

Water in soil

8.118. As mentioned above, the SEEA classification does not explicitly show water contained in soil. Nevertheless, this can be an important source of water and is referred to by agronomists as the "useful reserve" of water. In order to show the consequences of recording this useful reserve explicitly, Table 8.7 can be amended to show an extra column for water in soil. Such a presentation of the accounts permits an assessment of the relative importance of natural (spontaneous) evapotranspiration versus evapotranspiration artificially evoked in response to economic activity (for example the use of water for cooling). Another option in the account is to include water in permanent snow and ice. France, Spain, Chile and Moldova have compiled accounts including both permanent snow and ice and water in soil and vegetation.

8.119. When a column for water in soil is included, precipitation is measured gross of evaporation and is shown as increasing this stock of water which (mainly) then evaporates from the land although some finds its way into rivers. When such a column is not shown, the flows to land are consolidated with those for rivers. Table 8.9 shows the relevant entries from Table 8.7 in the consolidated version and how these may appear in an extended table.

Table 8.9 Showing water in soil explicitly

Million cubic metres

Consolidated version		Extended version	
	Rivers	Rivers	Water in soil
Net precipitation	2 175	175	12 000
Net transfers	-1 715	285	-2 000
Evapotranspiration	133	133	10 000

Source: Constructed water example.

Seasonal and geographical issues

8.120. One of the issues that has to be taken into account when compiling water accounts is the seasonal aspect. Water availability may change significantly over the seasons of the year with water being abundant during certain periods of the years and scarce in others. This variability is usually not reflected in yearly accounts. Depending on data availability and the length of the water cycle, it may be useful to compile water accounts more frequently so as to reflect water availability and water demands in different seasons.

8.121. Some countries experience long term cyclical patterns in water patterns, sometimes going several years without significant rainfall. In such cases, indicators which are useful for water-abundant areas may be of limited application.

8.122. Similar reservations apply in the context of the spatial dimension of water. Water may be widely available in certain locations, but absent in others. In Botswana, for example, there is only one river in the extreme north west of the country (the Okavango delta). While this represents a huge amount of fresh water, all of which comes from catchment areas outside the country, it is not available for commercial exploitation and the country as a whole is seriously water stressed, much of it being desert. For such a country, the indicators shown under Table 8.7 would be seriously misleading. As with many indicators, therefore, care in their use has to be taken when there are particular characteristics of a country which invalidate the usefulness of the indicators.

8.123. Water accounts compiled at the national level do not show regional variability. In order to identify this variability, it would be useful to link water data to regional economic accounts. However, water data are sometimes available by watershed. These do not fit tidily into administrative regions where rivers may often mark the border between one region and another.

Water quality accounts

8.124. The use to which water can be put depends crucially on its quality. For example, water used for hydroelectric power generation, industrial purposes and transportation does not require high standards of purity, whereas other uses (drinking, recreation, habitat for aquatic organisms, etc.) rely on higher levels of purity. Once quality classes are defined, water quality accounts can be constructed following the same general structure as an asset account in physical terms with quality as simply another dimension. The accounts show the opening and closing stocks together with the changes in stocks during the accounting period for each quality class. Table 8.10 shows the general structure for quality accounts.

Table 8.10 Quality accounts

	Quality classes				
	Q1	Q2	Q3	Q4	Q5
Opening stocks					
Changes in stocks					
Closing stocks					

8.125. Quality classes can be defined in various ways depending on the particular interest of the country or region concerned. In Australia, for example, groundwater assets are divided into four quality categories indicating the potential use of the resource. The quality classes are based on the total dissolved solids, which are measured in milligrams per litre (mg/L). Good quality water for human use has a salinity of less than 500 mg/L with an upper limit of 1,500 mg/L, which is also the limit for crop irrigation. Water for livestock is preferably in the lower ranges, but some salt-tolerant livestock can tolerate water salinity up to 15,000 mg/L. For coarse industrial process, such as ore processing, the upper limit may be much higher. By comparison, sea water has a salt concentration of about 35,000 mg/L.

8.126. Quality classes of surface waters can be defined according to of the level of pollution with organic matter such as BOD (biochemical oxygen demand), COD (chemical oxygen demand) or by other measures such as ammonium ion (NH_4^+) concentration. Usually, for surface waters a number of quality classes are defined at the national level. Table 8.11 shows the accounting structure for the accounts of the quality of rivers in France for the years 1992 and 1994. The quality classes are referred as 1A, 1B, 2, 3 and NC (not classified), with 1A being the highest and 3 the lowest quality class.

Table 8.11 The quality of watercourses (organic matter indicator) in France by size class of watercourses

Thousand kilometres of standard river (kmsr)

Group of water courses	1992 state					Differences by quality class[1]					1994 state				
	1A	1B	2	3	NC	1A	*1B*	*2*	*3*	*NC*	1A	1B	2	3	NC
Class A rivers	5	1253	891	510	177	3	*336*	*9*	*- 183*	*- 165*	8	1583	893	358	12
Class B rivers	309	1228	1194	336	50	*16*	464	- 275	- 182	- 22	325	1691	919	154	28
Class C rivers	260	615	451	128	47	*44*	*130*	- 129	- 17	- 28	306	749	322	110	18
Streams	860	1464	690	243	95	*- 44*	*- 176*	*228*	*15*	- 23	810	1295	917	258	72

Note: 1. The figures in the middle column (in italics) do not in all cases match precisely the calculated difference between the 1992 and 1994 states of the rivers in question. This is because of difficulties in comparing certain groups of water courses in some watershed basins between the two points in time.

Source: Institut français de l'environnement, 1999.

8.127. The general structure of quality accounts is simple conceptually; however it presents numerous problems of measurement. Temporal and spatial considerations play important roles in water quality and should be taken into account when compiling quality accounts, especially if the accounts are used for water management. The quality of a river, for example, might increase enormously during particular weather conditions, and decrease rapidly when the conditions change. Periodic variations, such as time of the day, season, year, are complemented by sporadic changes in quality due, for example, to a sudden catastrophe, such as a chemical spill. In addition, a long river may contain water of different quality at various points, with quality often being high at the source of the river and low at the mouth.

8.128. Another issue relates to the measurement of stocks of water of a certain quality. Water quality is measured at a single point and it is difficult to aggregate such measurements to represent large regions such as big lakes, rivers and even drainage regions. This problem is particularly difficult for rivers due to the flowing nature of the water. One measure that has been proposed by the French Environment Institute (IFEN) and used by several countries is the kilometre of standard river (kmsr), which is a standardised unit of account representing a river stretch of one kilometre with a water flow of one cubic metre of water per second. This measure entails multiplying each stretch of a river containing a certain quality of water by its flow. The river is thus divided in different sections with different quality classes, whose water flow can be aggregated without double counting.

8.129. Although the major changes in stocks of water are due to abstractions and returns, unless very detailed information on the quality of abstractions and returns is available, it will not be practicable to relate changes in water quality to these additions and subtractions from stock levels. Linking the quality of the river (expressed in standard river kilometres weighted by quality indices) to the flow of residuals and the flow of water which have generated this quality requires using analytical hydrological models. Such models exist but are very data demanding and more applied for local rather than national use.

8.130. On the basis of the quality accounts, global indices of water quality have been calculated by France and Chile.

3 Monetary Accounts

8.131. This section covers monetary valuation of flows, environmental expenditure and resource management accounts, and issues related to the valuation of water resources taking into account the particular nature of water.

Monetary valuation of flows

8.132. The physical supply and use tables presented in Table 8.3 and Table 8.5 have monetary counterparts. Water supply in monetary units records the major economic output of industries related to water and imports. In particular, it includes output of production of drinking water, non-drinking water, irrigation water, production of sewage removal and treatment services. The water use table in monetary units records the use of water by different economic agents.

8.133. There is a discussion in Section E of Chapter 7 on the various methods of placing a monetary value on water flows. However, of equal concern are the accounts concerned with managing and protecting water resources.

Environmental protection and management activities

8.134. As described in Chapter 5, environmental protection and management activities are considered under four main categories:

environmental protection activities;
natural resource management and exploitation activities;

environmentally beneficial activities; and
minimisation of natural hazards.

Environmental protection activities

8.135. Environmental protection activities related to water involve activities of "waste water management" and of "protection and remediation of soil, groundwater and surface water" in CEPA 2000. Wastewater management is mainly undertaken as part of the ISIC 90 "Sewage and refusal disposal, sanitation and similar activities" as well as treatment of wastewater as an ancillary activity. For soil and groundwater, they include activities which target the reduction or elimination of polluting substances that may be applied to soil and percolate into groundwater, decontamination of soil and activities related to monitoring and controlling soil pollution.

Management activities

8.136. Management activities cover primary, secondary and ancillary activities related to water management.

8.137. Management expenditure accounts for primary water activities include the production and generation of income accounts for ISIC 01, "Operation of irrigation systems", ISIC 41 "Collection, purification and distribution of water" and part of ISIC 75 "Public administration of services". These accounts may contain supplementary information regarding fixed capital and labour inputs.

8.138. Management expenditure accounts can be compiled for secondary and ancillary water related activities; that is, those activities carried out by industries different from ISIC 01, 41 and 75. These activities include, for example, direct abstraction of water by manufacturing industries for cooling purposes or by final consumers for own use. These accounts cover expenditures related to abstraction and purification of water. They include information on current expenditures such as intermediate consumption, compensation of employees, taxes and subsidies related to water, on capital expenditure, and, when possible, on consumption of fixed capital, stock of fixed assets and labour inputs.

Environmentally beneficial activities

8.139. Environmentally beneficial activities are those activities which may be primarily undertaken for economic reasons but yield substantial environmental benefits even though the primary purpose is not environmental protection. Environmentally beneficial activities related to water include those activities aimed at saving water, whether for final consumers, industries, services or agricultural users. They may take the form of investment (irrigation systems, facilities and appliances to reduce water consumption, recycle water, etc.) or the use of products adapted for lower water consumption; for example, specially adapted washing machines (Eurostat, 1994).

Minimisation of natural hazards

8.140. Expenditures to minimise natural hazards related to water include expenditures to prevent flooding, such as the construction of dams to restrict water flow, management of water retention areas, measures to avoid droughts and so on. These accounts may provide an indication of the effects of alteration of landscapes and water systems or global warming.

D Accounts for wooded land, timber and forest products

1 Introduction

8.141. The present section considers the compilation of accounts in greater detail for wooded land (SEEA asset category EA.23) and for the products coming from or related to it. These cover cultivated and non-cultivated timber, non-wood products and environmental services. These fall into the SEEA asset categories EA.1411, EA.1412, EA.1422, EA.1442 and EA313. Some of the accounts are described in both physical and monetary terms and some in physical terms only.

8.142. The second sub-section concentrates on physical accounts for forested land, introducing a more detailed classification such as may be used for an in depth analysis of the forestry industry and its environmental implications. The third sub-section applies this extended classification to the physical accounts for timber, both standing and harvested.

8.143. The monetary accounts for wooded land and for timber do not follow exactly the physical accounts. The separation of land and timber which can be followed in the physical accounts may be less easy and less useful in monetary accounts. The fourth sub-section discusses valuation techniques for timber and how monetary accounts can be constructed and drawn into the aggregate economic accounts.

8.144. Sub-section 5 shows accounts for all forest products. To the information on harvested timber, described in sub-section 4, information in both physical and monetary terms for non-wood products is added.

8.145. Current monetary expenditures on forest management, conservation and protection can also be linked to the forested land area concerned even though they may have no physical counterparts. These expenses can be presented in ways compatible with the accounts detailed in Chapter 5. They are described in sub-section 6.

8.146. Sub-section 7 looks at some of the supplementary information, often of an ecological nature, which is collected by the UN FAO and the International Union for the Conservation of Nature. The aspects mentioned here include ecofloristic zones, biodiversity, carbon-binding and the protection status of forests.

8.147. The last sub-section looks at the compatibility of different international data sources.

2 Physical accounts for forested land

8.148. This section describes how detailed accounts for forested land may be developed using Finnish data for illustration.

Extending the classification of wooded land

8.149. The standard SEEA asset classification divides wooded land and associated surface water (EA.23) first into cultivated and non-cultivated forested land. These latter may be further subdivided between those previously harvested and virgin forested land. As illustrated below, a country may develop a more extensive classification when forestry is an important industry and forested land an important type of land cover.

8.150. The definitions used in national forestry studies differ between countries, but for the purpose of international comparisons some international definitions have been developed. The definitions below are from the UN-ECE/FAO Temperate and Boreal Forest Resource Assessment 2000, commonly referred to as the

TBFRA-2000 (United Nations Economic Commission for Europe and Food and Agriculture Organisation of the United Nations, 2000). Similar definitions are used by the FAO for all ecofloristic zones in the Global Forest Resources Assessment 2000, also known as the FRA-2000 (Food and Agriculture Organisation of the United Nations, 2001).

8.151. **Wooded land** is divided first between forests and other wooded land. Both categories exclude land predominantly used for agricultural purposes.

8.152. **Forested land** is defined as land with tree crown cover (or equivalent stocking level) of more than 10 per cent and an area of more than 0.5 hectares. The trees should be able to reach a minimum height of 5 metres at maturity *in situ*. Forested land includes:

> young natural stands and all plantations established for forestry purposes which have yet to reach the crown density of 10 per cent or tree height of 5 metres;
>
> areas normally forming part of the forested land area which are temporarily unstocked as a result of human intervention or natural causes but which are expected to revert to forest;
>
> forest roads, cleared tracts, firebreaks and other small open areas, as well as forest nurseries and seed orchards that constitute an integral part of the forest;
>
> forested land in national parks, nature reserves and other protected areas such as those of special environmental, scientific, historical, cultural or spiritual interest;
>
> windbreaks and shelter belts of trees with an area of more than 0.5 hectares and a width of more than 20 metres;
>
> rubber wood plantations and cork oak stands.

8.153. The primary use of forested land is forestry, which includes activities related to the management of forested land and other wooded land for the production and supply of wood and/or other goods and services. This definition of forestry differs from that used in the ISIC classification, in which forestry is restricted to timber production and related activities.

8.154. **Other wooded land** is defined as land with a tree crown cover (or equivalent stocking level) of either 5-10 per cent of trees able to reach a height at least 5 metres at maturity *in situ* or a crown cover of more than 10 per cent of trees not able to reach a height of 5 metres at maturity *in situ* (for example, dwarf or stunted trees) and shrub or brush cover. Areas having tree, shrub or bush cover that are less than 0.5 hectares in size and less than 20 metres in width are excluded and classified as "other land".

8.155. The next stage is to sub-divide forested land according to its availability for wood supply.

8.156. **Forested land available for wood supply** covers areas where legal, economic, or environmental restrictions do not have a significant impact on the supply of wood. It includes areas where harvesting of timber is not taking place, for example, because of long term utilisation plans or intentions.

8.157. **Forested land not available for wood supply** includes areas where legal, economic, or environmental restrictions prevent any significant wood production. Legal and/or environmental restrictions refer to protection for environmental and biodiversity conservation and other protection, including restrictions to ensure protection against soil erosion, avalanches and so on, and for special environmental, scientific, historical, cultural or spiritual interest. Economic restrictions appear in areas where physical productivity or wood quality is too low or harvesting and transport costs are too high to warrant wood harvesting, apart from occasional cuttings for own consumption.

8.158. Forested land available for wood production can be further sub-divided according to the authenticity or naturalness of the forest. Such characteristics are very closely related to the definitions of cultivated and natural assets described in Chapter 7. As discussed below, this distinction is very important as it has an impact on the calculation of production of the forest industry. The 1993 SNA treats natural growth of cultivated assets as a process of production, and hence it is accounted for as output of the forest industry. Natural growth of non-cultivated forest is, in contrast, a natural process and therefore not treated as a productive activity. One classification useful for separating cultivated from non-cultivated forested land (and also for other purposes) is the classification of forests as natural, semi-natural or plantations. The following is the FAO classification of forests.

> **Natural forests** – Forests with natural species and ecological processes and for which there has been continuity of ecological processes over a very long period of time. The time period of continuity is sometimes quoted as being of more than 200 years but this may not be relevant for all types of forests.
>
> **Semi-natural managed forests** – Forests in which management has substantially altered the structure and ecological processes but in which growth is still mainly a natural process with no regular and continuous human intervention.
>
> **Plantations** – Forests for intensive fuel or industrial wood production, planted or artificially regenerated and made up of exotic (non-indigenous) species and/or mono-cultures.

8.159. Although the definitions in the 1993 SNA and FAO classifications are a result of different considerations, natural forests in the FAO classification are very close to natural forests in the SNA. Timber in natural forests is clearly non-cultivated and plantations are cultivated according to the SNA definition. Natural and cultivated aspects are mixed in semi-natural forests, since management does not necessarily substantially alter the ecological processes or end the continuity of those processes of the forests. The more stringent definition of cultivated biological assets proposed in Chapter 7 for use in both the SEEA and the SNA would classify most semi-natural forests as non-cultivated in both systems and that is the assumption made in the rest of this section.

8.160. The degree of naturalness of forests is difficult both to define and measure precisely. This is a new area in forestry statistics and results may not be fully comparable between countries. Eurostat (1999) discusses this problem based on test calculations for several EU countries and the UN-ECE/FAO for the results of the TBFRA-2000 (United Nations Economic Commission for Europe and Food and Agriculture Organisation of the United Nations, 2000). In practice it is often difficult to make a reliable separation of, on the one hand, the natural growth of timber that occurs in cultivated forests and, on the other hand, the wood removed from the non-cultivated forest. When no clear-cut data sources are available it may be useful to treat all forest as either cultivated or non-cultivated. In countries where most of the cultivated forests are plantations and/or are specific (non-indigenous) species, it is usually easier to distinguish between cultivated and non-cultivated forests.

8.161. Forested land not available for wood production can be further sub-divided into areas which are **strictly protected** (IUCN classes I and II) and **forested land under economic restrictions**. This disaggregation is useful, since changes in economic restrictions may occur with increasing market prices, improved technology, and new human settlements and road networks entering areas previously isolated.

8.162. Forests can also be classified on the basis of predominant tree species: **coniferous** (*gymnospermae),* **broad-leaved** (*angiospermae*) or **bamboo, palms, etc**. (*gramineae, etc.*). Forests are assigned to these categories if more than 75 per cent of the tree crown cover consists of the mentioned tree species. In **mixed forests** none of the species groups accounts for more than 75 per cent of the tree crown area.

8.163. A hierarchy for classifying forested land, alternative to the standard SEEA classification, is shown schematically in Table 8.12.

Table 8.12 Alternative hierarchy for classifying wooded land

Forests			
	Forests available for wood supply		
		Natural forests	
			Coniferous
			Broad-leaved
			Bamboo, palms etc.
			Mixed forests
		Semi-natural forests	
			Coniferous
			Broad-leaved
			Bamboo, palms etc.
			Mixed forests
		Plantations	
			Coniferous
			Broad-leaved
			Bamboo, palms etc.
			Mixed forests
	Forests not available for wood production		
		Strictly protected	
			Coniferous
			Broad-leaved
			Bamboo, palms etc.
			Mixed forests
		Under economic restrictions	
			Coniferous
			Broad-leaved
			Bamboo, palms etc.
			Mixed forests
Other wooded land			

8.164. It may be that not all these headings would be applicable in a given country. For example, in a country such as Finland there is no need to include the category for bamboo, palms, etc. since these plants do not grow at that latitude. There may also be data limitations in implementing this scheme. For example, it may be that the dominant species cannot be cross-classified by the "naturalness" of the forest. Productivity and species composition may differ across a country, due to climatic conditions or soil type, say. Regional forest accounts may be a very useful way of dealing with this. For example, France has established separate accounts for the main forest regions; see Eurostat (2000) for a summary.

Physical accounting entries for forested land

8.165. Changes in forested land may be brought about by:

increases in the stock (afforestation and natural expansion);
decreases in the stock (deforestation and degradation); and
changes in land classification and reassessment of stocks.

Afforestation and natural expansion

8.166. The stock of forested land may increase because of the establishment of new forest on land which was previously not classified as forested land or as a result of silvicultural measures or natural expansion. Additionally, land classified as other wooded land may be shifted to forested land as a result of silvicultural measures or natural restoration, including restoration after shifting cultivation.

8.167. Total increase in forested land can also be classified as either man-made afforestation (silvicultural measures including planting and seeding) including plantations, or natural expansion resulting from natural seeding, sprouting, suckering or layering.

8.168. Forest renewal by natural or silvicultural measures after clear cutting does not qualify as an increase in forested land. This land remains classified as forested land except when clear cutting is preliminary to putting the land to an alternative use such as agriculture or construction.

Deforestation and degradation

8.169. The stock of forested land may decrease because of the complete loss of tree cover and transfer of forested land to other uses than forestry (agricultural land, land under buildings, roads, etc.) or to no identifiable use. This is usually a result of deforestation from human activities. The stock may also be reduced because the forested land is degraded to a point where tree cover falls below 10 per cent and the land thus becomes classified as other wooded land. Degradation may appear for natural reasons, for reasons of human activity or for a combination of reasons.

8.170. Total removals of standing timber by felling are not decreases in forested land if the use of the land does not change after felling.

Changes in classification and reassessment of stocks

8.171. Changes in classification due to economic decisions include the decision to protect, or to cancel protection of, forested land; the decision to put the land to other uses; and changes in the conditions and infrastructure affecting forested land on which harvesting is currently limited due to economic conditions (distance from markets, prices, etc.).

8.172. Reassessment of the stock due to improved knowledge includes recognition of new resources and adjustments of area and volume estimates due to new data and estimation methods.

8.173. Catastrophic events (fires, storms, avalanches, etc.) affect the volumes of standing timber on forested land, although they do not necessarily decrease the forested land area. Areas where fires and catastrophic events decrease the crown cover below the level defined for forested land should be separately identified.

8.174. Changes in forested land can also be divided into elements based on economic decisions and those due to natural causes. Changes due to economic decisions consist of afforestation and deforestation, degradation, re-assessment of the stock and changes in classifications. Changes due to natural causes refer to natural extension, degradation and natural catastrophic events.

An example of a physical account for forested land

8.175. An example physical account for forested land is shown in Table 8.13. Here the classification and accounting entries described above have been applied to Finnish data for the years 1990 to 1995.

Table 8.13 Forested land area by type

Thousand hectares

Forest land	***Available for wood supply***							***Not available for wood supply***			
	Natural forests	Semi-natural forests	Plantations	***Total***	Conifers	Broadleaved	***Total***	Conifers	Broadleaved	***Total***	**Total forest land**
Opening area 31.12.1990	480	21 222	0	21 702	19 857	1 845	21 702	1 206	95	1 301	23 003
Changes in cover											
Man-made changes											
Afforestation		58		58	53	5	58				58
Deforestation	- 1	- 60		- 61	- 56	- 5	- 61				- 61
Natural events											
Natural expansion											
Degradation											
Change in classifications											
Economic decisions	- 104			- 104	- 95	- 9	- 104	95	9	104	0
Catastrophic events											
Closing area 31.12.1995	375	21 220	0	21 595	19 759	1 836	21 595	1 301	104	1 405	23 000

Source: Statistics Finland.

3 *Physical accounts for timber*

Classification of timber

8.176. Since the characteristics of forests have been used to classify wooded land, it is not surprising that the classification for timber is similar. The accounts focus on timber in forests available for wood supply. However, accounts for timber in strictly protected areas and in areas under economic restrictions are also very important and should be shown separately, since the possibility for changes in economic restrictions may affect the availability for wood supply. It is assumed here that only non-cultivated forests occur in strictly protected areas or in areas under economic restrictions.

8.177. The TBFRA-2000 (United Nations Economic Commission for Europe and Food and Agriculture Organisation of the United Nations, 2000) introduces a specific category for **trees outside the forest**; that is, trees on land other than wooded land. This category includes:

trees on land that meets the definition of forested land or of other wooded land except that the area is less than 0.5 hectares and the width is less than 20 metres;

scattered trees in permanent meadows and pastures;

permanent tree crops such as fruit tree orchards and coconut palm plantations;

trees in parks and gardens, around buildings, in hedgerows and in line along streets, roads, rivers, streams and canals;

trees in shelter belts and windbreaks of less than 20 metres in width and 0.5 hectares in area.

8.178. This is not an important category for countries with large forest resources, but may be of importance in less-densely forested countries. This category can be useful when consolidating data on timber stocks and removals from various sources, especially when trees in this category provide an important source of wood.

Timber accounting concepts

8.179. The TBFRA-2000 offers a set of normalised definitions which are presented below. Country-specific definitions (for example, those used in forest inventories) may differ from the TBFRA-2000 definitions.

Standing volume – The volume of standing trees, living or dead, above stump measured over bark to the top. Includes all trees regardless of diameter, tops of stems, large branches and dead trees lying on the ground which can still be used for fibre or fuel. Excludes small branches, twigs and foliage.

Growing stock – The living component of the standing volume.

Gross annual increment – The average annual volume of increment over the reference period of all trees, with no minimum diameter. Gross annual increment is thus equivalent to natural growth in a year.

Net annual increment – The average annual volume over the reference period of gross increment less natural losses.

Natural losses – The average annual losses to the growing stock during the reference period due to mortality from other causes than cutting by man; for example, natural mortality, disease, insect attack, fire, wind-throw or other physical damages.

Annual fellings – The average annual standing volume of all trees, living or dead, measured over bark (with no minimum diameter) that are felled during the reference period, including the volume of trees or parts of trees that are not removed from forested land, other wooded land and other felling sites. Includes silvicultural and pre-commercial thinnings and cleanings left in the forest, and natural losses that are not recovered.

Annual removals – The average annual volume of those fellings that are removed from forested land, other wooded land and other felling sites during the reference period. Includes removals during the reference period of trees felled during an earlier period and removal of trees killed or damaged by natural causes (natural losses); for example, by fire, storms, insects and diseases.

8.180. It should be noted that the TBFRA-2000 introduced an important change in the definition of (standing) volume, which it defines as measured without a minimum diameter. Previous definitions had defined standing volume as measured to a minimum diameter of 7 centimetres at breast height.

Timber accounting practices

8.181. Changes in stocks of timber are due to:

natural growth of timber (gross annual increment);
fellings of timber;
natural losses, including catastrophic natural events;
changes in land classification; and
reassessment of stock.

8.182. A **forest account for timber** in physical terms shows the opening and closing stocks of standing timber and the changes between the beginning and the end of the accounting period. Although the TBFRA-2000 does not provide any standard forest balance, according to the definitions, the change in stocks of standing timber between the beginning and the end of the accounting period is equal to gross increment less removals less any losses not accounted for in removals. Any changes in use or status should also be included.

8.183. For **material flow accounting** and **physical input-output tables** annual removals of timber should be separated from felled timber not removed from the forest. Further, the volume of fellings which is removed from the forest should be divided into saw logs, pulp wood and fuel wood by tree species or main group of tree species of most economic importance.

8.184. The **sustainable yield** of renewable natural resources is traditionally defined as the extraction level of the resource which does not exceed the growth. However, this definition is too restrictive in many cases. For a given stock of a biological resource, many sustainable yields can be defined in principle. Forests have several functions besides logging (such as, habitat protection, recreation and biodiversity) and the sustainable yield has to be defined on the basis of a particular objective. Ideally, the sustainable yield should be determined by forest experts on the basis of modelling, but if no such information is available natural growth can be used as a proxy. With respect to timber, the sustainable yield refers to fellings which are not more than growth of timber during the accounting period (i.e., net growth is positive or zero). The sustainable yield refers to total fellings and not only to timber removed for own consumption and use. Another way of putting this is to say that if the closing stock is at least as high as the opening stock the yield for the accounting period is sustainable. During transitional periods (for example, after afforestation) the sustainable yield will differ from natural growth. The same may apply during transition from a previously virgin forest to a regularly managed forest.

8.185. It should be noted here that even when the difference between the opening and closing stock in the physical account is positive or zero, depletion may still occur in monetary units as a result, for instance, of changes in the age structure of the standing timber.

An example of physical accounts for timber

8.186. Table 8.14 shows the standing timber corresponding to the forested land in Table 8.13.

Table 8.14 Asset account for standing timber (volume)

Million solid cubic metres, over 7cm diameter, over bark

	Forest land	***Available for wood supply***	Natural forests	Semi-natural forests	Plantations	***Total***	Conifers	Broadleaved	***Total***	***Not available for wood supply***	Conifers	Broadleaved	***Total***	**Total forest land**
Opening stock 31.12.1990			40.1	1 784.3	0.0	1 824.4	1 501.5	322.9	1 824.4		57.3	5.3	62.6	1 887.0
Natural growth			7.9	352.2		360.1	279.8	80.3	360.1		8.1	2.3	10.4	370.5
Fellings							- 215.2	- 55.9	- 271.1					- 271.1
Harvested timber							- 201.5	- 45.2	- 246.7					- 246.7
Saw logs							- 102.0	- 5.9	- 107.9					- 107.9
Pulp wood							- 91.7	- 23.5	- 115.2					- 115.2
Fuel wood							- 7.8	- 15.8	- 23.6					- 23.6
Timber left in the forest							- 13.7	- 10.7	- 24.4					- 24.4
Felling residuals							- 13.7	- 10.7	- 24.4					- 24.4
Other timber														
Changes in classification							- 7.9	- 1.7	- 9.6		7.9	1.7	9.6	0.0
Closing stocks 31.12.1995							1 558.2	345.6	1 903.8		73.3	9.3	82.6	1 986.4

Source: Statistics Finland.

4 Monetary accounts for forested land and timber

8.187. The general principles of valuing natural resources as they apply to timber and forested land are explained in Section E of Chapter 7. The present section elaborates these guidelines in the context of the numeric example given here.

Timber

Monetary asset accounts for timber

8.188. The monetary asset account for timber consists of the opening stock, flows, changes in classification, revaluations and closing stock. Flows include net natural growth, timber removals, timber left in the forests and catastrophic losses. Revaluation records the change in value due to changes in prices of standing timber between the beginning and the end of the period.

8.189. A disaggregation of the timber asset account between natural (non-cultivated) and plantation (cultivated) forests is needed since in the SNA natural growth in cultivated forests is treated as production. In natural forests only harvested timber is counted as production. However, the current SNA practice in many countries is to count only harvested timber as production in all forests. (This practice is a holdover from the 1968 SNA.) As explained above, depending on national practices it may be desirable to distinguish semi-natural forests also.

Valuing timber stocks and flows

8.190. As noted in the section on accounts in physical terms, changes in physical stock levels of timber are caused by the net annual increment (natural growth less natural losses), fellings, the effect of catastrophic natural events and changes in land classification. For monetary accounts the same elements appear, as well as changes due to other classification changes such as those restricting use and any holding gains and losses.

8.191. If the closing stock level is calculated as the sum of flows and the opening stock level, the valuation methods used for the opening stock and flows should be closely compatible. If not, one of the terms explaining the reconciliation between opening and closing stock levels will absorb any inconsistency in valuation methods used.

8.192. For timber **stocks**, the consumption value and stumpage value methods are applicable, as well as the net present value methods.

8.193. **Natural growth** can be valued by any of these methods also. The method chosen should be consistent with the valuation method used for the stock.

8.194. It should be noted that because of forest legislation and/or environmental and economic reasons the total amount of natural growth may not be available for utilisation. There is then a question about whether timber which cannot be harvested should be given the same value as harvestable timber, a zero economic value or some intermediate value. If the amount of non-recoverable timber is very significant, the restrictions on felling may be sufficient to increase the price of the amount which can be felled. In this case, an over-statement will be given if the elevated price is applied to both actual removals and growth left *in situ* and a lower value should be used. If a value lower than the harvestable value is used and if the share of the non-recoverable timber is significant, the average value of natural growth will be lower than the average value of the recoverable timber. It is likely to be reasonable to assume that the level of unrecovered timber in cultivated forests is minimal.

8.195. If the restrictions on felling are not considered to have a significant effect on the price of timber available, this value should be applied to the growth left *in situ* also. This choice will apply to forests which are available for wood supply but where protection (IUCN categories III-V) decreases felling potentials.

8.196. **Fellings** (harvested timber) consist of removals and felling residuals left in the forest.

8.197. The value of **removals** is always given by the stumpage value of the timber removed from the forest. When the stumpage prices are known, the removals (described as assortments of wood in the rough) must be translated into the corresponding volumes of standing timber (described by age/diameter) and then valued by the stumpage prices. When the stumpage prices are not available, harvesting costs must be deducted from the value of the wood in the rough. It is worth noting that in some circumstances stumpage values may be set artificially low for policy reasons; for example, to encourage employment in remote areas.

8.198. ***Felling residuals*** left in the forest may have a zero value or, if they are gathered for own use may have a value somewhat lower than the value of the harvested timber.

8.199. The value of **catastrophic losses** is given by the difference between the value of the stock of timber just before the catastrophic event and its value immediately after.

8.200. When the catastrophic event does not destroy the wood, it is necessary to take into account the value of the wood that will be salvaged. This value is a consumption value, although due to problems of quality and excess supply the prices to be used may be lower than “normal” prices. There may also be supplementary costs for the recovery and the storage of the felled timber, the clearance of the forest, and so on. The stumpage value of the salvaged timber has to be accounted for in the value of the stock for the period until it is removed from the forest, which, in some cases, may be some years.

8.201. Other changes that affect the value of stocks of standing timber as a resource for the logging industry are **changes in use or status**; for example, when forested land is protected and logging is prohibited. In this case the value of the standing timber is reduced to zero.

8.202. The value of **holding gains and losses** results from the change in the prices of timber, forestry costs and rate of discount between opening and closing balance sheets. When the net present value method is used, the value of the stock of standing timber also depends upon the assumptions made concerning the pattern of removals. These assumptions may differ from actual removals. In this case, the impact of these differences on the value of the stock has to be analysed and classified as an other change in volume.

Forest accounts by institutional sector

8.203. It is desirable to have asset accounts for timber disaggregated by institutional sector (for example, government and private enterprises) but this is possible only if the basic data for these sectors are available. Forest land area by ownership category may often be available, but timber volumes, changes in them and actual market prices by the same categories can only be derived from area and statistics on timber resources. At least the main elements of monetary timber balances (opening stock, fellings, closing stock) should be presented (as estimates of shares of the totals if necessary) by ownership (private and public).

An example of monetary accounts for timber

8.204. Table 8.15 gives an example of a monetary account for timber available for wood supply. The estimates are made by applying stumpage prices to the physical data for stocks and flows of timber.

5 Accounts for forest products

8.205. As well as the fellings harvested, there are other non-wood products which should be estimated for a full accounting of the environmental yield of a forest. Non-wood products for own consumption and industrial uses are grouped as:

food (game, berries, fruits, mushrooms, nuts, palm oil, honey, etc.);
medicines;
fodder/forage for animal breeding;
industrial extracts (cork, rubber, gum, tar, chemicals);
forest animals as agricultural products (wild boar, reindeer, etc.).

Table 8.15 Asset account for standing timber (value)

Million Finnish marks

	Conifers	Broadleaved	***Total***
Opening stocks 31.12.1991	242 187	32 112	274 299
Natural growth	36 343	6 811	43 154
Fellings	-28 960	-4 342	-33 302
Harvested timber	-28 182	-3 785	-31 967
Saw logs	-19 708	-1 342	-21 050
Pulp wood	-8 130	-1 831	-9 961
Fuel wood	- 344	- 612	- 956
Timber left in the forest	- 778	- 557	-1 335
Felling residuals	- 778	- 557	-1 335
Other timber			0
Changes in classification	-1 015	- 141	-1 156
Revaluation of stocks	-24 351	- 518	-24 869
Closing stocks 31.12.1995	224 204	33 922	258 126

Source: Statistics Finland.

8.206. Flows of non-wood products are expressed as extracted kilograms for own consumption and industrial use (cork may be measured in cubic metres). If possible, a separation should be made between products coming from forests which are available for wood supply and those which are not. Not all products listed above will exist in all countries or in sufficient quantity to make quantification either desirable or possible.

8.207. Non-wood products are linked to material flow accounts, physical input-output tables and physical accounts showing volumes of goods for own consumption and sent to market. The values of products are separated into those for own consumption and those used by industries (classified by ISIC or NACE).

Valuation of non-wood products

8.208. The volumes of non-wood products are converted from physical to monetary terms using average market prices for the products concerned. These values are imputed for non-wood products for own consumption as well as for products for sale. Market values include the costs of collection and thus timber and non-wood product values will not be fully consistent because the value of timber is calculated directly as the product of the stumpage price and the volume of timber harvested without allowing for logging costs.

An example of an account for forest products

8.209. Table 8.16 shows illustrative figures for timber and non-wood products. In this case, the value of the non-wood products is approximately 10 per cent of the value of timber extracted.

Table 8.16 Volume and value of all forest products

	Volume in thousand tonnes	Value at current prices, 1991-1995, Million Finnish marks Branches of industry (ISIC)					
	Total 1991-1995	Agriculture	Hunting as branch of industry	Forestry and logging	Charcoal production	Others, including own consumption	Total
Timber	204 000			30 842		958	31 800
conifers	161 000			27 689		345	28 034
broadleaves	43 000			3 153		613	3 766
others							
Industrial extracts							
cork							
rubber							
tar							
chemicals							
other							
Forest animals (reindeer)	17	454					454
Food							
fruits							
meat from hunting	40					1 293	1 293
berries and mushrooms	130	360				960	1 320
nuts							
palm oil							
honey							
others							
Medicines							
Fodder/forage	2	46					46
Total		860		30 842		3 211	34 913

Source: Statistics Finland.

6 *Expenditures on forest management and protection*

8.210. The ISIC industry forestry and logging includes silviculture, forest improvement and logging activities. This should be included in the data in the SNA for forestry and logging. Costs of environmentally sound forestry and logging methods which aim, for example, at improving biodiversity and ensuring the possibility of multiple forest uses should be separated from conventional forest management and recorded as a sub-category of expenditures.

8.211. Expenditures on environmental protection are described in detail in Chapter 5. Expenditures on forest protection include conservation of protected forests (according to IUCN categories) and costs of environmental protection activities; such as, the prevention of forest degradation and pollution, and the restoration and reparation of forests. Restoration and reparation costs should be separated from the cost of forestry and logging for purely wood-production purposes. Actual expenditures may represent new investments or maintenance costs. Costs should be split not only by industry but also between the public and private sectors.

8.212. Table 8.17 shows an illustrative table on expenditures on forest management and protection.

Table 8.17 Expenditure on forest management and protection

Million Finnish marks 1991-1995

	Forestry and logging*							
	Private	Forest industry	State	Environmental protection services	Public administration, other public services	Other branches of industry	Total	*Of which public sector*
Forestry and logging								
forest improvement and silviculture	4845	415	564				5824	564
logging	3557	6256	2014				11827	2014
environmentally sound forestry and logging**	350	40	50				440	50
Forest protection	..	..	..					
prevention								
restoration								
Forest conservation					920		920	920
Total								

*Included into forestry and logging sector in SNA
**Estimated stumpage values lost because of the use of environmentally preferable methods in loggings (for example standing trees left in the logged area for biodiversity protection).
Source: Statistics Finland.

7 Supplementary tables

8.213. This section gives a brief overview of some of the supplementary tables it may be useful to compile when wooded land is being studied in depth. The topics covered are:

ecofloristic zones;
protection status (protected (IUCN) / non-protected);
carbon binding;
age structure of forests;
forest health;
biodiversity and ecosystems; and
non-wood services.

Ecofloristic zones

8.214. Ecofloristic zones are structured as:

tropical forests;
dry (Mediterranean-type) forests;
temperate forests; and
boreal forests.

8.215. Typically, only one or two main types of ecofloristic zones occur in a single country, so national disaggregation of a single ecofloristic zone to sub-categories can be done on the basis of information needs on ecological and forest quality, climate condition and geographical aspects.

8.216. **Tropical forests** can be subdivided into:

a. rainforests – lowlands with a pluvial regime (more than 2000 mm/year of rain);

b. moist deciduous forests – lowlands with a moist regime (1000-2000 mm/year of rain with a short, less than 3 to 4 month dry season);

c. dry deciduous forests – lowlands with a moist regime (1000-2000 mm/year of rain with a long , more than 6 to 7 month dry season);

d. very dry deciduous forests – lowlands with a tropical dry regime (500-1000 mm/year);

e. desert zone – lowlands with less than 500 mm/year of rain;

f. hill and montane zone – forests within the altitude range of 1000-3000 metres; and

g. other tropical and sub-tropical forests.

8.217. **Dry (Mediterranean-type) forests** include forested land characterised by evergreen and sclerophyllous tree species associated with dry, hot summers.

8.218. **Temperate forests** include forested land with predominantly broad-leaved, mixed and, on certain sites (such as higher elevations), coniferous tree species associated with mild or cool climate conditions and precipitation around the year.

8.219. **Boreal forests** include forested land in the northern latitudes with predominantly coniferous tree species associated with harsh winter conditions and a short growing season.

Protection status

8.220. The IUCN defines the **protection status** for forested land in five categories as follows:

I scientific reserves and strict nature reserves;

II national and provincial parks;

III natural monuments and natural landmarks containing unique geological formations, special animals or plants or unusual habitats;

IV managed nature reserves and wildlife sanctuaries protected for specific purposes (e.g., conservation of significant plant or animal species);

V protected landscapes and seascapes, which may be entirely natural or include cultural landscapes (e.g., agricultural areas).

8.221. Protection according to IUCN classification does not match perfectly the division of forested land into available/not available for wood production. Fully (strictly) protected areas are maintained in a natural state and are closed for extractive uses. These include those classified to IUCN categories I and II. For areas classified to category I, public access to the area is limited; areas classified in category II are open for recreation and study. Some extractive uses are allowed on lands classified to categories IV and V (not strictly protected areas). It may sometimes be unclear whether category III belongs to strictly protected areas or to areas where some extractive use of timber is allowed. The recommendation here is to include category III in not strictly protected areas, since the possibility exists that management for specific uses includes felling and monetary output of timber.

8.222. Timber in not strictly protected forests available for wood supply is not available for forestry and logging activities to the same extent as in forests that are not protected at all. This may affect monetary value of the timber in such forests in the ways explained above in the discussion of the valuation of timber.

8.223. Table 8.18 and Table 8.19 show the stock levels and changes of timber and forested land according to protection status. In the case of these data for Finland, there is only a slight difference in the information conveyed by the two tables; the proportion of standing timber which is protected is slightly greater than the proportion of protected forested land.

Table 8.18 An asset account for standing timber according to protection status

Million cubic metres

	Opening stocks 31.12.1990	Growth of timber	Fellings	Catastrophic events	Changes in land classification	Reassess-ments of stocks	Closing stocks 31.12.1995
Forest land							
Available for wood supply							
Not protected	1 756.3	347.1	- 261.1		- 12.4		1 829.9
Not strictly protected	68.1	13.0	- 10.0		2.8		73.9
Not available for wood supply							
Strictly protected	62.6	10.4	0.0		9.6		82.6
Total	1 887.0	370.5	- 271.1		0.0		1 986.4

Source: Statistics Finland.

Table 8.19 An asset account for forested land according to protection status

000 hectares

	Opening stocks 31.12.1990	Afforestation	Deforestation	Natural events	Changes in classification	Reassess-ments of stocks	Closing stocks 31.12.1995
Forest land							
Available for wood supply							
Not protected	20 532	58	- 58		- 134		20 398
Not strictly protected	1 170		- 3		30		1 197
Not available for wood supply							
Strictly protected	1 301				104		1 405
Total	23 003	58	- 61		0		23 000

Source: Statistics Finland.

Carbon binding

8.224. The amount of carbon bound into wood and tree biomass can be derived from volumes, growth and fellings of standing timber using average coefficients for biomass by tree species from national sources, the FAO or the United Nations Framework Convention on Climate Change (FCCC). Carbon binding is related to the non-wood services of forests; specifically, protection services concerning climate. Carbon balances should correspond to any data provided to the FCCC.

8.225. The biomass of trees is divided into above-ground biomass of stem wood (including bark) and other above-ground tree biomass (branches, leaves, needles, etc.). The above-ground biomass of woody plants is the biomass of bushes, shrubs and twigs (including foliage). Carbon balances derived from stem wood and other above-ground tree biomass are compiled both for forests available and not-available for wood supply and for main groups of tree species. Balances can be expanded to total carbon stored in the forest ecosystem by adding the carbon bound into below-ground vegetation and forest soils.

8.226. The average coefficients used in Finland to convert the data in Table 8.14 showing timber by cubic metres over bark to tonnes of carbon are 0.3091 for pine, 0.3715 for spruce and 0.4152 for broad-leaved species. Below-ground biomass is taken to be 23 per cent of the above-ground estimates. These conversions result in the figures shown in Table 8.20.

Table 8.20 Carbon binding and the accumulation of tree biomass

Million tonnes of carbon

	Forest land	***Available for wood supply***	Conifers	Broadleaved	***Total***	***Not available for wood supply***	Conifers	Broadleaved	***Total***	**Total above ground tree biomass**	**Total below ground tree biomass**	**Total tree biomass**
Opening stock 31.12.1990			511.0	134.1	645.0		19.5	2.2	21.7	666.7	199	866
Natural growth			95.2	33.3	128.6		2.8	1.0	3.7	132.3		
Fellings			- 73.2	- 23.2	- 96.4					- 96.4		
Changes in land classification			- 2.7	- 0.7	- 3.4		2.7	0.7	3.4	0.0		
Change in carbon			19.3	9.4	28.7		5.5	1.7	7.1	35.8	11	47
Closing stocks 31.12.1995			530.2	143.5	673.7		25.0	3.9	28.8	702.6	210	913

Source: Statistics Finland.

Forest age structure

8.227. The age structure of a forest is often expressed as the area of the forest consisting mainly of trees of the same age (i.e., by age class) or by proportions of trees in different age classes. The age-class division used is dependent on the ages of trees of different species. For forest accounting purposes, it is useful to have the age-structure expressed in terms of timber volumes. This may be derived by combining data on the number of trees with the average volume of timber for a tree of a given age. Since the volume of a mature tree is much larger than for a young tree, the distribution of timber volume may be very different from the distribution of number of trees.

8.228. Over-maturity is a combination of biological and economic characteristics (age of trees compared to average rotation period by tree species, soil productivity and climate conditions). Over-mature forests, which are defined as forests of age higher than the length of rotation period, can be recorded as natural forests if no silvicultural and/or logging activities have taken place in those forests during the previous thirty years.

8.229. Table 8.21 gives an example of the age profile of Finnish forests. It is from a single forest census and shows the percentage of the total area of forested land in each of the age-classes specified. It is of interest to be able to compare such profiles for different periods to ascertain whether and how the average age of the forest is changing.

Table 8.21 Age profile of a Finnish forest

Percentage distribution of total area; Age in years

Treeless	Up to 20	21-40	41-60	61-80	81-100	101-120	121-140	Over 140
1.5	15.4	18.0	16.8	16.0	12.0	6.9	4.3	9.2

Source: Statistics Finland.

8.230. Table 8.22 gives similar information in volume terms and by dominant species.

Table 8.22 Age and timber volumes by dominant species in a Finnish Forest

Solid cubic metres over bark per hectare; Age in years

	Up to 20	21-40	41-60	61-80	81-100	101-120	121-140	Over 140
Pine	14	63	101	133	155	153	141	140
Spruce	24	80	171	198	208	211	192	185
Broadleaved	19	81	123	167	174	182	208	191

Source: Statistics Finland.

Forest health

8.231. Forest health is affected by both natural and human factors. A correlation of forest health with a single factor such as air pollution is seldom very clear. Defoliation is the most commonly used factor in describing forest health. It is expressed as the amount or proportion of trees whose crown is more than 25 per cent defoliated. Other symptoms of forest damage that reduce stand quality are the amount and percentage of dead, fallen and broken trees, decayed trees, stem defects, top damage, discoloration and multiple symptoms. It should be noted, however, that dead and decayed trees are also often seen as a forest characteristic that improves biodiversity.

8.232. Defoliation and other elements of forest health are measurable for forest area in either hectares or percentages, but data on them do not directly relate to volumes of standing timber. Defoliation data should be presented by authenticity/naturalness classes and by predominant tree species or groups of tree species.

8.233. Table 8.23 shows the state of defoliation for different types of tree species. It covers only timber growing in mineral soil and not peat land.

Table 8.23 Degree of defoliation by tree species (%)

	Total forest land - Mineral soil sites		
	Pine	Spruce	Broadleaves
1990	6.9	34.2	13.0
1995	4.8	27.8	11.0

Source: Statistics Finland.

Biodiversity

8.234. Biodiversity is a very wide concept whose importance varies from one country to another. Factors in forest biodiversity are, for example, forest soil types (mineral, peat, wetland, etc.); forest altitude (lowlands, ridges, hills, mountains, etc.); proximity to water sources such as inland waters, groundwater, estuaries and archipelagos; and proximity to agricultural areas. The suitability of a forest for multiple uses (e.g., supply of timber and non-timber forest products) is also closely connected to biodiversity. Describing biodiversity and its development in semi-natural managed forests by ecofloristic zones and by predominant tree species is thus very important in forest accounting.

8.235. In forest accounting, biodiversity focuses on diversity of forest ecosystems and diversity of forest-dwelling species. If, due to changes in climate say, there is an increase in species not previously growing locally, it is useful to document this. Some elements of biodiversity are included in the accounting of the qualitative and quantitative aspects of forests, including ecofloristic zones, protection status, and proportions of tree species in total standing timber and in forested land area. Authenticity/naturalness of forests is of importance because the state of and changes in biodiversity are often different in natural forests, semi-natural managed forests and plantations. The biodiversity of plantations is usually lower than that of other forest areas and the introduction of foreign tree species involves higher ecological and economic risks than the planting of traditional species. In countries where plantations are important, it can be useful to describe the biodiversity of these areas separately.

8.236. The number of endangered species of flora and fauna (that is those with a high risk of extinction in the near future) is a useful biodiversity measure for all forest types. The number of endangered species should, if possible, be further disaggregated by areas of predominant tree species, by ecofloristic zones, and by natural and semi-natural forests. Table 8.24 gives an example of such information on endangered species. There is a discontinuity in the information available for 1997 compared with earlier years.

Table 8.24 Number of endangered species

	Total number of known species		Number of endangered forest species		
	1985	1990	1985	1990	1997
Vascular plants	1350	1550	34	38	
Trees					8
coniferous					
broadleaved					
others					
Flowers					35
Non-vascular plants	13700	14740	207	356	
mosses					37
macrofungi					
algae					
lichen					62
Vertebrates	372	373	17	15	
mammals					7
birds					13
other					
Invertebrates	25000	25500	200	318	
butterflies					47
others					

Source: Statistics Finland.

8 Compatibility with international data sources

8.237. The structure, definitions and classifications of the asset accounts for forests in the SEEA framework are compatible as far as possible with international forest and forestry product statistics.

8.238. Statistics compiled by the FAO cover tropical, temperate and boreal forests world wide. FAO has undertaken periodic forest assessments since 1946. The latest assessments have been compiled for 1990 and 2000. The framework for the 2000 assessment is an update from the previous version. In the FAO assessment, original national data are reorganised in order to obtain a common classification, format and reference date. The FAO framework emphasises the sort of accounts discussed above but also includes a number of supplementary tables, many of which have an ecological orientation.

8.239. The FAO forest assessments are based on national forest inventories, on survey data or on estimates made by FAO. The length of national forest inventory cycles is 1-15 years and the number and frequency of inventories and surveys varies between countries. Continuous annual forest inventories or surveys are hardly ever undertaken. Opening and closing stocks or balance sheets are available for the reference year (or period when forest inventories are done on a rotating basis) but the time span between opening and closing figures usually varies between 5 and 40 years.

8.240. The Intergovernmental Panel on Climate Change (IPCC) was, at the time of writing of this handbook, in the process of preparing guidelines for the preparation of national communications on annual greenhouse gas emission reports. In the guidelines definitions and a classification concerning forest assets are proposed. The SEEA accounts presented here are compatible, although not fully harmonised, with the IPCC guidelines. National reporting to meet IPCC requirements and the separate compilation of forest assets accounts should serve as complementary data sources. It may prove necessary to update the methodology for asset accounting for forests presented here to take account of the final version of the IPCC guidelines.

8.241. A considerable amount of data on physical and monetary flows related to forests is available on an annual basis or for other periods shorter than that typical in national forest inventories or surveys. This makes it possible to build asset accounts according to the general structure "opening balance sheet, changes in balance sheet, closing balance sheet". Even so, physical forest asset accounts, especially for opening and closing stocks and balance sheets, are seldom possible for one-year accounting periods at an adequate level of statistical reliability, though annual asset accounts may be estimated using models.

E Accounts for aquatic resources

1 Introduction

8.242. This section gives an overview of the issues involved in compiling accounts for aquatic resources. At the time of writing of this handbook, a new handbook to be called the *System of Integrated Environmental and Economic Accounting for Fisheries* (SEEAF) was in the course of preparation. This new handbook's joint publishers are the UN, FAO and UNU and it deals at much greater length with the subject of accounting for aquatic resources. There is discussion of the use of these accounts in Chapter 11.

8.243. The economy interacts with the whole aquatic ecosystem in several ways. Fish stocks are subject to exploitation for commercial as well as recreational and subsistence fishing activities. The abundance and health of wild fish stocks in inland and marine waters are also increasingly affected by water pollution and by the degradation of fish habitats through landfills, damming and diversion of rivers, clearance of mangroves, sedimentation, coral mining, deforestation in the hinterland and other activities. The dual impacts of excessive exploitation levels and habitat degradation result in the loss, or reduction, of the economic value of the goods and services provided by the aquatic ecosystems and a loss of biodiversity and genetic resources.

8.244. In most parts of the world, fishing capacity has reached the level where unrestricted fishing would result in over-exploitation and lead to smaller catches and economic benefits than would be possible if the exploitation were managed. In extreme cases, there is the risk of extinction of some fish stocks with attendant impacts on the aquatic ecosystem. Fisheries management depends upon available information to maximise economic benefits from the use of renewable aquatic resources. In many cases this information is limited and uncertain.

8.245. Accounting for aquatic resources is a means to improve the informational basis for fisheries management. In particular, it allows for:

identification of production, income, prices, trade in fish and fishery products for the fishing industry and all industries connected with the extraction and processing of fish;

assessment of the physical size of the most important aquatic resources, especially commercially exploited fish stocks and, in those cases where it is deemed realistic, estimation of the monetary value of these natural resources;

assessment of the cost of over-exploitation and the benefits from efficient management of the aquatic resources exploited by the commercial fisheries;

analysis of the efficiency of the management of the natural resources in the past and analysis of possible costs and benefits from the exploitation of these natural resources in the future;

analysis of the effects of public policies on the fisheries sector (both general macroeconomic policies such as taxes and interest rates and policies aimed at the fishing sector such as subsidies);

assessment of fisheries management and habitat protection costs; and

assessment of the value of aquatic resources shared with other countries.

2 Characteristics of the fishing industry

8.246. It is necessary to consider some special characteristics of the fishing industry, especially deep sea fishing, in order to make sensible decisions about how to compile useful accounts for aquatic resources. These characteristics cover where and under what legislative controls fishing is carried out and the attribution to country of the fishing boats.

Exclusive Economic Zones

8.247. Since the introduction of two hundred mile Exclusive Economic Zones (EEZ) in the 1970s and 1980s most commercially important aquatic stocks have been under the jurisdiction of individual countries. Some wild stocks migrate between EEZs belonging to different countries. Some stocks migrate between EEZs of countries and international waters and some stocks live completely in international waters. Efforts have been made, within the United Nations framework, to ensure that the countries which exploit these so-called “straddling stocks” do so in an environmentally responsible manner.

8.248. The *Law of the Sea* (United Nations, 1983), the *Agreement on the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks* (United Nations, 1995) and the *Code of Conduct for Responsible Fisheries* (Food and Agriculture Organisation of the United Nations, 1995) created a legal framework for fisheries management. As a result, countries are able to set rules for fishing within their EEZs to prevent over-fishing. International bodies have been set up and agreements on the management of fishing out of stocks in international waters have been reached to manage stocks, including those which straddle EEZs of different countries.

8.249. Methods for managing fisheries vary greatly. In some cases, fishing is largely free but the authorities make efforts to reduce the fixed capital devoted to fishing through purchase and then decommissioning of fishing vessels. In other cases, fishing effort is controlled by closing the fisheries during certain periods, establishing regulations on the types of fishing gear which may be used, or requiring a licence to fish. Management through catch quotas is common.

Fishing licences and quotas

8.250. In many countries, a fishing licence issued by government is required in order to practice either fresh water or marine fishing. If these licences apply for a period not exceeding one year, they are recorded in the SNA as taxes. For enterprises they are treated as taxes on production; for private individuals fishing for pleasure they are recorded as taxes on income. In some instances, a private individual or unit such as an angling club may own the fishing rights over a stretch of water and also charge a fee to would-be fishermen. This fee should be recorded as expenditure on recreational services.

8.251. An increasingly common form of controlling marine fishing to prevent over-fishing is to issue fishing quotas. These are usually issued by government (which is responsible for ensuring their enforcement as well) and may apply both to fishing within the waters of the country's EEZ and to fishing on the high seas. Quotas typically apply to a particular species of fish. Quotas may be given away free to certain designated persons (for example people in locations where fishing is the main source of livelihood) or may be sold. A quota may be valid for one year only or for a longer period, sometimes for the life-time of the quota holder. It may be tradable to third parties or not. Even if not tradable, in certain circumstances it may still be transferable; say, from one generation to the next.

8.252. If a quota can be sold by the holder to a third party, then the quota is recorded as an asset quite separately from the fish to which it relates. Quotas are classified as intangible non-produced assets in the SNA and are included as memoranda items in the SEEA asset classification.

8.253. One solution to the problem of country A exhausting the stocks of country B is for country A to issue licences or quotas to country B for which a payment must be made. The licences or quotas are treated as described above. If a licence or quota is valid for more than a year, it is recorded as an intangible non-produced asset which is sold by country A to country B. Technically, therefore, country B does not pay country A for the fish it harvests *per se* but does pay for the right to harvest them. Similar considerations hold for licences and quotas issued to residents; the holder of a long term license has an asset technically distinct from the fish whose harvest the license controls.

8.254. The value of the licence or quota should ideally be determined by the price it would fetch on the open market. When no such price is available, the value of the licence or quota should be set equal to the net present value of the resource rent of the amount of fish which can be caught under it.

8.255. In a perfectly functioning market (which the market in fishing licences and quotas may not be for all sorts of reasons, including lack of knowledge and accessibility to the market, government social policy, etc.), the value of the licence or quota would be equal to the net present value of the resource rent of the fish covered by the licence/quota. If the fish are to be harvested over a period of years, the value of the licence should be equal to the net present value of the resource rent from fishing over the period for which the license/quota is valid.

8.256. Whether or not a monetary valuation can be placed on fishing licenses and quotas, it is useful to have information available on their existence and the proportion of various fish stocks covered by them.

Harvesting fish and the production boundary

8.257. The production boundary of the SNA includes all activities carried out under the responsibility, control and management of a resident institutional unit in which labour and assets are used to transform inputs of goods and services into outputs of other goods and services. In the case of fisheries, the growth of fish in fish farms is treated as a process of production whether the fish are harvested or not. The fish harvested in the open seas or inland waterways by commercial or recreational fishing count as production regardless of whether they are sold in the market or used for own consumption. On the other hand, natural growth of fish stocks in the open seas or inland waterways is not counted as production.

8.258. The output of an aquaculture establishment should be recorded as being produced continuously (that is, as a work-in-progress) by distributing the value of the slaughtered fish over time in proportion to the costs incurred in each period (1993 SNA, paragraph 6.96).

8.259. All capture fishing by residents should be recorded as production, including, data permitting, that part of the catch which fishermen use for feeding their families and the landings of catches from recreational fishing even if not sold in the market. The catches used for own consumption should be valued at the prices for which they could be sold in the market excluding any taxes payable at the time of sale.

Capture fishing by non-residents

8.260. There is one issue involved with capture fishing by non-residents where an exception is made by the SNA to its own rules on the boundary of production and one issue where the distinction between natural resources and products in the SEEA must be varied.

Non-resident vessels

8.261. Determining the residence of a fishing vessel is not always straightforward. In earlier international manuals, it was assumed that the country of registration (that is, the flag under which the ship sails) indicated the ownership of the vessel and thus the country of residence to which the activity of the ship should be attributed. With the increasing practice of registering ships under flags of convenience, this assumption became unrealistic. The effect of the 1993 SNA and the corresponding balance of payments manual was that the attribution of residence to vessels and other movable equipment was changed.

8.262. The determining factor for residence of vessels is now the residence of the operator of the vessel. In many cases, this will still coincide with both the country of registration of the vessel and the residence of the owner but neither of these considerations is germane to the decision on residence. If a vessel is charted to a resident of country A, whether it is chartered with crew and equipment or without, it is operated from country A and for fishing vessels the catch is production of country A. If the operator of the vessel, even though personally resident elsewhere, is licensed and is recognised as such by the tax authorities of country A, the vessel is regarded as being operated by a resident and again the catch is production of country A. On the other hand if a fishing ship belonging to a resident of country A is chartered to a resident of country B, the catch is part of the production of country B and not of country A. The rental payment to the owner of the ship will be part of the service income of country A but not part of the fishing account.

8.263. Note that the determination of the residence of the operator of the fishing vessel has no reference to where the fish is caught or landed. This introduces an important difference in coverage between economic production and the physical removal of fish from national waters. In fact it is necessary to consider a two-way classification as in Table 8.25. Total economic production is the sum of the two entries marked X and Y. Total extraction from national waters is the sum of X and Z. The fourth entry, covering fish caught by non-residents outside national waters is not relevant to the accounts for country A.

Table 8.25 Fish catch by residence of operator and location caught

	Fish in national waters	Fish outside national waters	Total
Vessels operated by residents	X	Y	Total economic production
Vessels operated by non-residents	Z		
Total	Total extraction from national waters		

Illegal fishing

8.264. If a resident fishes beyond the scope of his license, he is fishing illegally. Nonetheless, the SNA requires that this harvest still be recorded as production with an income accruing to the fisherman, even though he is acting illegally. The application of the rules to non-resident vessels described above, though, implies that there will be no production recorded by fishing by non-residents above the level authorised by licence. Nevertheless, there are still physical removals of fish and these should, in principle, be taken into account in the physical accounts.

Products and natural resources

8.265. In Chapter 3 it was stated that exports of natural resources should always be recorded as routed *via* the economy. The extraction of iron ore, say, converts iron ore in the ground (a natural resource) into iron ore ready for transport (a product) and it is the product not the natural resource which may then be exported to another country. Fish is the exception to this general rule in consequence of the convention on the activity of non-resident fishing vessels. It is the only form of extraction of natural resources which can be envisaged as taking place by a non-resident unit. For all other extraction activities, a unit must be registered in the country where the natural resource is located.

3 Classification

8.266. Aquatic resources cover fish, shellfish and other aquatic resources such as sponges and seaweeds as well as aquatic mammals such as whales. Where no ambiguity can result, the word fish is often used as a loose synonym for all aquatic resources. The classification of aquatic resources in the SEEA asset classification is as follows:

EA. 143 Aquatic resources
EA. 1431 Cultivated
EA. 14311 For harvest
EA. 14312 For breeding
EA. 1432 Non-cultivated

8.267. A distinction between biological assets used for breeding and those for harvest is made generally in both the SNA and the SEEA. It is included in the case of fish although fish kept for breeding purposes are uncommon.

8.268. The types of aquatic resources which are never drawn into the economic sphere are regarded as being covered within the category of aquatic ecosystems (EA.32 Aquatic ecosystems). They are assets in the SEEA but not the SNA.

8.269. A pragmatic approach for the determination of the boundary between cultivated and non-cultivated assets is to follow the FAO definition of aquaculture and consider all farmed aquatic organisms as cultivated assets and all types of wild, enhanced and ranched fish stocks as non-cultivated assets. Capture fishing and aquaculture both take place in marine waters and freshwater. Capture production is much greater than the production of aquaculture both globally and in marine waters but not in inland waters.

Aquaculture

8.270. Aquaculture is described by the FAO as follows:

> Aquaculture is the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants. Farming implies some form of intervention in the rearing process to enhance production, such as regular stocking, feeding, protection from predators, etc. Farming also implies individual or corporate ownership of the stock being cultivated. For statistical purposes, aquatic organisms which are harvested by an individual or corporate body which has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms which are exploitable by the public as a common property resource, with or without appropriate licences, are the harvest of fisheries.

8.271. From this definition, it is clear that aquaculture stocks correspond to cultivated resources. Globally, about 60 per cent of aquaculture is in inland waters and 40 per cent in marine waters.

8.272. Not all countries are heavily involved in aquaculture and for many it may be negligible. FAO publishes data for many countries showing a breakdown first between fish and shellfish and then other aquatic organisms and finally by individual species at a very detailed level. About 90 per cent of the global total for fish and shellfish shown by FAO comes from Asia (mainly from China) as do virtually all of the other aquatic organisms.

Capture fisheries

8.273. Capture production of fish, as itemised by FAO, covers nominal catches of freshwater, brackish-water and marine species of fish, crustaceans, molluscs and other aquatic animals and plants, killed, caught, trapped or collected for all commercial, industrial, recreational and subsistence purposes. This definition can be taken over to define stocks of fish also. The nine divisions FAO uses are:

1. freshwater fishes;

2. diadromous fishes;
3. marine fishes;
4. crustaceans;
5. molluscs;
6. whales, seals and other aquatic mammals;
7. miscellaneous aquatic animals;
8. miscellaneous aquatic animal products; and
9. aquatic plants.

8.274. Diadromous fish are those which either normally live in salt water and spawn in fresh (for example, salmon) or those which normally live in fresh water and spawn in the sea (for example, eels). Miscellaneous aquatic animal products covers pearls, mother-of-pearl, shells, corals and sponges. Below these nine divisions there are 50 groups covering 1073 species.

4 Measuring the physical levels of stocks

The stock level

8.275. The SEEA and the SEEAF adopt a pragmatic approach whereby all fish stocks within the EEZ of a country are considered assets and therefore included in the asset boundary.

8.276. In addition to the fish stocks within the EEZ, the asset boundary may be expanded to include also those stocks over which control over the exploitation has been established and the access rights have been shared among countries (migrating and straddling stocks and stocks that complete their life-cycle in international waters). In some cases these international agreements state explicitly the share of total catches that should be allocated to each country. When this is so, each country's share of the stock of the common resource can be determined on the same basis.

8.277. In some cases the fishing vessels of the countries concerned are not able to catch the full share that has been allocated to them, making it necessary to estimate the effective share in the resource from the actual share of the total catch rather than the allowable share.

8.278. The share of catches allocated by international agreements to the countries sharing the resources are frequently amended so values of the additional stock to be added to the national wealth must be updated to reflect these changes.

Measuring stocks of wild fish

8.279. While the capture fishery clearly corresponds to a flow of non-cultivated aquatic resources, measuring stock levels and determining what should be included in a nation's balance sheet remains subject to particular measurement issues.

8.280. Biologists define a stock of animals as a group of individuals from the same species which live in the same area and co-operate in breeding new offspring. In some cases mating between members of different groups may be so infrequent that the overall dynamics of the groups is not influenced by their proximity. It may, therefore, be impractical from both a biological and a management point of view to regard them as belonging to the same stock. In other cases, different stocks of the same species spawning in separate grounds may mate in common feeding grounds. For management purposes, the stocks could be considered as one stock.

8.281. Definitions of stocks for use in measuring stock sizes have to be adapted to the availability of data. For many species, biologists estimate the size of the stock in terms of the weight of those cohorts which appear in catches. This means that the total stock may be defined as the weight of all cohorts aged *y* years or older, where *y* is the age of the youngest fish in the catch. Too little is known about the cohorts which are younger than *y* to include them in statistics which are to be used for management purposes. The sexually mature part of the stock (the spawning stock) is frequently estimated, as it is believed that these estimates give indication of the growth potential of the stock and the probability of a collapse.

8.282. Like all living creatures, wild fish form a part of a complicated ecological system where some fish are predators and others are prey. To be able to understand the dynamics of the biological system, estimate its productive potential and avoid serious over-fishing, it is important to gather information on stocks and catches of all species.

Virtual population analysis

8.283. Physical data on stocks are usually compiled by biologists who use different methods to estimate the size of the stocks. Virtual population analysis (VPA) is usually the most reliable method. It employs data on catches from different cohorts of the same stock, together with data on catch per unit effort. This method can only be used to estimate the size of the stock of those species that are relatively long-lived and where data on the proportions of the different cohorts in the catches are available. When this information is not available, the biologists rely on other models which relate the size of the stock to the availability of fish, estimated by catch per unit effort. These methods are often very imprecise, partly because it is very difficult to estimate the volume of effort in homogenous units. A special case is when fish gather into schools making it possible to use observations from echo integrators (instruments that use sound-waves to observe the fish in the water) to estimate the size of the total stock. Stocks of bigger aquatic animals like seals and whales can be estimated by direct enumeration of the number of animals in randomly sampled areas.

8.284. In most cases, biologists' estimates of the fish stocks are very imprecise. The variability in the recruitment to the stock (births), the effects of environmental factors affecting the growth of the individual fish and the rate of natural death from accidents, sickness, old age and predators make it very difficult to estimate the productive potential of the fish stock. When the stock of fish declines, it may be difficult to identify whether this decline was caused by over-fishing or by adverse environmental conditions.

8.285. On the basis of the data obtained with the VPA method, it is possible to get consistent estimates of the size of the stock at the beginning and at the end of the accounting period. The technique also permits estimates of all flows to be made; that is, catches, recruitment, increases in weight and losses because of sickness, accidents and predators. As more information becomes available about individual cohorts, it may be possible to improve estimates of stock levels made for earlier points in time.

8.286. When using the VPA method for estimating the size of fish stocks, biologists must make assumptions about natural mortality of the stock. These assumptions may involve the size of some predator stock. Even so, biologists have rarely found it useful to present this physical information in an accounting format, because of doubts about the reliability of data, in particular the natural mortality rates.

5 An asset account for aquatic resources in physical terms

8.287. Ideally, an asset account in physical terms shows a time series of the stocks of all commercially important species (the species currently harvested), detailed by geographical area or by local fishery if this is applicable. Additional information on related species (the prey of commercial species) could also be included, as could other relevant information on spawning habitat or environmental quality. All of these data are useful in assessing the viability of the economic activity. Geographic detail may be important when local or regional economies are dependant on the fisheries or if the fisheries shift activity to different areas when new stocks are discovered or stocks in some areas are depleted.

8.288. In addition to stock levels, a physical account should show changes due to harvest, natural loss, growth (in volume) and recruitment (growth in numbers). Catch data are published by the FAO, and by the agencies which manage the fisheries in a number of countries. Data on stocks and changes are estimated by many fisheries agencies, but may not be published.

Aquaculture stocks

8.289. Increases come from cultivated recruitment and growth; planned decreases from harvesting. In addition, disease or a natural catastrophe may lead to unplanned decreases.

Freshwater aquatic resources

8.290. Increases come from natural recruitment and growth, regular decreases from harvesting and natural death. Irregular decreases may be the result of water pollution, abnormal climatic conditions or natural disaster.

8.291. Harvesting of freshwater fish may be subject to controls but usually by general limitations on when and how harvesting may occur, or the issuing of licenses for recreational fishing rather than *via* the sort of quotas which apply to marine fish.

Marine aquatic resources within a country's EEZ

8.292. The causes of increases and decreases are the same for marine fish as for freshwater fish but it is necessary to distinguish several classes of harvesting to take account of the considerations described under Section 2 above on the harvesting of fish and the production boundary:

- (i) fish may be caught without limit by nationals of the country;
- (ii) fish may be caught by nationals of the country of ownership under a general quota system;
- (iii) fish may be caught by nationals of the country of ownership under an individual quota system;
- (iv) fish may be caught by nationals of another country under an individual quota system;
- (v) fish may be caught by nationals of the country beyond a quota allocation;
- (vi) fish may be caught illegally by nationals of another country.

8.293. For different species different classes of harvesting will apply. When preparing physical accounts, it is useful to record the amount of harvest for key species under whichever of these headings apply.

8.294. Obviously, the quantity of fish harvested either by nationals or non-nationals beyond a quota cannot be known exactly and even if a total of illegal fish taken can estimated, judgement may have to be used to determine how much, if any, is attributable to nationals and non-nationals respectively. Nevertheless, if management of natural fish resources is seriously threatened by illegal fishing, it is important that estimates of this harvest be made even if they are only approximate.

Measuring the harvest of fish

8.295. In physical terms, all fish harvested, whether by residents or non-residents and whether legal or illegal, should be recorded. In practice, little firm evidence may be available on the harvest by non-residents, but increasingly quotas apply and it is possible to use these as approximations of the actual harvest.

8.296. It is important that all catches be duly recorded for estimations of the stock sizes and their productive potential. This means that not only should all landings, legal and illegal, by commercial and recreational fishermen be recorded, but also all fish that are discarded at sea. The discarded fish should not be counted as part of production, but be recorded as an other change in volume.

8.297. One other difficulty that may be encountered when compiling production accounts for fisheries is the separation of the harvesting from the processing activities, both in the case of factory vessels and where companies whose primary activity is land-based fish processing (that is, manufacturing) also operate some fishing vessels. Although it is desirable to allocate the production to the relevant activity, this may be difficult in practice. If data are not available, it may occur that some on-board fish processing will have to be included in fishing and some fishing activities may have to be recorded under fish processing (United Nations and Food and Agriculture Organisation of the United Nations, 1999).

8.298. There may be differences between volumes of catches and landings, and conversion is necessary to reconcile catches on a live-weight basis to landings on a landed-weight basis. Some countries may also refer to nominal catches on either a round, fresh basis; a round, whole basis; or an ex-water weight basis. Figure 8.4 shows schematically the relationships between these alternative concepts. For whales, seals and other aquatic mammals (FAO division 6), the term catch is preferred to nominal catch and it is usually measured by number rather than by weight. For miscellaneous aquatic animal products (division 8) it is more usual to speak of production than nominal catch.

8.299. An example of part of a physical account developed for Norway is shown in Table 8.26.

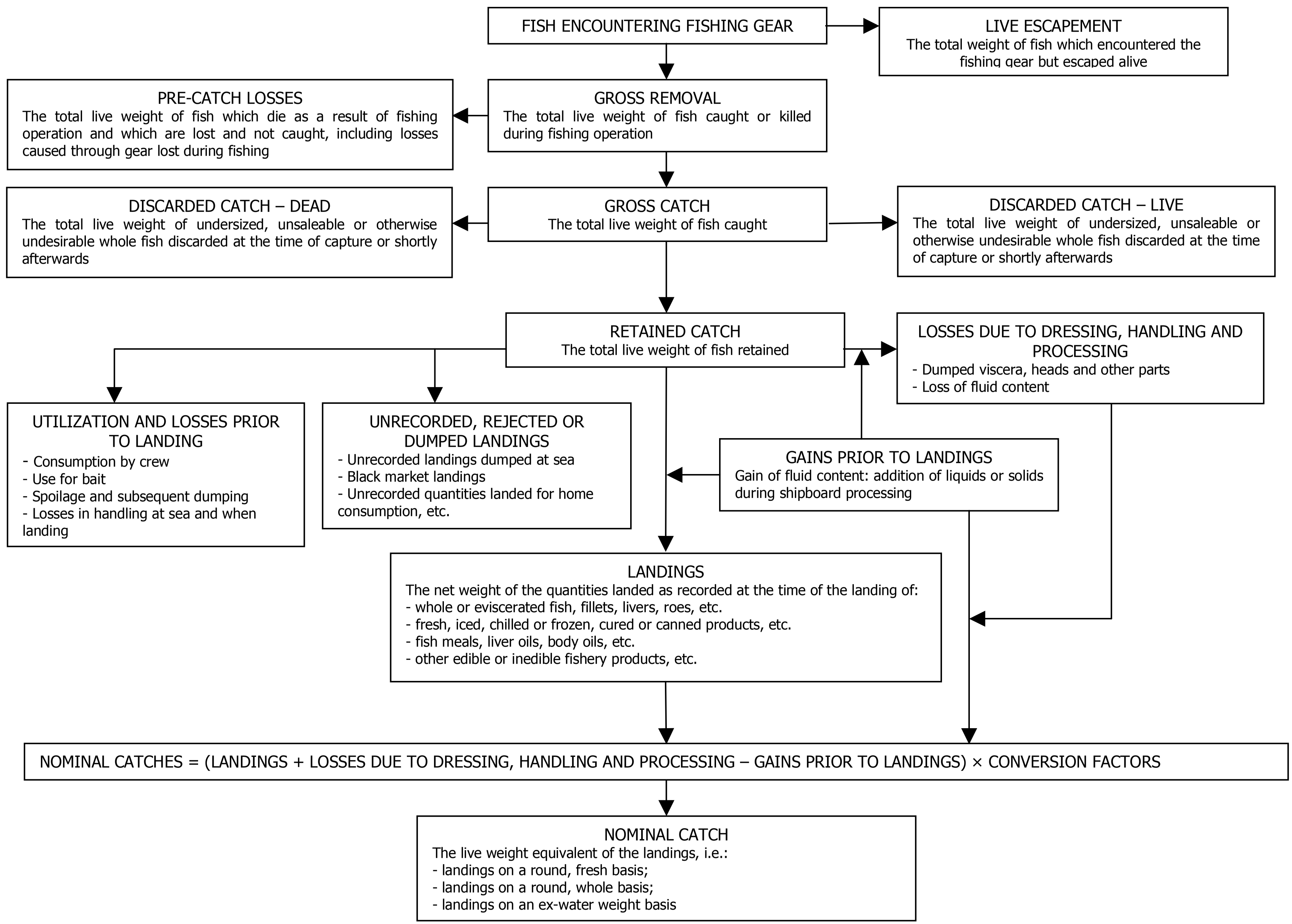
Table 8.26 Physical account for north-arctic cod (Norway)

Thousand tonnes

Year	1993	1994	1995	1996
Opening stock	2510	2340	2100	2040
Catch (landings)	(532)	(746)	(740)	(722)
Other changes in volume (recruitment and natural mortality)	362	506	680	622
Closing stock	2340	2100	2040	1940

Source: International Council for the Exploration of the Sea (www.ices.dk).

Figure 8.4 Alternative catch concepts



6 Monetary asset accounts

8.300. The basis of calculating the value of the stock of fish and of the harvest based on either an appropriation method linked to the value of fishing quota or on the value of the resource rent of the harvest is discussed in detail in Section E of Chapter 7.

8.301. A change in the value of an aquatic stock may be brought about by:

(1) changes in physical size of the stock;

(2) changes in technology which allow increases in the catch of fish for the same cost, thus increasing the resource rent;

(3) the effect of catastrophic losses; and

(4) changes in prices of the products (landings).

8.302. When it is not possible to identify reasons for changes in the size or value of stocks and attribute the changes to natural causes or fishing activity, it will only be possible to prepare a minimal asset account. The physical accounts may consist of catch data for a number of species but without corresponding stock estimates for all of the species. It may not be possible to value the stocks of individual species, so that only a regional or national aggregate stock value can be produced.

8.303. Increasingly, though, estimates are available of stock levels for individual species since this is the basis on which quotas are determined. Even when stock levels are not available, it is necessary to consider the causes of increases and decreases in the (unknown) levels in order to determine how to record these in monetary accounts. Ideally, recruitment ("births"), growth, and natural loss could all be estimated and recorded separately. Due to data limitations, this category is often only available as a composite "other changes" measured as the residual difference between the amount harvested and the change between opening closing stock levels.

8.304. The interactions between different stocks add to the complications of estimating the value of the fish stocks. For example, the size of the catch, and therefore the value, of some prey stocks depends on the size of some predator stock. If the predator species has little commercial value it can pay to catch it to increase the stock and thus eventually the catch of the valuable prey species. In this case the value of the predator stock can become negative when the stock is big as it then does more economic harm than good. Though important, the interactions between the different species are usually poorly understood and difficult to quantify.

8.305. Catastrophes are often taken to be synonymous with natural disasters such as floods, hurricanes, and earthquakes. Biological resources, whether cultivated or not, are particularly vulnerable to disasters which can be traced back to human intervention; such as, loss of spawning habitat due to the damming or diversion of rivers or toxic spills into rivers or the sea. The impact of such man-made disasters should also be recorded in the accounts. The SNA records these in the other changes in assets account but it could be argued that in the SEEA such decreases in the stock of biological resources should be recorded in the same way as harvesting; that is, as changes due to economic activities. Indeed, in some instances it may not be possible to know how much of a decrease in stocks is due to over-fishing and how much to detrimental environmental impacts caused by production processes. It is therefore suggested that in an account for aquatic resources, separate estimates for such impacts should be made if at all possible.

7 Ancillary fishing industry information

8.306. If the fishing industry is of particular importance to an economy, in addition to drawing up accounts showing the physical and monetary characteristics of the fish stock, there are other variables it would be helpful to document and present at the same time. These include information about the nature of the industry showing whether it is all organised formally or whether and to what extent artisanal fishing is important. When artisanal fishing is significant, it is useful to know how much of it is undertaken for own consumption as a form of subsistence activity and how much is undertaken for purposes of selling the catch and thus represents market activity, even if of an informal nature.

8.307. It may also be useful to document the extent of employment in the fishing industry and the number and type of fishing boats in use. Further it is interesting to know whether a country is self-sufficient in fish, or even a net exporter of fish, by comparing production with consumption, imports and exports.

8.308. It may also be desirable to identify expenditures for the management of fish stocks or for the protection of the aquatic ecosystems. The first would comprise expenditures for research for fisheries management purpose, monitoring, control and surveillance, data collection and statistics, costs of the fisheries management authority (local, national and regional) as well as temporary costs for facilitating structural adjustments of the fishery related industries (e.g., vessel buy-back programmes, re-training, etc.). Environmental protection expenditures would include expenditures geared towards the protection of the habitat and water quality of the aquatic ecosystem. Examples of categories in CEPA which may refer to the fisheries are "Protection of ambient water" and Protection of nature and landscape" (United Nations and Food and Agriculture Organisation of the United Nations, 1999).

F Land and Ecosystem Accounts

1 Role of land and ecosystem accounting

8.309. In the SNA, land is treated as a non-produced asset which provides economic benefits to its owner. It has a significant part in the total wealth of the nation. There is discussion of the problems of valuing land in Section E of Chapter 7; this discussion is not pursued further here.

8.310. In environmental accounting the view of land as providing economic benefits is only part of the picture. The economic use of land is often connected with short- or long-term processes of deterioration (or improvement); for example, the opening of uncultivated land (such as virgin forests or wetlands) for recreational or agricultural purposes may upset ecological balances, the use of land for transportation or human settlement may radically change its characteristics and agricultural use may cause soil erosion. On the other hand, the introduction of less intensive management practices (for example organic farming) or restoration activities may lead to improvements. The objective of a better understanding of the relationship between economic activities and the environment requires that both the use of land by different economic activities and the potentials of land from an ecological view to be taken into account. The latter relates, for example, to the extent and quality of habitats and ecosystems or the characteristics of the soil.

8.311. Land and ecosystems are closely related environmental assets. From an economic and ecological point of view, the value of assets that deliver services to human systems (indirect use benefits) in the long term depends heavily on complete ecosystems and not on individual species or elements. However, it is often difficult to find suitable indicators even in physical terms to describe some of these aspects. It is relatively easy to record the quantities of residuals that are emitted into the natural environment; it is much more difficult to describe the effects of ambient concentrations that result in a contamination of biota and soil and the final effect on health of biota, ecosystems and human beings.

8.312. A comprehensive set of land and ecosystem accounts links the economic and the environmental dimensions and permits aggregated indicators to be derived. These indicators can provide the background for land-related policies such as nature protection, agricultural and transport policy.

8.313. In general, the integration of a comprehensive land and ecosystems accounting module in the SEEA is useful for several reasons:

- it provides a complete picture of land cover and land use for a nation and allows the derivation of trends and indicators of change;
- it aids the integration of diverse data sources on land cover and land use as well as with other data (for example, on population, economic activity, water balances, species or fertiliser use);
- it promotes standardisation and classifications of land cover, land use and causes of changes in land cover and land use;
- it allows changes in land use, land cover, habitats and biodiversity to be linked as far as possible to driving forces;
- it can be applied at national, regional, watershed or landscape type level.

8.314. In the following section general features of accounting for all land and ecosystem categories are described. More details on integrated descriptions of selected land and ecosystem types can be found in the earlier sections on forest, fishery and water accounts.

2 *State of development of land and ecosystem accounting*

8.315. The concepts for the description of land as an economic asset are well developed in the SNA and practical experience exists on implementing these concepts. Land statistics in general have a long tradition. They are compiled to satisfy the needs of many diverse users and, as a result, different definitions, classifications and methods are used in different countries.

8.316. The economic treatment of land in the SNA is straightforward from a conceptual point of view; land as a non-produced asset is defined as the ground itself, including the soil covering and the associated surface water. A high-level classification with four types of land is included in the SNA asset classification: land underlying buildings and structures; land under cultivation; recreational land and associated surface water; other land and associated surface water.

8.317. The development of land and ecosystem accounts that adequately deal with the complexity of land and ecosystems as environmental assets is new and closely linked to the appearance of georeferenced land-use or land-cover data.[3] A general consensus on the need and the basic structure of a comprehensive approach to land and ecosystem accounting is emerging within and between many countries. On the other hand, conflicts concerning the use of land and ecosystems are often characterised by specific regional or national interests or

[3] A major input has been the work done by the Conference of European Statisticians of the United Nations from 1992 to 1994 and the subsequent discussions in meetings of the International Association in Income and Wealth and of the London Group on Environmental Accounting.

circumstances. This results in a high heterogeneity of observation methods, reporting formats and data available at these different levels.

8.318. Environmental impacts resulting from the deposition or emission of harmful substances (such as nutrients, toxics and other pollutants) may be different according to local environmental conditions. This is also true for other pressures resulting from natural resource use, either through withdrawal and operation or *in situ* use, including land use (Parker *et al.,* 1996). Policy interest in land and ecosystems accounting is therefore not restricted to general tables with a high level of aggregation, but often focuses on issue-oriented accounts (for example biodiversity, quality of land and habitats) or accounts by region (for example catchment areas, coastal zones), which require more detail.

8.319. Land and ecosystem accounts will be characterised by a compromise between standardisation and flexibility. It is extremely difficult to develop a single standard land classification that serves all the different purposes in a meaningful way. Co-operation between statisticians, economists, geographers and biologists as well as flexibility in adjusting the accounts to the available data sources and the classifications they use is therefore essential in the implementation of land and ecosystem accounts. Data sources available may include information based on satellite images, aerial photographs, maps and data sets based on field surveys or cadastral administrative databases.

3 Observation units and classifications

8.320. A special feature of land and ecosystem accounting is the extremely close link between the objectives of the studies and the determination of the observation or accounting units and classifications used, the latter being determined in light of the specific objective.

Land cover and land use

8.321. A basic distinction in land and ecosystem accounting is that between land cover and land use. Land cover reflects the (bio)physical dimension of the earth's surface and corresponds in some regard to the notion of ecosystems. Typical examples for land cover categories are built-up areas, grassland, forests or rivers and lakes. Land use, on the other hand, is based on the functional dimension of land for different human purposes or economic activities. Typical categories for land use are dwellings, industrial use, transport, recreational use or nature protection areas.

8.322. Land use is a more complex issue than land cover because of the different functions a single land cover unit can fulfil. Often there are parallel or multiple land uses, in particular with regard to recreation /tourism and to use restrictions due to the protection status of land. A forest, for example, serves to provide timber, regulate climate and water regimes, sequester carbon dioxide, retain soil, provide habitat for wildlife and provide recreational functions. Land use in terms of human activities may result in changes in biophysical land cover (for example deforestation, transportation corridors, urbanisation) or in changes to the conditions of the natural or modified biotopes (due, for example, to use of fertilisers or pesticides or to leaving land fallow, to intensity of traffic on a road or to the density of population in a town). These trade-offs among functions of natural assets are one of the focuses of the ecological-economic interrelationships that are studied in environmental accounting.

8.323. Land cover results from both the use of land by activities and natural processes, whether modified by human activities or not (Conference of European Statisticians, 1995). Land cover is normally observed by satellite observation, aerial photographs and ground surveys. Information on land use is gathered by cadastral surveys, surveys of economic units, aerial photography or ground surveys.

8.324. The distinction between land use and land cover is basic from an analytical point of view. Statistical work is, however, often characterised by more or less mixed classifications of land use and land cover. In principle land use can be better linked to economic activities. Sometimes land cover at a large scale is considered as a proxy for the use. Often built-up areas are more land-use oriented parts of the classification whereas the disaggregation of more natural categories (such as forest and woodland, wetland or semi-arid and arid land) reflects more land cover aspects. Sometimes the whole mixed classification is more use- or more cover-oriented. When a primary or dominant use is hard to determine, multiple allocation or a separate recording of multi use can be considered.

Observation units

8.325. Land-use and land-cover data are produced for different observation units. In the SNA, the basic units for land are not explicitly discussed. The type of land use and ownership are usually documented in land registers based on legal units or can be surveyed by questionnaires to economic units.

8.326. In environmental accounting, additional types of land units are used. Land-cover or ecosystem-oriented presentations use land registers, aerial photographs and field surveys as well as georeferenced satellite data. In all information systems, the scale of the study determines the delimitation and the homogeneity of the basic land units. Land units are defined as surface areas with certain cover characteristics. At a small or medium scale, the land cover units are largely composite and must be classified according to their main characteristics (including, possibly, mixed classes). They could be regarded as ecosystems on a higher hierarchical level. In studies at large geographical scales including fieldwork, rather homogenous land units such as biotopes are common. In the economic sphere, the same type of unit can apply to a multinational firm as to a small family enterprise. In land accounting, however, no consensus is available on the “ideal” type of unit and the fact that different objectives of analysis require different basic units is widely recognised. A consensus on the choice of biotopes, ecosystems and more heterogeneous land cover units as basic units for land cover seems to be emerging. In some cases land-cover or land-use aspects are combined with geometrical units (for example grids of 1 km) which are described by the dominant type of land use or cover.

Ecosystems

8.327. Ecosystems are inhabited spaces and cover both the abiotic biotopes and the biocoenosis for communities – in other words its organisms. Ecosystems are best seen as the systems of interactions between the abiotic habitat and the organisms (flora and fauna) in a spatial unit. The holistic system does not react in the same way as its individual components would. Ecosystems can be defined for different hierarchical levels. Examples of higher-ranking ecosystems are the sea, the forest, the meadow, etc., with all the organisms which live there and their interactions. Such systems consist of subsystems (for example pond, river, marshland, etc.). The notion of an ecosystem is, however, not restricted to more natural parts of the land. In principle it covers all types of land including urban ecosystems. There is no classification that allows for the clear-cut geographical separation of the theoretical notion of “ecosystems” in the landscape. Depending on the relief, the species of fauna, etc., different geographical demarcations will be applied. Biotopes in the strict sense of the word are abiotic areas that can be clearly defined geographically and that feature a combination of specific abiotic, non-living factors (regarding climate, soil, light, temperature, water, nutrients, etc.). They therefore offer specific habitat conditions for organisms. Biotopes in the pragmatic sense in vegetation science incorporate both the spatial components and the vegetation within an area, i.e. parts of the biocoenosis. They are typically land-cover units. Where there are no plants, the existing abiotic land cover (for example buildings, roads, landfills or glaciers) is used for descriptive purposes. The notion of biotope is not restricted to protected areas or areas of particularly high ecological value. It covers the total land of a country.

8.328. For a pragmatic differentiation of units of ecosystems at a low hierarchical level the biotopes in the sense of vegetation units are often used. At a higher hierarchical level the more heterogeneous land cover units or ecozones (or even the biographic regions in the world) can be interpreted as ecosystems (Hoffmann-Kroll *et al.,* 1999). In land accounting, more heterogeneous land cover units are often used. They can be understood as aggregates of connected biotopes, where the dominant type of biotope determines the land-cover class. In Europe, for example, the project CORINE Land Cover is based on satellite data and on basic units with a minimum size of 25 ha and a classification of 44 different land-cover categories. In this context large areas with the same land-cover class are often described as ecozones or landscapes (for example agricultural ecozones or landscapes). As species are part of the ecosystems, they are included twice in the asset classification of the SEEA, once as individual plants or animals in the biotic natural resources and again as parts of ecosystems.

Classifications

8.329. In the SEEA classification of assets, land and ecosystems are included twice: once as land and surface water (area) and again as ecosystems. Soil is also included separately as a natural resource.

8.330. Land characterises the space used in human activities. The SNA includes only land which provides a direct input into human activities. In the SEEA, five major types of land resources are distinguished:

land underlying buildings and structures (EA.21);
agricultural land and associated surface water (EA.22);
wooded land and associated surface water (EA.23);
major water bodies (EA.24); and
other land (EA.25).

8.331. The asset classification in Annex 1 provides a further disaggregation of the above categories. The total area of a country is shown as naturally divided between the five categories listed above.

8.332. In the asset classification of the SEEA, ecological aspects of land, the aspect of land cover and the provision of services to humans, are taken into consideration by the inclusion of terrestrial and aquatic ecosystems. They are identified separately and are further subdivided into five major types of biographic regions to be found on the planet. More detailed classifications which could be used in environmental accounting on a national or a regional level have to be based on the definition of the corresponding observation units and the scale of observation. At the moment, internationally agreed land-cover classifications are available from FAO and for selected regions; for example, the CORINE land cover classification for Europe. A complete and internationally agreed biotope or ecosystem classification is not yet available; nor are the different regional land-use/land-cover classifications standardised.

8.333. For land use in general the more detailed ECE land use classification should be used. This classification is better suited to the analysis of types of land use with different environmental impacts rather than for the land classification in the SNA. The ECE classification is not entirely satisfactory and several international agencies (such as the FAO and Eurostat) were at work towards an improved land use classification at the time of writing of this handbook.

8.334. Countries will differ considerably in terms of both the main and the detailed classifications for land use, land cover and landscape types. For example, forests may be of major or of very minor importance for a country. National data sources available for land accounts will use classifications which are already adapted to the characteristics of that country.

4 Structure of the land and ecosystem accounts

Overview and basic accounts

Overview

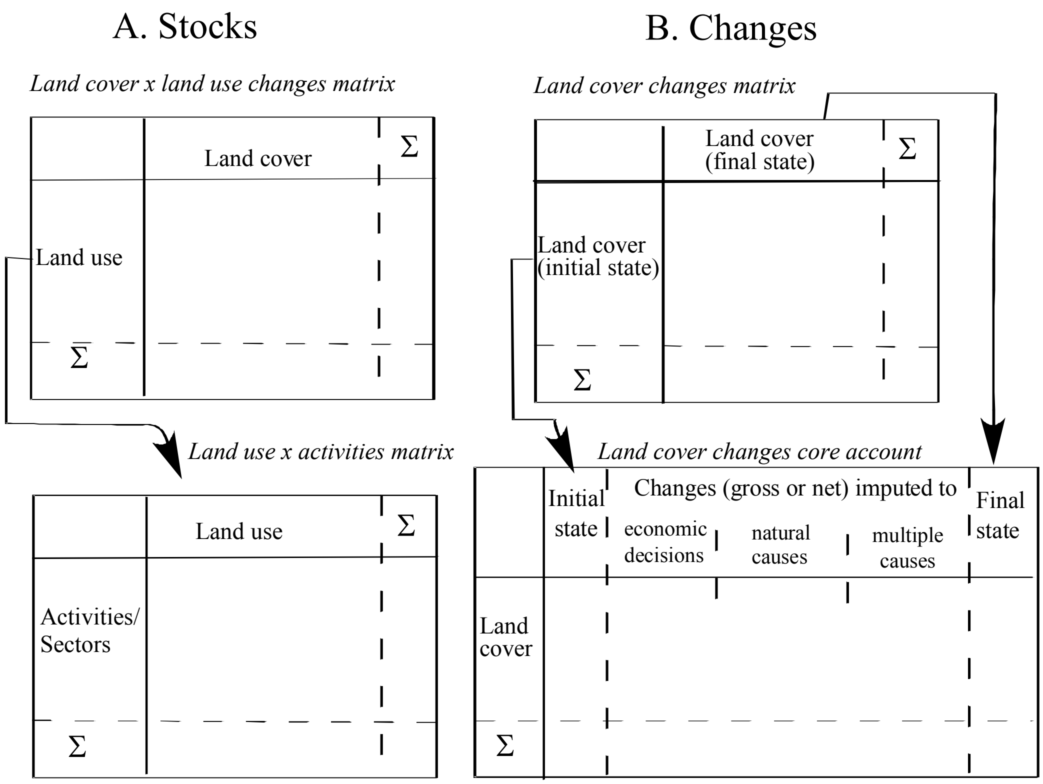
8.335. Although market price valuations are relevant when assessing the economic aspects of nature as a fixed asset, they are not suitable for representing ecological aspects. Market prices are based on human use and exploitation potential and do not reflect the ecological significance of an area. Areas of high ecological value that are protected or use-restricted have considerably lower market prices than unprotected agricultural land or city centres heavily used for economic purposes. For purely environmental accounting, priority is often given to physical accounts that measure land in units of surface area (hectares or square kilometres) or in some cases in length or number of units (zones, biotopes, etc).

8.336. The next section presents basic accounts of land use and ecosystems which would be desirable to standardise in layout across countries. From an environmental point of view, information obtained from basic accounts is necessary but often not sufficient in formulating and monitoring policy. For this reason, supplementary accounts that are issue-oriented and take into account national and regional situations as well as the data availability are introduced into the classification used. Supplementary accounts cannot be standardised to the same extent as the basic accounts due to their nature, but are made consistent with them. In the case of ecosystems accounting, for example, the land-cover aspect is included in the basic accounts and biotope accounting in the supplementary accounts. Since supplementary accounts are often indispensable for users, they form an important part of land and ecosystem accounting. The distinction between basic and supplementary accounts characterises a compromise of standardisation and flexibility. As experience develops, proposals for standardisation may be made in the future.

Basic accounts

8.337. For land and ecosystem accounting, basic accounts establish the interface between the use of land and land cover from an environmental perspective. The different aspects treated in this context are shown by Figure 8.5. In terms of stock levels, the relation between land use and land cover and between land use and economic activities is shown. In terms of changes in stocks, there are tables showing the change in land classified to each type of land cover over a period and an identification as to whether this is due to human or natural processes.

Figure 8.5 Structure of the basic set of land cover/land use accounts



Source: Conference of European Statisticians, 1995; p.6.

8.338. Detection and indication of changes in land use and land cover are key aspects of land accounting. Often significant changes in land cover and land use are observable only over a longer time scale. Therefore the land and ecosystem accounts are often only compiled every four or more years whereas data on an economic asset based on land use may be available and analysed on a yearly basis. In land accounting the notions of initial and final year are sometimes more appropriate than opening and closing stocks. The land accounts in physical terms allow a much better understanding of the environmental developments over time than accounts in monetary terms.

Land use/land cover

8.339. The presentation of a land-use/land-cover matrix relates to a single point in time. Table 8.27 shows the land-use/land-cover matrix on the basis of the classifications of land and of ecosystems in the SEEA asset classification. For some categories of land cover, for example arable land and permanent crops, the link of the cover to one use category (primary production) is quite evident. For others, for example slightly artificialised areas, the table indicates the importance of different types of use or the part of the area that is not used at all. The compilation of this table assumes georeferenced basic data for land use and land cover either on the total area of a country or for a given area.

Table 8.27 Land use/land cover

EA.3 Land cover (Ecosystems)		EA.2 Land use: EA.21 Land underlying building and structures	EA.22 Agricultural land	EA.23 Forest land	EA.24 Major water-bodies	EA.25 Other land	**Total**
EA.31 Terrestrial ecosystems	EA.311 Urban	108	2	1			**111**
	EA.312 Agricultural		326				**326**
	EA.313 Forest	6	25	278			**309**
	EA.314 Prairies and grassland	15	133				**148**
	EA.315 Tundra						
	EA.316 Dryland	1				9	**10**
	EA.317 Other					75	**75**
EA.32 Aquatic ecosystems	EA.321 Marine						
	EA.322 Coastal						
	EA.323 Riverine	1	3	1	9	1	**15**
	EA.324 Lacustrine		1		3		**4**
	EA.325 Other				2		**2**
Total		**131**	**490**	**280**	**14**	**85**	**1 000**

Source: Constructed land example.

8.340. Most countries will only be able to fill in the column and the row totals, sometimes supplemented by limited information inside the matrix. The compilation of the table is in fact very data demanding. If data are available only for a single classification which mixes land use and land cover, Table 8.27 will be in practice a diagonal matrix. If more detailed classifications and different data sources for land use and land cover exist, their combination will provide extra insights.

Land use by industries and households

8.341. The second basic table on stock levels (Table 8.28) links land use to economic activities. In this context land is regarded as a production factor rather than as part of a balance sheet. As a consequence the presentation is normally based on the actual use of land (not on ownership) in the production and consumption processes. It is however restricted to physical data (surface area).

Table 8.28 Land use by industries and households

Industries (ISIC) and households	EA.21 Land underlying building and structures	EA.22 Agricultural land	EA.23 Forest land	EA.24 Major water-bodies	EA.25 Other land	**Total**
	Land use as in SEEA classification					
Agriculture, hunting, forestry, fishing (A+B)	21	470	160	2	2	**655**
Mining quarrying (C)	1				1	**2**
Manufacturing, electricity (D+E)	10					**10**
Construction (F)	4					**4**
Wholesale, retail trade, repair motor vehicles, hotels and restaurants (G+H)	6					**6**
Transport, storage, communication (I)	3			4		**7**
Financial intermediation, real estate, other business services (J+K)	3					**3**
Education, health, social, personal services (M+N+O+P)	4					**4**
Public administration, defence, social security, other public services (L)	1					**1**
Private households[1)]	74		40	2	1	**120**
Sub-total	**127**	**470**	**200**	**8**	**7**	**812**
No direct use	4	20	80	6	78	**188**
Total	**131**	**490**	**280**	**14**	**85**	**1 000**

Note: 1.User-oriented concept, including residential land and public area used by private households.

Source: Constructed land example.

8.342. In principle different options exist for the allocation of land to industries and households. One option is to closely follow national accounts classifications and categories (for example, based on ownership for transport infrastructures or recreational areas). Another option is to proceed in a more use-oriented way by allocating areas for selected public goods (for example, roads or parks) to the units that actually use these areas. Subsequently, indirect land use linked to land used by industries producing intermediate goods can be included in the analysis.

8.343. A land use by economic activities matrix can be estimated on the basis of non-georeferenced data as well. A precondition is that the use-oriented categories of the classification are highly disaggregated and that other basic data (for example, on land for housing, kitchen gardens, use of land by industries from housing and industry surveys) are available or can be estimated in a reliable way.

8.344. A table on land use by industries (or products) and households allows, for example, indicators for land productivity (value added per unit of land used) to be derived. However, the allocation rules of land to producers (industries) on the basis of actual use are sometimes difficult to determine and standards are not yet fully developed (see Krack-Roberg and Schäfer, 1998; Leurs and van Dalen, 1998). Often there are multiple uses, in particular with regard to recreation (for example agricultural land, forests or waters may be used for several purposes) or protected areas. It is sometimes hard to determine a "primary" or "dominant" use so that multiple allocation or a separate recording of multiple uses could be considered.

Land-cover change matrix

8.345. The land-cover change matrix, Table 8.29, cross-tabulates land cover at two different points in time. It shows how much of the opening stock of a land cover category is still the same in the closing stock and the gross flows between the different categories of land cover. The total increase, the total decrease, the total change (increase + decrease) and the net change (increase – decrease) can be calculated from this table. The same analysis can be done for land-use changes. The production of such a table has normally to be based on georeferenced data sources because single data for the same unit cover in the opening stock (initial year) and in the closing stock (final year) must be known and analysed. The analysis can in principle be done on the basis of the total area or of a sample. In the latter case the size of the sample determines to what extent the gross flows can be assessed reliably.

Changes in land cover by categories of changes

8.346. The land-cover change matrix forms the ideal starting point for developing an analysis of the causes of changes in land cover (or land use). Table 8.30 provides an illustration of possible changes (Eurostat, 1999). So far this is another area where standard classifications on the types of changes are not readily available at the international level; only selected national approaches exist. Table 8.31 presents a land-cover account for Great Britain as an example of a national application. The account is based on a random stratified sample of 502 areas of one square kilometre each surveyed in both 1990 and 1998 as part of the national *Countryside Survey* (Haines-Young *et al*., 2000). The account uses classifications specifically adapted to the types of land cover and land cover changes in that country.

8.347. From the stock accounts, net flows between the opening and closing stocks can be established. However it is important from an ecological point of view to show increases and decreases separately because the replacement of "old" nature (old growth forest for example) by "new" stocks (through reforestation for example) is normally linked to a considerable change in ecological quality.

8.348. In general two levels of changes between categories of land use or land cover can be distinguished. Changes in classification are referred to as external changes and changes within categories as internal changes. External changes are described in the basic accounts. They can be described to some extent by more detailed classifications of land use and cover. Internal changes will typically be described in supplementary accounts. To some extent the more detailed the classifications used, the larger the part of the total changes that can be covered by the external changes in the basic accounts (Eurostat, 1999).

Table 8.29 Land-cover change matrix

Land cover (initial year)	Land cover (final year)														Total (initial year)	Decrease
	EA.31 Terrestrial ecosystems	EA.311 Urban	EA.312 Agricultural	EA.313 Forest	EA.314 Prairies and grassland	EA.315 Tundra	EA.316 Dryland	EA.317 Other	**EA.32 Aquatic ecosystems**	EA.321 Marine	EA.322 Coastal	EA.323 Riverine	EA.324 Lacustrine	EA.325 Other aquatic ecosystems		
EA.31Terrestrial ecosystems																
EA.311 Urban		69	2	2	6			1							**80**	**11**
EA.312 Agricultural		20	307	15	25			8							**375**	**68**
EA.313 Forest		4	1	285	3			12					1		**306**	**21**
EA.314 Prairies and grassland		9	11	4	114			3							**141**	**27**
EA.315 Tundra																
EA.316 Dryland				2			10								**12**	**2**
EA.317 Other			8	2	3			51							**64**	**13**
EA.32 Aquatic ecosystems																
EA.321 Marine																
EA.322 Coastal																
EA.323 Riverine			1									15			**16**	**1**
EA.324 Lacustrine		1											3		**4**	**1**
EA.325 Other														2	**2**	**0**
Total (final year)		**111**	**326**	**309**	**148**		**10**	**75**				**15**	**4**	**2**	**1 000**	**144**
Increase		**42**	**19**	**24**	**34**		**0**	**24**				**0**	**1**	**0**	**144**	
Total changes (Increase + Decrease)		**53**	**87**	**45**	**61**		**2**	**37**				**1**	**2**	**0**	**288**	
Net changes (Increase – Decrease)		**31**	**-49**	**3**	**7**		**-2**	**11**				**-1**	**0**	**0**	**0**	

Source: Constructed land example.

8.349. The analysis of the causes of changes in Table 8.30 is restricted to external changes. The table can be compiled using georeferenced land data for all units of the total area or for a permanent sample of units and data on gross changes. This type of data is actually more often available for land cover than for land use. For every unit the cover category of the initial stock (opening stock) and the final stock (closing stock) is identified. If they are different, the change is allocated to a type of change according to fixed allocation rules.

8.350. To carry out this procedure, individual data on gross flows are required. In traditional, non-georeferenced land statistics only the net flows are available and in the physical accounts the types of changes cannot be derived.

Table 8.30 Changes in land cover by categories of changes

Land cover	Initial stock	Increase: **Changes due to economic decisions**	Artificialisation/ urbanisation	Changes in agricultural practices	Restoration and rehabilitation	**Changes due to other causes**	Multiple causes	Natural causes	Catastrophic causes	**Total**	Decrease: **Changes due to economic decisions**	Artificialisation/ urbanisation	Changes in agricultural practices	Restoration an rehabilitation	**Changes due to other causes**	Multiple causes	Natural causes	Catastrophic causes	**Total**	**Final stock**
EA.31Terrestrial ecosystems																				
EA.311 Urban	**80**	**42**	42			**0**				**42**	**9**	2	2	5	**2**		2		**11**	**111**
EA.312 Agricultural	**375**	**19**		19		**0**				**19**	**56**	24	22	10	**12**	3	9		**68**	**326**
EA.313 Forest	**306**	**18**			18	**6**	1	5		**24**	**20**	4	3	13	**1**			1	**21**	309
EA.314 Prairies and grassland	**141**	**30**	6	24		**4**	1	3		**34**	**27**	9	11	7	**0**				**27**	**148**
EA.315 Tundra																				
EA.316 Dryland	**12**	**0**				**0**				**0**	**2**		2		**0**				**2**	**10**
EA.317 Other	**64**	**19**			19	**5**	1	3	1	**24**	**13**	8	2	3	**0**				**13**	**75**
EA.32 Aquatic ecosystems																				
EA.321 Marine																				
EA.322 Coastal																				
EA.323 Riverine	**16**	**0**				**0**				**0**	**1**		1		**0**				**1**	**15**
EA.324 Lacustrine	**4**	**1**			1	**0**				**1**	**1**	1			**0**				**1**	**4**
EA.325 Other	**2**	**0**				**0**				**0**	**0**				**0**				**0**	**2**
Total	**1 000**	**129**	**48**	**43**	**38**	**15**	**3**	**11**	**1**	**144**	**129**	**48**	**43**	**38**	**15**	**3**	**11**	**1**	**144**	**1 000**

Source: Constructed land example.

Table 8.31 Land cover account for Great Britain, 1990-1998

	1990 Stock	Types of change in stock										1998 Stock	Change account			
		Woodland creation	Woodland rotation	Agricultural intensification	Agricultural rotation	Semi-natural creation	Semi-natural rotation	Water body creation	Development	Developed land recycling	Loss to unknown		Reductions 1990-98	Additions 1990-98	Net Change 1990-98	Stock unchanged since 1990, in %
Broadleaved and mixed woodland	1 371.2	132.4	13.5	-22.2		-42.1		-0.8	-12.9		-0.4	1 438.7	78.4	145.9	67.5	89.9
Coniferous woodland	1 369.3	67.2	-13.5	-9.0		-48.3		-0.6	-5.0		0.0	1 360.2	76.4	67.3	-9.1	95.1
Woodland sub-total	**2 740.5**	**211.6**	**0.0**	**-31.2**		**-90.4**		**-1.4**	**-17.8**		**-0.4**	**2 798.9**	141.2	211.5	**70.3**	92.9
Arable and horticultural	5 246.1	-28.8		59.2	118.2	-41.4		-1.0	-19.3		-0.2	5 332.9	90.7	177.6	86.9	96.7
Improved grassland	5 538.6	-34.1		341.0	-118.2	-232.0		-0.5	-53.9		-5.3	5 435.5	444.0	340.9	-103.1	93.7
Intensive agriculture sub-total	**10 784.7**	**-62.8**		**400.2**	**0.0**	**-273.4**		**-1.5**	**-73.2**		**-5.5**	**10 768.4**	**416.4**	**400.2**	**-16.2**	**96.3**
Neutral grassland	569.5	-24.4		-153.6		238.9	-18.2	-0.5	-33.2		-0.1	578.3	230.0	238.8	8.8	58.7
Calcareous grassland	81.4	-1.1		-13.3		3.7	-3.8	0.0	-0.2		0.0	66.7	18.4	3.8	-14.6	94.5
Acid grassland	1 470.9	-24.0		-133.7		43.3	-34.7	0.0	-4.6		-0.7	1 316.5	197.7	43.4	-154.3	96.7
Bracken	456.9	-21.8		-8.7		20.4	38.9	0.0	-0.5		0.0	485.1	31.0	59.2	28.2	87.8
Dwarf shrub heath	1 487.1	-24.5		-1.2		13.1	-41.4	0.0	-3.3		0.0	1 429.7	70.4	13.1	-57.3	99.1
Fen, marsh, and swamp	456.4	-6.1		-25.1		61.0	71.3	-0.7	-1.2		-0.6	554.9	33.7	132.2	98.5	76.2
Bog	2 297.3	-17.9		-0.7		10.5	-10.1	-0.3	-0.2		-0.1	2 278.5	29.3	10.5	-18.8	99.5
Montane	49.8	0.0		0.0		0.0	0.0	0.0	0.0		0.0	49.8	0.0	0.0	0.0	100
Coastal habitats	274.1	-0.3		-0.8		2.6	-2.0	-0.3	0.0		0.0	273.3	3.4	2.6	-0.8	99.0
Semi-natural sub-total	**7 143.3**	**-120.1**		**-337.2**		**393.5**	**0.0**	**-1.8**	**-43.2**		**-1.5**	**7 032.9**	**503.8**	**393.4**	**-110.4**	**94.4**
Standing open water and canals	208.4	-0.2		-1.0		-0.9		5.2	-1.2		0.0	210.3	3.3	5.2	1.9	97.5
Rivers and streams	66.7	-0.2		-0.1		-1.4		0.3	-0.1		0.0	65.2	1.8	0.3	-1.5	99.5
Water bodies sub-total	**275.1**	**-0.4**		**-1.1**		**-2.3**		**5.5**	**-1.2**		**-0.1**	**275.5**	**5.1**	**5.5**	**0.4**	**98.0**
Inland rock	53.6	-0.6		-2.2		-7.6		0.0	13.2	3.8	0.0	60.2	10.4	17.0	6.6	71.8
Built up areas and gardens	1 230.4	-14.2		-12.3		-9.4		-0.7	100.4	-2.1	-1.2	1 291.0	39.9	100.4	60.5	92.2
Boundary and linear features	495.0	-1.0		-14.5		-7.8		-0.1	21.9	-1.7	-0.1	491.7	25.2	22.0	-3.2	95.5
Developed sub-total	**1 779.0**	**-15.9**		**-28.9**		**-24.8**		**-0.8**	**135.5**	**0.0**	**-1.3**	**1 842.9**	**71.7**	**135.6**	**63.9**	**92.6**
Sea	298.5	0.0		0.0		-0.7		0.0	0.0		0.0	297.8	0.7	0.0	-0.7	100
Unknown	73.9	-0.3		-1.8		-2.0		0.0	0.0		8.8	78.6	4.1	8.8	4.7	88.8
Unsurveyed urban land	463.0											463.0	0.0	0.0	0.0	100
Total	**23 557.9**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**0.0**	**23 558.0**	**0.0**	**0.1**	**0.1**	**100**

Source: Haines-Young *et al.*, 2000.

8.351. Additional aspects can be added to the basic accounts to expand the analysis, for example linear landscape features and regional accounts. Linear landscape features (for example hedgerows and walls) are a typical example. Linear features are often rather poorly represented in land cover classifications. Nevertheless reporting on their quantity in the form of length units in some countries adds important information on significant elements in the landscape.

Data availability

8.352. A precondition for policy relevant and scientifically sound land and ecosystem accounts is a good database with georeferenced land-use and land-cover data. In practice, land-cover and land-use data are often presented in mixed classifications and most data are not georeferenced. The use of mixed classifications means that it is impossible to construct land-use/land-cover cross-tabulations for fixed points in time. The absence of georeferenced data means that it is impossible to construct land-use or land-cover change matrices showing the flows between categories of land-use (or land-cover) during a period; the most that can be done is to compile stock accounts for different points in time.

Supplementary accounts

General aspects

8.353. The supplementary accounts are strongly driven by policy interests. They can be divided into two groups. The first group concerns problems of naturalness and intensity of land use. Phenomena such as sealing or fragmentation are incorporated and closer links to the economic activities are established than in Table 8.28 of the basic accounts on land use by industries and private households. The focus of the second group is more closely related to land-cover aspects, the state of the natural environment or biotope accounting. Aspects such as biodiversity are included.

8.354. Georeferenced data allow regional accounts**,** which are often of particular policy interest, to be derived. For describing land cover, environmentally relevant regional classifications like ecozones, landscape type units[4] or watersheds are widely used; for land use administrative regions can also be relevant.

8.355. In general, supplementary accounts are characterised by the fact that they integrate land-use or land-cover data with data from a great variety of other economic and ecological data sources. In this regard one of the problems in establishing ideal supplementary accounts often is the availability of well-suited data and statistical instruments or monitoring programmes. Compared to economic and social statistics or to data on the pressures exerted by economic activities, data to characterise the quality of the environment are often fragmented.

Land use-oriented accounts

8.356. In land use-oriented supplementary accounts the land use parts of the basic accounts are differentiated in a consistent way by more detailed descriptions of issue-oriented aspects. The main themes are the description of changes in the artificiality of land and the link to human driving forces or pressures and the intensity of use of land. Typical issues in this context are the sealing of soil, the partitioning (fragmentation)

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[4] Landscape type units are spatial units characterised by homogeneous natural conditions; for example, soil, climate, geology, hydrology or relief (Haines-Young *et al.,* 2000; Schäfer *et al.*, 2000).

of land by transport networks and the impacts on land by industries, agriculture, tourism, transport and human settlements (Conference of European Statisticians, 1995). Often both production patterns including technological aspects and consumption patterns have to be considered.

8.357. Soil sealing is a good and simple example to explain the relation to the basic accounts. In some countries the sealing of soil is a major environmental problem as the functions of the soil are totally disturbed. Typical consequences are the destruction of biotopes and impacts on microclimate and water balances. The units used to produce results for land use in the basic accounts are normally sealed to very different degrees. In the case of dwellings, for example, the ground area of the house often is completely sealed whereas the garden around it is not or only to a very limited extent. To detect general trends of soil sealing in a country or in a region the degrees of sealing of the different land use (or even land cover) categories have to be derived from other data sources (for example interpretation of aerial photographs, housing statistics or field surveys) and linked to the volume of the different land use categories. Depending on the objective this can be done on the basis of the land use classification in Table 8.27 of the basic accounts, a classification where single categories (for example land underlying building and structures) are further disaggregated, or even in the context of Table 8.28 by economic activities.

8.358. Other data that can be integrated in the supplementary accounts are data on the intensity of use of agricultural, urban or infrastructure land such as the use of chemicals in agriculture, emissions, disposal of waste, extraction of water or other resources, transport related information like traffic density, and so on (for examples, see Conference of European Statisticians, 1995). An important feature of the supplementary accounts is that in many cases the issues demand data that are classified by region or even geocoded. The detail of geographical referencing determines the detail of possible accounting (Parker *et al*., 1996).

Land cover-oriented accounts

8.359. In the land cover-oriented supplementary accounts the information in the basic accounts is extended by describing in more detail the potentials of land and aspects of biodiversity. The potentials of land relate to the richness of natural habitats in terms of extent of biodiversity, to their vulnerability, to the characteristics of the soil, to the social and economic activities which it supports. The potentials can be assessed from several points of view, one of them being the capacity of the landscape to sustain natural life under the pressure of human activities (Parker *et al.*, 1996). In the case of the cover-oriented accounts, the link to economic activities and pressures is more difficult to establish than for use-oriented accounts. Data on biotopes, flora and fauna and information on the natural conditions in a country or region (climate, soil, water, etc.) are important inputs to the land cover-orientated accounts.

8.360. For analysing land cover or ecosystems on a more sophisticated level more homogenous land units are used. Biotope accounting is a very important example in this regard. Biotope accounts are normally better targeted to nature conservation policy or to (ecosystem) theory than land-cover descriptions. The link to the basic accounts can be established by a table cross-classifying land cover and biotopes in the same way as Table 8.27 of the basic accounts does for land use and land cover. As in the basic accounts, a biotope change matrix (corresponding to Table 8.29) and a table indicating the causes of changes (corresponding to Table 8.30) distinguishing human influences from natural developments can be produced. Basic data in biotope accounting are often georeferenced (Stott and Haines-Young, 1996; Seibel *et al*., 1997).

8.361. Table 8.32 shows an example of such a cross-classification of land cover by major biotope types based on the results of the *Countryside Survey* in Great Britain (Haines-Young *et al*., 2000). The data show the number of random vegetation plots sampled in 1998. The land cover types refer to the parcel of land from which the vegetation was sampled as determined by field survey. The biotope type refers to a statistical classification of the classification of vegetation based on species composition. Some of the land-cover types, such as broadleaved woodland, consist of a mixture of vegetation types. Repeat surveys in 1978, 1990 and 1998 enable assessment of changes in extent and ecological condition of land cover types. (Haines-Young *et al*., 2000).

Table 8.32 Cross-classification of land cover and biotope types for Great Britain, 1998

Land cover type	Biotope type								**Total**
	Crops and weeds	Tall grass and herb	Fertile grassland	Infertile grassland	Lowland wooded	Upland wooded	Moorland grass	Heath/bog	
Broadleaved woodland	3	18	7	23	70	60	10	5	**196**
Coniferous woodland	0	5	1	4	12	92	29	30	**173**
Arable	442	89	51	6	0	0	0	0	**588**
Improved grassland	23	18	384	315	0	0	12	0	**752**
Neutral grassland	7	8	10	57	0	8	4	2	**96**
Calcareous grassland	0	0	0	9	0	0	1	0	**10**
Acid grassland	0	0	2	25	0	10	119	51	**207**
Bracken	0	0	0	12	1	31	23	9	**76**
Dwarf shrub heath	0	0	0	2	0	13	82	143	**240**
Fen, marsh, swamp	0	5	2	26	0	5	41	16	**95**
Bog	0	0	0	1	0	4	50	239	**294**
Total	**475**	**143**	**457**	**480**	**83**	**223**	**371**	**495**	**2 727**

Source: Haines-Young *et al.*, 2000.

8.362. An important aspect of biotope accounting is the integration of quality indicators; for example, on biodiversity aspects. Changes in biodiversity are most often a consequence of human activities, but only the diversity of species can be integrated in biotype accounts. To include habitat diversity, which can be understood as diversity of biotopes in a landscape, in land and ecosystem accounts more heterogeneous landscape units like ecozones or landscape type units have to be described by the corresponding quality indicators. In the case of biodiversity the parallel use of different accounting units is therefore essential (Hoffmann-Kroll *et al*., 1999).

8.363. Table 8.33 shows an example of a biodiversity indicator linked to land cover and biotope accounts in Great Britain. It shows the mean number of plant species recorded in the same vegetation plots sampled in both 1990 and 1998. The vegetation plots are classified according to the biotope type present in 1990 and linked to land cover types. In this example, "moorland grass" has the highest overall species richness and "crops and weeds" the lowest. Statistically significant declines in species richness occurred in "tall grass and herb", "fertile grassland" and "infertile grassland" biotopes. This indicator is one of the core indicators used in the UK government's sustainable development strategy (Haines-Young *et al*., 2000; United Kingdom Department of the Environment, Transport and the Regions, 1999).

8.364. In general, the surface area accounts for landscapes and ecosystems or biotopes that are required to reflect biodiversity can be linked not only to diversity indicators but also to the relevant material (for example degradation by residuals) or functional indicators for describing the state of the environment. It leads to a systematic, theory-based description of the state of environment, which would extend (from a conceptual point of view) the current data reporting conducted on a media or sectoral basis.

Table 8.33 An example of a biodiversity indicator

Biotope type	Mean species number per plot		% change 1990-98
	1990	1998	
Crops and weeds	5.6	6.2	10.9
Tall grass and herb	14.7	13.5	-8.1
Fertile grassland	13.1	12.3	-5.6
Infertile grassland	19.9	19.1	-4.0
Lowland wooded	12.1	11.9	-1.5
Upland wooded	13.4	13.4	-0.4
Moorland grass	20.4	20.7	1.5
Heath/bog	14.5	14.5	0.1

Source: Haines-Young *et al*., 2000.

Integration of quality aspects

8.365. The integration of quality aspects of land is a common feature of both land use- and land cover-oriented supplementary accounts. Quality aspects can only be integrated directly in an accounting structure based on surface areas to the extent that they can be described by more detailed classifications based on quality. (See the discussion on this in the section on water accounts also.) However, there are two clear limitations to such an approach of general, aggregated quality classes from a methodological and practical point of view.

8.366. Often, there are no concise breakdowns by complex quality classes of land or ecosystems types which are scientifically sound. For forest ecosystems, for instance, the health of the trees, the soil, the abundance of wild plants and animals or the state of the soil would all have to be considered. Given the current state of the art, a quality classification encompassing these aspects would be feasible only if normative standards as well as statistical descriptions were applied for the aggregation of the individual factors to quality classes.

8.367. Because of the combination of the various quality characteristics, any attempt to avoid normative elements in the assessment by cross-classifications results in a very large number of quality classes. This would be unrealistic and/or extremely costly to quantify in a reliable way at present.

8.368. The only practical solution is a pragmatic approach. The surface area of ecosystems or land cover units can be depicted by integrated accounting methods, whereas the indicator method is used for any further qualitative differentiation of these units. If suitable non-additive quality indicators are defined for the classes used for describing land use, land cover or biotopes in the corresponding accounts, the quality indicators can be added to the surface values as separate columns in stock matrices. From a methodological point of view this approach is similar to monetary valuation in the treatment of land as an economic asset. In the latter case the additive measure is the price as an expression of the productivity of land; from an ecological point of view, internal quality is expressed by different quality indicators instead.

8.369. This approach opens the field to a lot of policy relevant analyses by combining the advantages of accounting and indicator methods. For example, aspects of biodiversity (especially habitat and species diversity) can be reflected by accounting methods only to a very limited extent. A consistent methodological link between accounting methods such as surface area balances and the respective biodiversity indicators are necessary for a satisfactory result. Some examples of indicators which give a clear idea of the kind of links between area balances and quality aspects follow. The biodiversity of habitats in a landscape or ecozone (heterogeneous land cover units) on the one hand can be recorded by indicators such as the naturalness of landscape (percentage of area covered by natural and mostly natural biotope types), biotope diversity of landscape (number of non-technical biotope types), length of linear features/verges, number of small biotopes or occurrence of endangered biotopes (in percentage of area). On the biotope level, biodiversity of species can be characterised by indicators such as the mean number of species (in biotopes or sample units in biotopes), the share of endangered species (as mean number or percentage of all species) or the share of specific strategy types that describe the stress to which for example plants are subjected (see Hoffmann-Kroll *et al*., 1999 or for some other indicators Haines-Young *et al.*, 1996).

8.370. Another policy relevant example is soil degradation. Soil degradation is defined as a process that lowers the capacity of the soil to produce goods and services. The two categories of soil degradation are displacement of material by water or wind erosion and soil deterioration by chemical or physical processes. Examples of indicators used in the supplementary accounts to cover the aspect of chemical deterioration of soils are loss of nutrients and/or organic matter, salinisation, acidification, pollution, acid sulphate soils or eutrophication (see United Nations (1999b) especially paragraph 299 for the link between soil, land, socio-economic data and data on natural conditions).

8.371. In general the degree to which quality indicators are combined with the accounts depends on the objectives of the analysis; in environmental accounting a more limited use of quality indicators than in natural science reporting systems on the state of environment is normally adequate.

5 Integration of soil

8.372. In the SNA soil is treated as an integral part of land and not as a separate economic asset. If the quality of soil is important for the use of land, as, for example, for agricultural or forest land, the quality of soil is a factor influencing the price of land. There is some discussion on this in Section E of Chapter 7 under the discussion of the valuation of land and the effects of degradation on it.

8.373. In the asset classification and in the physical accounts of the SEEA, soil is recognised explicitly as a distinct natural resource. This reflects the quantitative dimension of soil, such as soil erosion as a consequence of direct human use reducing the availability of soil at a given site. Physical flows connected with soil erosion are treated as involving a decrease in soil in one area and an increase in the soil of the area to which the soil has been transported by wind and water. This underlines the character of soil as an asset which is in principle depletable. On the other hand, the use of soil is different from that of sand and stone extracted by the mining industry[5]. The negative impacts of soil degradation are integrated in the land and ecosystem accounts also. The qualitative dimension of soil (type of soil, nutrients, etc.) is an important aspect of all terrestrial ecosystems. If soil erosion is included in this type of analysis, it is done more under the aspect of surface area (in hectares) that is affected by erosion problems or has a high risk to be eroded.

8.374. The way in which soil is included in environmental accounting, either as a separate natural resource or as part of land and ecosystem accounts, depends on the importance of the quantitative and qualitative dimension of soil in a country or region. For a more detailed presentation see United Nations (1999b, p.123ff).

[5] Though not entirely since to a limited extent soil is sold in much the same way as sand and gravel.

Chapter 9 Valuation techniques for measuring degradation

A Chapter overview

1 Objectives

9.1. Degradation is one of the three major environmental issues discussed in this handbook, the others being depletion and defensive expenditure. Defensive expenditure puts a monetary value on environmental damage which is either prevented or rectified. This chapter discusses how monetary values might be ascribed to damage which is neither prevented nor rectified. Much of the text is concerned with the practical issues of how such valuations can be attempted. Just as important, though, is the material in this first section explaining why valuation can be useful and also explaining the problems associated with trying to put a monetary value on environmental services which currently have no price in the market.

9.2. The main reason to try to put a monetary value on degradation is to try to answer the question "how much does it matter?" Some answers to this question can come from traditional environmental statistics. They can show the quantitative size of air emissions, for example, and even set these in context as explored in chapters 3 to 6. They can show whether degradation is getting worse or not and, if it is, whether it is getting worse at a faster rate. However, if the question "How much does it matter?" is to be followed by "What shall we do about it?" it is desirable to have answers to the supplementary questions "How much harm does it do?" and "What would it cost to avoid it?".

9.3. These supplementary questions lead into the area of cost benefit analysis and the problems which arise when those causing the polluting and those suffering the consequences are not the same. This subject is also discussed in the first section below.

9.4. The whole issue of placing a notional valuation on degradation when no such valuation is actually observed in the economy raises important questions about how far a statistical system can account for hypothetical costs and prices. These implications for the whole accounting system are postponed until Chapter 10.

2 Why value degradation?

9.5. Most interest in degradation concerns the impacts of pollution in air and water. In many countries now, even some that are resource rich but economically poor, the problems of degradation are seen as being much more pressing than those of depletion. Chapter 3 discussed how these impacts could be measured in physical terms. Often the physical data is more robust and may be seen to be more precise than monetary values. However, when decisions have to be made about restricting the amount of emissions to be permitted, the question of how much it will cost inevitably arises. It is a particular problem when externalities are concerned because those who bear the costs of avoiding pollution are not necessarily the same as those who benefit. There is thus a question about how far the former can be obliged to incur costs to benefit the latter or how far the latter should bear damages to benefit the former.

9.6. Physical data sets are necessary to reveal the detailed processes taking place with respect to natural resources and environmental assets and are therefore essential for monitoring the progress of regulatory or conservation policies and for modelling the impacts of proposed policies or actions. Monetary data sets invoke valuation as, ideally, the means to allow "unpriced" goods and services to be compared with goods and services that have a market value. Valuation also permits the aggregation of different environmental goods and services, allows costs and benefits to be compared and supports the internalisation of externalities into monetary accounting. Monetary estimates can provide a common numeraire essential for comparison across different activities or products and permit decisions which necessarily involve trade-offs between alternative policies. This involves choices between alternative environmental goals as well as choices between environmental and non-environmental objectives.

9.7. Many of the effects of environmental pollution are specific to a particular location (for example, a busy multi-level motorway intersection) or to a specific industry (for example, crop damage caused by acid rain) and may be caused by particular emissions rather than the totality. Thus integrated environmental economic accounting involving valuation may be useful in these specific instances as part of project evaluation quite apart from any use of valuation techniques to derive macro-economic aggregates.

3 Valuing costs and damages

9.8. Degradation causes damages and costs would need to be incurred either to prevent the damage or to rectify the harm caused. These questions lie at the heart of project appraisal where it is usual to consider the costs and benefits of a project and to proceed only if the benefits are at least as great as the costs. This approach can be modified so that instead of observing the price of a product, we can try to estimate the impact on the price of internalising the costs to producers that would permit them to reduce or eliminate the generation of residuals and thus avoid the decline in welfare that degradation causes. Alternatively, instead of measuring benefits, we may measure the damages caused by residuals as if they were a sort of negative benefit.

9.9. In standard cost-benefit analysis, though, the costs and benefits accrue to the same unit which can assess whether to proceed with the project or not independently of the decisions to be made by other units. The problem with environmental degradation is that not only are we concerned with dis-benefits, or damages, rather than positive benefit, but these damages affect units other than the unit causing the damage. The disconnection between costs and damages where there is no penalty applied to the unit causing the damage gives rise to what economists refer to as externalities.

9.10. The damages take the form of negative externalities associated with production and consumption. Negative externalities are assumed to give rise to inefficiencies because the unpriced components or characteristics of the environment will be over-exploited, leading to social costs that are higher than the private benefits derived from this over-exploitation. Conversely, positive externalities may arise (for example, from carbon sequestration by managed forests) where the social benefits will be higher than the private benefits.

9.11. In general, just as a unit will undertake a project if the benefits are at least as great as the costs, so it will undertake costs to avoid damages of a greater value. While there is no equality between costs and benefits or damages, for a single unit operating rationally there would be no case where damages would persist if the cost of avoiding them were less than the value of the damage. When the damage is felt as an externality, though, it is no longer the case that the damage is likely to be avoided even if it is greatly in excess of the costs of avoiding it.

9.12. A comparison of costs and benefits is of particular use to government as policy maker. If there seems a compelling case to impose costs on polluting units for the general benefit which will result, government may wish to bring in legislation to enforce it. Increasingly, as discussed in Chapter 6, there is a move away from environmental protection by means of legislation towards the use of market instruments, either taxes or licences such as emissions permits. This gives the polluter an incentive to find ways to reduce pollution and thus reduce tax payments or realise the value of the permit by selling it to another unit which has not yet reduced its pollution levels.

4 What is being valued?

9.13. It is important to note that trying to put a value on environmental degradation is not the same as trying to value environmental media. Traditionally air and water were held to be free gifts of nature. It is not only that a shortage of water in the strict quantitative sense is now a real threat but that the quality of air and water deteriorates as economic production generates more residuals than can be absorbed by natural assimilation. If a product is so abundant that no amount of demand causes a scarcity of the product, the product has no price attached to it and is freely available to all who demand it. When a product is scarce, demand exceeds supply and in consequence the price will rise; when supply exceeds demand and the product is less scarce the price will fall. The "product" we are trying to value here is clean rather than contaminated environmental media. The task is thus to attribute a notional value to the decline in the quality rather than the quantity of a resource.

9.14. Another way of considering what it is we are valuing is to reconsider the notion of environmental function first introduced in Chapter 1. These functions can be thought of as falling into three categories. There are resource functions whereby the environment provides materials which are taken into the economy and transformed into produced goods and services. There are sink functions whereby residuals generated by production are emitted to the environmental media of air, water and land for assimilation. Lastly there are service functions which can be further subdivided into survival functions and amenity functions. What we are doing, therefore, is to try to find a way to value reductions in the sink and service functions provided by the environment.

5 Problems with valuing degradation

9.15. Chapters 7 and 8 discussed how valuations relating to certain environmental assets could be determined even though they appear to be free gifts of nature. This depended on the fact that the assets in question (timber, minerals, fish, etc.) are absorbed into the goods and services which are produced in the economy. The method involved was essentially one of dividing the income derived in the production process into one part attributable to natural resources and another part due entirely to human endeavour.

9.16. Degradation cannot be valued in this way. There is no point in trying to put a value on a cubic metre of clean air or clean sea water if only because there is no useful corresponding total volume. While we might desire to value the services or functions that environmental media provide, this is generally not possible. Instead, as explained above, we must concentrate on the costs involved in combating residual generation or the damages incurred when generation takes place.

9.17. These costs actually incurred to avoid pollution and the costs to remedy damages caused by pollution are captured in the standard national accounts. These are described in Chapter 5 and are referred to again briefly in this chapter. Knowledge of these actual costs is instrumental in placing a value on the pollution not avoided and the non-remedied damage incurred. Further, for some analyses it may be useful to aggregate both the actual costs and potential costs necessary to reach a certain environmental standard.

9.18. Degradation is seldom an absolute condition. It is difficult to imagine an economy as we know it functioning without some contamination of environmental media. The problem is whether the degree of contamination is “excessive” according to some norm. The most rigorous norm is that it should not exceed the natural assimilation properties of the media but in practice less rigid norms are specified; for example, the level of emission generation agreed under the Kyoto protocol to be, currently, “acceptable”. Depending on which environmental standards are taken as goals, the value to be placed on degradation will differ.

9.19. This is where the discussion above on the value of costs and damages becomes relevant. There is no assurance that the cost-based and damage-based estimates will be equal because the market mechanism to juxtapose them is missing but either or both approaches may be used depending on the focus of interest.

9.20. Unfortunately, given the lack of information and the scientific and other uncertainty often associated with environmental issues, the valuation of both the costs and benefits of environmental issues is often difficult, if not impossible. Usually in these cases, only the costs, and not the benefits, of a given policy can be determined with any confidence, as the policy will typically involve easily identifiable costs of marketplace materials, capital and labour. The benefits, however, refer to improvements, additions or prevention of damage to natural resources and environmental assets and thus to the value of the assets that frequently do not have observable market prices. The lack of a market in these assets means not only are there no prices, but there is no mechanism for confronting the costs and benefits. Prioritisation must therefore occur through some other medium.

9.21. One means depends on the political process itself to reveal a ranking of concerns. However the ranking is established, once done, the appropriate response may be identified through analysis to identify the most cost-efficient policies that will address a pre-specified priority to a pre-specified standard of success. The advantage over cost-benefit analysis is that this approach requires monetary valuation not of the natural resource or environmental asset itself, but of the proposed responses. These activities may also involve environmental costs that cannot be easily measured; again, the political process may suggest whether these costs are perceived to exceed the benefits and whether the activity should be undertaken.

9.22. Ambitious as these approaches are, they are still limited in some respects. Typically only some costs and damages will be estimated. Because the links between residuals and damages are not perfectly understood, even attempts to cover the same problems under both methods may fail. Some problems may be amenable to easier measurement by one technique rather than another. Neither approach will give a full estimate of the value of environmental services, resource by resource, nor are they intended to do so. That is a task for the future. But with all these caveats, progress on the application of both cost-based and damage-based estimates of degradation can be reported.

6 Methods of valuing degradation

9.23. Most methods of valuing the prevention of degradation consist of combining information on the degree of emissions to be combated with the costs per unit of amelioration. These costs are not linear. Often initial, large improvements can be made at much lower per unit cost than the cost necessary to cleanse the last unit of emission. Sometimes it may be impossible to completely eliminate the last unit of pollutant, implying an infinite cost. A similar pattern is observed for damage costs. The goal, therefore, is to derive cost and damage functions which relate costs and damages to varying levels of emissions and thus degradation.

Cost-based valuation methods

9.24. The information on emissions used in cost-based estimates typically comes from the sort of studies described in Chapter 3. Information on the costs of combating these emissions may come from the sort of information described in Chapter 5 or from special studies.

9.25. There are three ways in which emissions can be controlled. Steps can be taken to avoid the emissions in the first place, either by refraining from the activity giving rise to the emissions or by substituting less damaging inputs and outputs. The second solution is to capture the emissions and make them less harmful; for example, by installing scrubbers on processing equipment. The third option is to restore the environment by means of clean-up activities.

9.26. The pricing options and methods of applying these alternatives are described in Section B.

Damage-based valuation methods

9.27. Damage-based valuation methods are based on two sets of information not discussed in earlier chapters. The first is to assess the extent of the damage which has occurred. The damage of most immediate concern to many observers is the damage caused to health by pollution. To assess this damage, use is made of so-called "dose-response" functions. This is a technique whereby the existence of a pollutant is correlated with the "receptors" of another condition, specifically here different types of illness. This technique is discussed in Section C.

9.28. Once the extent of damage is established, it is necessary to find a way of putting a monetary valuation on it. To some extent some of the pricing methods used for cost-based methods can be used but more commonly alternative valuation methods are employed. Each can be seen as a measure of the respondents' "willingness to pay" for a given service. Market prices are characterised as a directly revealed willingness to pay. Various econometric techniques can be used in connection with observed pricing behaviour to determine willingness to pay indirectly. Alternatively, and more controversially, surveys of stated willingness to pay can be undertaken and used.

9.29. The method of "benefits transfer" is also discussed. Benefits transfer is a method used to estimate economic values for ecosystem services by transferring available valuation information from studies already completed in another location and/or context. In other words, benefits transfer is not a separate valuation method, but a method to estimate benefits for one context by adapting an estimate of benefits from some other context.

9.30. These pricing alternatives and their applications are described in Section C.

7 Degradation crossing time and space

9.31. There is a time dimension in degradation occurrence and remediation which needs to be recognised. Degradation which occurs in one period and is not remedied by either natural or man-made processes carries forward to the next period. This accumulation is referred to as environmental debt and may affect the rate at which natural assimilation of waste will occur in future periods. Should values of degradation apply only to the amount of emissions generated in the period in question or should they cover environmental debt also? If the latter, should it be assumed that the debt is to be cleared in a single period or over a number of years?

9.32. There is a further problem with applying pricing assumptions in either cost-based or damage-based estimates and that is that the assumptions involved are not always, indeed are usually not, strictly conformable with the assumptions built into economic accounting. Another problem of concern is that emissions in one country may cause damages not just in that country but also in another country. Approaches to both these problems are contained in Section D.

8 Status and future work on valuing degradation

9.33. The techniques described in this chapter are still being developed and the data requirements to implement them are both extensive and resource intensive and thus generally incomplete. This work therefore should be seen as being in its early stages and is liable to change, perhaps radical, in the medium term. In its present state it may be applied to valuation in special contexts; for example, the analysis of the costs of a toxic waste site or the impact economy-wide of particular emissions. It is not sufficiently well developed to put a monetary value on biodiversity or the threats from global warming, but the threats these pose may not be further illuminated by monetary valuation.

9.34. The last section of the chapter, Section E, provides an assessment of the suitability of the pricing techniques discussed in sections B and C as well as comments on methodological reservations and data limitations.

B Cost-based pricing techniques

9.35. There are only a limited number of ways of dealing with environmental degradation. One can try to prevent it before it happens or try to reverse it once it has happened. These two alternatives are referred to as avoidance and restoration respectively. They can be further elaborated as in the taxonomy of pricing methods for cost-based estimates as shown in Box 9.1. These methods are discussed in turn below. The term "maintenance cost" was used in the 1993 SEEA as a generic term for cost-based methods and it is convenient to preserve this usage since it is evocative of the underlying principle of maintaining environmental functions.

Box 9.1 Taxonomy of cost-based estimates

Avoidance costs
Structural adjustment costs
- Reduction of activities or complete abstention
- Changes in production and consumption patterns

Abatement costs
- Input substitution and changes in technology to achieve the same output
- Treatment costs (end-of-pipe, safe disposal, etc.)

Restoration costs

1 Structural adjustment costs

9.36. These costs can normally only be estimated by modelling or by assumption. They are therefore discussed in Section D which deals with modelling approaches. It should be noted, though, that in some cases this may be a very cost-effective way to make considerable savings on environmental pollution with little direct impact on GDP.

2 *Abatement costs*

9.37. Imputed abatement costs refer to expenditures which reduce the direct pressures on natural assets (for example from air emissions or waste disposal). Their calculation does not require the definition of absolute environmental quality levels or standards but of reductions in levels (for residual flows in particular). Ideally, imputed abatement costs should always be calculated as the sum of direct and indirect cost effects of additional prevention measures. This section concentrates on the conceptual and empirical steps necessary for the calculation of direct abatement costs.

Conceptual considerations

9.38. Usually abatement cost data are collected on a micro-economic level and describe the costs of technical options for reducing a certain type of pollution. This is presented as cost functions (abatement cost curves). Such cost functions plot, for each type of measure, the cost per unit of avoided pollutant against the volume of avoided pollutants. In practice such curves often confirm the standard economic assumption of increasing marginal costs. However, exceptions often exist. In studies of CO_2 abatement costs it is often found that substantial initial reductions can be obtained at negative costs for instance by implementing energy saving measures that are actually profitable. It should also be noted that abatement cost curves are not stable over time. Ideally, they reflect the technological possibilities and knowledge available in a given accounting year. Costs will tend to decrease over time with technological progress and rate of application of techniques (economies of scale) so that the cost data need to be updated regularly.

9.39. Once a marginal abatement cost curve is developed, it may be used to help determine the targets to be set for environmental standards. Alternatively, total abatement costs can be derived from cost functions by combining them with given environmental standards or targets, for example a certain reduction of annual CO_2 emissions. Abatement costs can be calculated for a single pollutant, for a set of pollutants contributing to a certain environmental problem or theme or even jointly for all environmental problems. Obviously the complexity of the cost calculation increases as the extent of the environmental concern widens.

9.40. The additional costs to implement technical measures for one statistical unit are defined as direct costs. This is the extent to which the costs can be captured in the maintenance cost approach. If the measures were applied (hypothetically) to a whole industry, this would immediately affect the cost structure, the prices and level of output of this industry. In many cases a broader economy-wide application of such measures is necessary to achieve given environmental targets (CO_2 reduction, reduction of air pollution in general, reductions in the amounts of solid waste generated, changes in agricultural practices, etc.). This influences the structure of output and intermediate consumption of many industries, which leads to changes in the structure of prices throughout the economy. These cover both direct and indirect costs, both of which are captured in the modelling approaches to be discussed in Chapter 10.

Data considerations

9.41. Three types of data are required:

data on emissions by economic activities and underlying production processes disaggregated according to technical characteristics;

parameters of available abatement techniques/measures (for example reduction potential, actual rate of application for each production process/economic activity); and cost data for these measures.

9.42. The physical data underlying cost-based calculations will very often come from the sorts of analyses described at length in Chapter 3 where use is made of emission data and technical abatement data often originating from technology-oriented databases. Such databases may be held by research institutes but increasingly are being held also by governments for regulatory purposes; for example, for prescription of best available technologies (BAT). These data bases use technical classifications and, therefore, need to be converted to the standard industrial classification to be used in conjunction with economic data.

9.43. Abatement cost calculations are based on pressures by economic activities on the environment of a single country and in a single year. Pressures mostly comprise discharges of different kinds of residuals but may include land use and quantitative use of natural assets as well.

9.44. Cost data for abatement measures are available on a micro-economic level relating to a particular technology or process; that is, they may relate to a sub-establishment process. Aggregation is needed to establish abatement cost curves at the level of the sector and for economy-wide indicators but this is not just a question of straightforward aggregation for the reasons described above. Consequently, the accounting of abatement costs is different for the micro-economic (individual economic agents and establishments), the meso-economic (industries and homogeneous branches of production, and groupings thereof) and the macro-economic accounting levels.

Practical aspects/limitations of the method

9.45. In order to obtain the total costs of technical measures including both direct and indirect costs a modelling approach is necessary. Normally this will have an input-output core and will be closely linked with direct cost calculations.

9.46. Direct abatement-cost calculations should take account of interactions between technical abatement measures, interactions between pollutants, incompatibility of abatement measures and the uncertainties of measurement of integrated techniques. Such problems are very rarely covered in primary data sources.

9.47. It is not always easy to distinguish between costs for environmental protection and other costs. For example, is end-of-pipe technology entirely a cost for environmental protection? Even when the cost for energy-saving technology to reduce CO_2 emissions is deemed to be entirely a cost for environmental protection, questions still remain. When new vehicle engines reduce NO_X and CO_2 emissions but also increase energy efficiency and generate more power, it is difficult to specify the portion of the greater engine cost due to environmental protection. This issue of allocation is addressed in detail in Chapter 5 for actual expenditure.

9.48. It is important to note that cost estimates do not represent the value of the damage caused by the additional environmental deterioration. That is to say, the size of the value obtained by the cost-based method does not represent the severity of environmental problems; rather, it represents the effort, in terms of costs, of taking measures to rectify the environmental problems. Measuring the severity of the problem depends on an assessment of the significance of the environmental function affected. For example, drinking water may be “cleaner” than river water but represent a more severe problem if it is not potable than the river water which poses no threat to river life or (human) swimmers. It is particularly important to note the problems of scale and non-linearity in this respect. Significantly large reductions in damage may be amenable to treatment and restoration at reasonable cost with very large associated benefits. However, the cost for the last few per cent of damage may be very much greater or even infinitely expensive even though little extra benefit results.

Use in national accounts

9.49. This section uses the concept of costs in the same way that the costs of production are defined in national accounts. These should include costs of both labour and capital as well as intermediate costs. Theoretically, marginal costs (and benefits) should be used for valuation. However, in practice such marginal costs are often very difficult to determine. When direct information on costs and prices is not available to national accountants, they may have recourse to using average costs and prices and a similar process is used in estimating environmental costs. This approximation, however, is equivalent to the assumption that there are no economies of scale in production, a situation which may occasionally be true but is not the general case. The dangers of using average coefficients as if they were marginal is one which should be kept in mind in environmental (and economic) analysis especially when based on input-output coefficients. [1]

3 Restoration Costs

9.50. Some restoration costs are (or should be) implicit in costs associated with other assets; for example, the costs to decommission nuclear power stations and rehabilitate agricultural land. The appropriate treatment of these is discussed in Chapter 6 and assumed to be an "actual" cost in the sense that it can be accounted for directly even if it has not yet taken place. The costs of concern here are restoration costs which have no such association with SNA assets and are not accounted for elsewhere. An obvious example is the restoration of contaminated water bodies.

9.51. Hypothetical restoration costs are one of the categories of the costs for present environmental deterioration. Hypothetical restoration costs are only used in cost-based estimates if they are the "least-cost option". The hypothetical costs of restoring the environment to defined standards are important outside the national accounting framework. The hypothetical costs include the mitigation/abatement of accumulated damage required to return to this standard.

C Damage- and benefit-based pricing techniques

9.52. The previous section described how to estimate the costs of maintaining an adequate standard of environmental functions in terms of the quality of the environmental media used as sinks. This section looks at the consequences of over-using environmental sinks in terms of the damage this overuse causes. Sometimes the damage caused can be priced directly; for example, estimating the cost of cleaning a building blackened by atmospheric pollution. For other damages, including and importantly the damage to human health, it is necessary first to make an estimate of the damage and then to find suitable prices to apply to this quantification to reach the total damage-based estimate of the type of degradation being studied.

9.53. The pricing techniques to be described are all based on an assessment of what the unit suffering from the effects of the overuse of environmental sinks would be willing to pay to be free of the effects. This can also be interpreted as the price of an environmental service or, broadly, environmental quality. Prices which are observed in the economy and used in the national accounts reveal a minimum amount that the purchaser is prepared to pay to acquire a given product. This concept of "willingness to pay" is carried over to services which are not currently priced.

9.54. There are two broad ways of estimating willingness to pay. The first is by observing it directly or estimating it indirectly using statistical or econometric techniques. These are described as revealed preference

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[1] Average environmental costs do approximate marginal costs and benefits under certain conditions (see Bartelmus, 1998, pp. 290-291).

methods. The second approach is to ask people about their preferences and these stated preference methods can also be direct or indirect. A taxonomy of these different methods is given in Box 9.2. Each of the two main groups of valuation techniques is discussed below after considering how damage is quantified.

1 Estimating the damage done

9.55. The task is to translate residual generation, as described in Chapter 3, to monetary estimates of particular forms of damage. In order to do this, a sequence of steps must be followed, a sequence which is sometimes referred to as the "impact pathway".

9.56. The first step is to apply a physical transmission model to see how residual generation affects ambient concentrations of the pollutant in question. This is then related to physical damage done and only then can valuation techniques be applied. Where appropriate, allowance must be made for the effect of imports and exports of residuals in making the conversion from domestic generation to domestic ambient concentration.

Box 9.2 Taxonomy of benefit/damage valuation techniques

- **Revealed preferences**
  - Direct
    - Market prices
  - Indirect
    - Hedonic price analysis
    - Travel cost method
- **Stated preferences**
  - Direct
    - Contingent valuation
  - Indirect
    - Conjoint analysis

9.57. One technique for making the stage of translating from ambient concentration to damage is the dose-response function which is described next. The name derives from treating the ambient concentration as the "dose" and the physical damage resulting as the "response".

Dose-response functions

9.58. Dose-response (or more specifically exposure-response) functions measure the relationship between exposure to pollution as a cause and specific outcomes as an effect. They refer to damages/production losses incurred in the current year, regardless of when the pollution occurs. A mathematical relationship is established which relates how much a certain amount of pollution impacts on production, capital, ecosystems, human health etc. By relating a specific measure of an environmental impact to a measure of pollution exposure while controlling for other factors, the role of pollution in causing the environmental impact can be estimated. This estimate can then be used to predict the environmental improvement (deterioration) corresponding to a decrease (increase) in exposure.

9.59. Dose-response functions come in a variety of forms, which may be linear or non-linear and may or may not contain thresholds (levels of exposure above which damages increase sharply). For example, those describing effects of various air pollutants on agriculture have proved to be particularly complex, incorporating both positive and negative effects, because of the potential for certain pollutants (for example, those containing sulphur and nitrogen) to act as fertilisers. Ideally these functions and other models are derived from epidemiological studies which study the observed effects of pollutants on actual populations of people, crops, etc., rather than relying on simulations.

Derivation of dose-response functions

9.60. The key issues relating to the use of dose-response functions can be clearly illustrated by considering the linkages between air quality and health impacts. For example, a large number of studies have focused on the acute mortality effects of exposure to particulates of less than 10 microns in aerodynamic diameter (PM_{10}). The number of studies is important since whilst a single study that finds a significant association between a health effect and a specific air pollutant does not prove causality, the inference of causation is strengthened if epidemiological results are duplicated across several studies. An approach for reducing the uncertainty associated with individual studies is to use meta-analytical techniques that, on the basis of the statistical pooling and aggregating of results from several studies, produce a "best estimate" of a causal relationship that is less uncertain.

9.61. The reported epidemiological studies involve two principal study designs, time-series and cross-sectional. The more common time series studies correlate daily variations in air pollution with variation in daily mortality in a given city. The advantage of these studies is that they do not have to control for a large number of "confounding factors" since the population characteristics (age, smoking, occupational exposure, health habits, etc.) are essentially unchanged.

9.62. A cross-sectional analysis compares differences in health outcomes across several locations at a selected point or period of time and, in principle, captures both acute and chronic effects of particulate pollution. The common concern about these studies is whether potential omitted and confounding variables such as those mentioned above have been adequately controlled for. For example, although individuals may be affected by a combination of pollutants, the presence of other pollutants may not be incorporated into the study due to the limited availability of pollution data. Cohort studies, in which a population sample is selected and followed over time, avoid these types of problems but are expensive and therefore not often carried out.

9.63. One meta-analysis of the results of a number of studies (Commission of the European Communities, 1999) presents an average percentage change in average mortality per microgram per cubic metre ($\mu g/m^3$) change in PM_{10} of 0.040. In other words, the dose-response function relating the increase in mortality to PM_{10} is the following equation:

Change in mortality rates = 0.040 *multiplied by* change in PM_{10} concentration

The total physical impact of a change in PM_{10} concentration therefore depends on the size of the population exposed to the concentration change and the change in the mortality rate of the population.

Coverage

9.64. The vast majority of work on the estimation of dose-response functions has been in relation to the impacts of ambient air quality on health, materials and agricultural crops. These are the impacts that can currently be quantified with the greatest confidence. To a lesser extent the impact of air quality on forests and the impact of noise on amenity have also been quantified with a reasonable degree of confidence. These dose-response functions were surveyed by the Commission of the European Communities (1999 and 2000) where they were applied to the assessment of environmental damage costs from energy and transport across the EU.

9.65. In other environmental media the evidence is less certain and subject to a greater variation in dispersion patterns and confounding factors. To give a simple example, in the case of water pollution the estimation is complicated by the fact that human health is affected less by ambient water quality than by access to clean drinking water and adequate sanitation and by the household's level of income and education. Surveys of the derivation of dose-response functions relating water pollution to health impacts are given in Fleisher *et al.*, (1998) and Preuss (1998).

Applications

9.66. The use of dose-response functions in environmental accounting practices primarily relates to the application of part, or whole, of the impact-pathway methodology, which traces quantitatively the consequences of pollutant emissions from a given source to an increase in ambient concentrations via dispersal to the environmental impact step.

9.67. An estimation of the physical environmental impact may then be converted to monetary terms (provided there are valuation data available) to give an estimate of the value of environmental damage. A large scale application of this methodology has recently been made in the Green Accounting Research Projects, GARP-I (Markandya and Pavan, 1999) and GARP-II (Commission of the European Communities, 1999), where the value of damage was assigned to economic sectors in the United Kingdom, Germany, Italy and the Netherlands. More generally, knowledge of the dose-response function for any specific environmental damage being considered in a policy-making process is valuable, since it indicates the degree to which a polluter must modify its activities to reduce environmental damage to a socially acceptable level. Monetisation of the costs and benefits of changes in emissions further informs environmental policy analysis.

Main results of the GARP project

9.68. Damages have been measured and attributed for impacts of sulphur dioxide, particulate matter and ozone on human health, crops and building materials for Germany, the Netherlands, Italy and the United Kingdom, health damages representing the largest share of impacts.

9.69. Other important results include the effects of different industrial sectors on water pollutant levels in Italy and Germany. These results are useful in targeting policies more effectively towards the most polluting industries and the most damaging pollutants (Markandya and Tamborra, 2001).

Transfer of dose-response functions

9.70. Recently, dose-response functions estimated for one country have been applied to populations lacking their own epidemiological studies in order to estimate the effects of exposure to pollution. Although this practice does provide a rough estimate of the environmental effects in previously unstudied countries, it should be applied with caution.

9.71. Without further testing there is no reason to believe that the dose-response relationship calculated for one area will be exactly the same as that for another. In the case of the air pollution-health context outlined above, differences in the composition of air pollution, in the age distribution of the population, in access to and quality of medical care, in baseline health and education and in other behavioural and socio-economic variables all may cause variations in the response to air pollution.

9.72. Despite these constraints, it may often be sensible to provide some indication of the types of functional relationships to be expected in the context considered, with appropriate caveats describing the uncertainties inherent in such a transfer process.

Conclusions and outlook for future use

9.73. The estimation of dose-response functions has, in recent years, dramatically improved the quantification of environmental damages from a given pollution concentration, particularly in relation to air pollution. Confounding factors are more difficult to control-for in deriving dose-response functions for water and land-based pollution, though some relationships have been estimated.

9.74. Uncertainty in the robustness of existing dose-response functions remains. However, with increased awareness of the impacts of pollution on human health in particular and a need to justify policy actions in cost-benefit and sustainability terms it is likely that further research will refine these functions and reduce the need for function transfer between contexts.

2 Revealed-preference pricing techniques

9.75. The values of some environmental goods or services can be measured using market prices. Some natural resources, such as fish or wood, are traded in markets. There was discussion in chapters 7 and 8 about how a value for these environmental goods can be determined.

9.76. Some ecosystem services, like aesthetic views or many recreational experiences, may not be directly bought and sold in markets but the prices people are willing to pay in markets for related goods can be used to estimate their values. For example, people often pay a higher price for a home with a view of the ocean or will take the time to travel to a special spot for fishing or bird watching. This revealed preference for environmental services can be used as a proxy for the economic or market value of the view or the recreational experience. The methods that use revealed preferences include market valuation of economic losses, hedonic pricing methods and travel cost methods.

Market Prices

9.77. The market price method is limited in its applicability, since much environmental damage cannot be associated with a marketed good directly.

9.78. The effects of environmental damage on a fixed asset may be such that its useful life is fore-shortened or it is less effective than previously. This will result in a fall of the price of the asset and this decrease can, in principle, be attributed to environmental damage. However, if the national accounts calculations allow for the effect of environmental damage on the service life of the asset, this effect will already be captured in the measures of consumption of fixed capital and should not be double counted by allowing for it again as environmental damage.

9.79. Similarly if falling soil quality leads to falling agricultural production, the decrease in the current year will have been allowed for in the measure of agricultural output and should not be deducted a second time. If the consequence is that yield in later years will also fall, so there will be an element to be deducted to allow for the effect of this on the land value. Following the discussion in Chapter 7, this decrease will show the fall in the net present value of the agricultural yield expected in future years.

9.80. There are some cases where maintenance cost techniques may also be appropriate in the damage-based approach. Knowing the cost of restoring some items, an estimate can be made for similar items which have been damaged but not restored or replaced. Some avoidance costs such as the purchase of water purifiers, noise insulation and the like can be considered as a form of defensive or preventive expenditures. At the limit, the amount spent on such items shows how much consumers are willing to pay to avoid the damage or nuisance in the first place.

9.81. Market valuation of economic losses reflects the economic effects of environmental damage but does not include impacts on well-being. Estimates of these impacts would require supplementary information.

Hedonic pricing

9.82. The hedonic pricing method is based on the idea that the market value of goods depends on a number of separately identified characteristics and this dependence can be established analytically. It is a technique increasingly being used to measure the price indices of goods such as computers where the technical specifications change very quickly and it is desirable to isolate the technological effect from the general price effect. The idea can be applied to areas where environmental factors influence prices in order to quantify these effects separately from others.

9.83. Good examples are land and houses. Property values reflect a variety of different attributes, both non-environmental properties such as room numbers and sizes, proximity to work or access to transport and other infrastructures and environmental properties, such as noise levels from road and airports, the surrounding landscapes and so on. Given data on a sufficient number of properties where these characteristics have been identified, it is possible to derive estimates of how much of the price is due to each of the effects. The price effect of the environmental factors can then be taken as a proxy for the market price of the environmental service that they represent.

9.84. Similarly, the technique can be applied to wage rates in different industries to take account of such occupational factors such as noise, air pollution and the risk of fatal injuries.

9.85. The method requires large amounts of good quality data where all the relevant characteristics are enumerated and a high degree of statistical expertise, since the results depend heavily on model specification (see, for example, Braden and Kolstad, 1991).

Travel cost method

9.86. The travel-cost method seeks to estimate a money value on the basis of the amount that people actually pay (in money and time) to gain access to beautiful sites, wilderness and so on, or to avoid various forms of damage and degradation. The costs incurred by visitors to a site are used to determine a demand curve for the recreational value they place upon that site. This can be the basis for estimates of the value of the site, and hence of the significance in monetary terms of benefit or damage to or loss of availability of the site.

9.87. There are typically three components to the "travel costs" that can be directly observed; the direct travel costs such as fuel costs, entrance fees where they exist and the time-costs to the individuals understood as the opportunities that have been forgone in using their time to go to the site. The number of visits an individual will make to a site will be a function of such factors as the distance to the site, how accessible the site is by road, the income of the respondents, the alternative sites available. Cost data can be estimated for different zones around the site. Data on visiting frequencies are in some instances readily available, or might otherwise be estimated through surveys at the site. Statistical methods are used to plot the relationship between travel and time costs and the number of visits made to the site, from which it is possible to calculate an average value per visit. This is subsequently employed to calculate a monetary value for the recreational value of the site.

9.88. To value a change in the environmental quality of the site, the value of the site after the change must be re-estimated. The change in the number of visitors will be an important factor in this but not the only one as the value of the visit could also have changed.

9.89. The quality of the results from this method depends on the validity of the assumptions made in deriving them. Some studies involve multiple variables, allowing for substitute sites, multiple sites visited and time spent on site. The most difficult variable to quantify is the opportunity cost of the time spent getting to and from the site. Further, measuring recreational quality, and relating it to environmental quality can be difficult. The method is limited in scope since it can only be used to value recreational land and watercourses (with public access).

3 Stated preferences

9.90. Many ecosystem services are not traded in markets, and are not closely related to any marketed goods. Thus, people cannot "reveal" what they are willing to pay for these services through market purchases or actions. In these cases, surveys can be used to ask people directly what they are willing to pay, based on a hypothetical scenario. Alternatively, people can be asked to make trade-offs among different alternatives, from which their willingness to pay can be estimated. These methods include contingent valuation which is a direct method and conjoint analysis approaches (contingent ranking, rating, etc.) which are indirect. Both generate welfare estimates of environmental benefits/damages based on stated willingness to pay. The methods are referred to as "stated preference" methods, because they ask people to directly state their values, rather than inferring values from actual choices, as the "revealed preference" methods do.

9.91. Stated preference techniques, unlike revealed preference techniques, can elicit information about both use and non-use values (see, for example, Mitchell and Carson, 1989). This can be a strength when the desired measure is well-being or welfare. Set against that there is continued scepticism about the worth of hypothetical assertions of willingness to pay, though recently there has been growing respect for the techniques at least in academic circles.

Contingent valuation

9.92. The contingent valuation method presents hypothetical situations to a representative sample of the relevant population designed to elicit statements about how much they would be willing to pay for specific environmental services. In some cases, people are asked for the amount of compensation they would be willing to accept to give up specific environmental services. Contingent valuation studies can be conducted as in-person or telephone interviews or mail surveys. The method is called "contingent" valuation, because people are asked to state their willingness to pay, contingent on a specific hypothetical scenario and description of the environmental service. Respondents may be asked a question with only yes or no answers such as "would you pay X for the following service" or more open ended questions allowing the respondent to name their own figure. This method, in its various forms, can be applied for a broad range of environmental questions.

9.93. The results of contingent valuation surveys are often highly sensitive to what people believe they are being asked to value, as well as the context that is described in the survey. Thus, it is essential for contingent valuation researchers to clearly define the services and the context, and to demonstrate that respondents are actually stating their values for these services when they answer the valuation questions.

9.94. Application of contingent valuation methods received a strong boost by the emergence of legal frameworks, notably in the United States, where the question arose (among others) of the role of contingent valuation estimations for defining compensation for damages such as the 1989 Exxon-Valdez oil tanker wreck in Alaska. A panel of renowned economists referred to as the NOAA panel (for National Oceanic and Atmospheric Administration of the United States) chaired by Kenneth Arrow and Robert Solow was established to examine the issue. Their report concluded that:

> contingent valuation studies can produce estimates reliable enough to be the starting point for a judicial or administrative determination of natural resources damages–including lost passive use (Arrow *et al*., 1993).

9.95. The panel suggested guidelines to help ensure the reliability of contingent valuation surveys on passive use values including the use of in-person interviews, a binary discrete choice question, a careful description of the good and its substitutes and the inclusion of several different tests in the report on survey results.

9.96. The approach adopted by the NOAA panel was generally conservative, advocating those procedures that tend to produce modest environmental damage valuations. It included recommendations to eliminate "extreme" responses and to prefer willingness to pay formats to willingness to accept formats since the latter generally resulted in higher values. Other recommendations included attention to the importance of accurate description of policies or programs and information about alternative undamaged "substitute" sites available and the opportunity costs involved, follow-up questions to discover reasons for apparently discrepant replies to willingness to pay questions, procedures for the elimination of "illegitimate" bids, and so on.

9.97. A number of possible sources of bias are often cited in contingent valuation studies including the following:

> Strategic and protest bids – Individuals can understate (free riders), overstate (strategic bidding) or give a zero or very large bid because they do not accept the contingent valuation method itself (protest bidding).
>
> Design effects – The way a bid is elicited can affect the outcome and different elicitation formats will produce different results.
>
> Presentation and information effects – Generally the better the information and its presentation the higher the bid.
>
> Payment vehicle biases – The popularity or unpopularity of taxes has a strong influence on willingness to pay bids, while willingness to pay into a private trust fund can be affected by the perceived trustworthiness of the fund.
>
> Embedding and part/whole effects – Respondents to willingness to pay surveys are apt to bid almost the same for the preservation of watering sites for two thousand migratory birds as they would for 200 thousand (Desvouges *et al*., 1993) or to bid the same to clean lakes in one part of a region as they would for the whole region (Kahneman and Knetsch, 1992). Similar embedding effects can be arrived at by altering the payment periods for the goods in question.
>
> Ordering effects – The order in which options are presented to the individual can affect the payments.

Framing effects – The way options are framed can change the response.

Compliance bias – Individuals may respond in order to try to please the interviewer.

9.98. In the absence of any real market for the goods or damages for which they are attempting to infer values, and given the speculative character of projections into the future, it is difficult to demonstrate that contingent valuation establishes "correct" prices; for example, consistent with allocative efficiency. One validation test is to compare results from different elicitation procedures to see if they converge on the same results. However, results from comparisons of contingent valuation, hedonic and travel-time measures are mixed, and in any case the validity of the comparison depends on the exact parameters of the investigation. Another form of validation is to concentrate on the internal consistency of the method. This involves trying to eliminate sources of ambiguity or "bias" that distort the discovery of the "correct" value for the good or amenity in question. It can also involve inferring the underlying meanings and determinants of people's responses through statistical or sociological analyses.

Willingness to pay and consumer surplus

9.99. No one is constrained to buy particular goods and services in the economy. Notionally each consumer may have a list of the prices he or she is prepared to pay for each of the goods and services desired. Assuming for the sake of simplicity no budget constraint, the individual will purchase those goods and services whose prices are no higher than the matching willingness to pay figure. For many products, the prices will be lower than the maximum an individual would be prepared to pay. The difference between the price paid and the maximum an individual would pay is called the consumer surplus.

9.100. For any single good, there will be at least one purchaser who has no consumer surplus; he is paying the maximum he is willing to pay. Thus the market price represents the willingness to pay only of the last, marginal consumer of the product. Other purchasers of the product will benefit from a degree of consumer surplus but the amount of this will vary with preferences and income levels. Consumer surplus is often identified with satisfaction or welfare and in this connection we should note that it may also vary with the level of expenditure on the product in question. If one is very thirsty, the consumer surplus from the first drink is very high but this falls as the thirst is quenched.

9.101. One problem with the use of contingent valuation to value environmental damage is that it gives an average willingness to pay figure which includes an element of consumer surplus of indeterminate amount. This poses a problem when using contingent valuation in the accounting context, since the national accounts exclude consumer surplus. The absence of budget restrictions in the context of contingent valuation surveys may also lead to higher valuation levels than would be faced in fact and is another source of incompatibility with the national accounts.

Conjoint analysis approaches

9.102. In their recommendations for future research, the NOAA panel referred to the "conjoint analysis" method which has been used in estimating the demand for highly innovative commercial products in the field of market research. The motivation was that practitioners have found that survey methods are better at estimating relative demand than absolute demand.

9.103. Valuation methods based on conjoint analysis differ from contingent valuation because they do not directly ask people to state their values in monetary terms. Instead, values are inferred from the hypothetical choices or trade-offs that people make. The respondent is asked to state a preference between one group of environmental services or characteristics at a given price or cost to the individual and another group of environmental characteristics at a different price or cost. “Conjoint analysis” has been used as a designation for a number of related approaches where choices, ranks or matches between alternatives are involved (Hanemann and Kanninen, 1996).

9.104. There are a variety of formats for applying conjoint analysis including choice experiments, contingent ranking, paired comparisons, contingent rating and self-explication. Whatever format is selected, the choices that respondents make are statistically analysed using discrete choice techniques to determine the relative values for the different characteristics or attributes. If one of the characteristics is a monetary price, then it is possible to compute the respondent’s willingness to pay for the other characteristics.

9.105. Because conjoint analysis focusses on trade-offs among scenarios with different characteristics, it is especially suited to policy decisions where a set of possible actions might result in different impacts on natural resources or environmental services. For example, improved water quality in a lake will improve the quality of several services provided by the lake, such as drinking water supply, fishing, swimming, and biodiversity. In addition, while contingent choice can be used to estimate monetary values, the results may also be used to simply rank options, without focusing on monetary welfare measures. (Hanley and Mourato, 1999; Morrison *et al*., 1999)

9.106. The hypothetical choices in conjoint analysis can relate to both market and non-market goods and services. If it is applied to market prices, then the estimated values are compatible with SNA values. If, however, the technique is applied to willingness-to-pay values, the same ambiguities apply as in the contingent valuation method.

4 Benefit transfer

9.107. Benefit transfer is not a separate pricing technique as such but a practice sometimes used to estimate economic values for ecosystem services by transferring information available from studies already completed in one location or context to another. This can be done as a unit value transfer or a function transfer.

9.108. In a unit value transfer, it is assumed that the well-being of the average individual at the study site is the same as that of the average individual at the policy site. This cannot be done between countries with different income levels and standards of living without making income adjustments. Studies have found error rates of plus or minus 38 per cent on willingness to pay to avoid symptoms of respiratory illness across a number of European countries, which compares with an error within a country of plus or minus 16 per cent from Monte Carlo studies.

9.109. The benefit transfer function is more appealing than transferring unit values because more information is transferred. It can be used in conjunction with travel cost and hedonic pricing (revealed preferences) as well as with contingent valuation or choice experiments (stated preferences). The willingness to pay is set-up as a function of the characteristics of the environmental good or service and the characteristics of households. To apply this, the analyst needs to find a study in the literature with estimates for the coefficients and apply them to his own data values using the estimated equation.

9.110. Instead of using just one valuation study, work has also been done to combine data from several studies in meta-analysis. Environment Canada and the U.S. Environment Protection Agency have set up the *Environmental Valuation Reference Inventory* (EVRI), a network and database of valuation studies categorised by various characteristics. EVRI includes the database, a module to capture new studies, a search engine and a screening module. As of March 2000, the database contained detailed descriptions of about 700 environmental valuation studies, primarily from North America. Its extension to include more valuation studies undertaken in Europe was under way at the time of writing of this handbook.

9.111. Comparative research in benefit transfers has only just begun. Preliminary results suggest that often the results transferred are within a range of plus or minus 50 per cent of the "true" value (that is, a value established by directly applying a valuation method to the new site). In principle, transferability achieves best results when:

- data to be transferred are adequate;
- populations are similar;
- the goods or services in question are similar;
- the sites are similar; and
- the "markets" (that is, the context within which the choice is being made) are similar (for example, they are of similar sizes and have similar substitutes at hand).

9.112. The advantages of using benefit transfer methods are primarily in saving time and costs. Benefit transfer is often used when it is too expensive or there is too little time available to conduct an original valuation study, yet some measure of benefits is needed. However, benefit transfers can only be as accurate as the initial study. In addition caution needs to be exercised about the transitivity of costs and preferences from one situation to another.

5 An assessment of different benefit/damage pricing techniques

9.113. ***Market prices*** are conceptually preferable but difficult to implement in practice because the subjects concerned are not only items which are currently not marketed but those where it may be difficult to envisage normal markets. In these cases other pricing techniques must be used.

9.114. The ***travel cost*** and ***hedonic price*** methods are quite limited in terms of the environmental services and assets they can cover and in terms of providing national aggregates for the issues they can cover. The market valuation of economic losses is also limited in scope since it focusses on marketed assets and well-defined goods and services.

9.115. A common feature of the ***stated preferences*** valuation techniques is that they are concerned with limited, local and relatively small environmental questions. For the construction of environmentally adjusted national income figures these estimates of the values of all the various environmental services need to be aggregated to a national level. That is a formidable problem, as recognised for example by Atkinson *et al.* (1997).

9.116. Applying the ***contingent valuation*** method is generally a complicated, lengthy, and expensive process. In order to collect useful data and provide meaningful results, the contingent valuation survey must be properly designed, pre-tested and implemented. Contingent valuation survey questions must focus on specific environmental services and a specific context that is clearly defined and understood by survey respondents. A contingent valuation survey to access the monetary value of the results of an environmental improvement cannot be based on the environmental improvement itself but on increases in specific environmental services that the improvement is expected to provide.

9.117. Equally significant have been efforts with the more pragmatic intention of arriving at values that are acceptable for policy makers. Particularly influential have been the recommendations of the NOAA panel.

The general conclusions drawn by this panel have given some legitimacy to the application of the contingent valuation method in assessment of environmental benefits/damages (given that the panel's guidelines are followed). Although still controversial, the contingent valuation method has managed to gain increased acceptance amongst both academics and policy makers as an applicable methodology for estimating the monetary value of environmental changes.

9.118. Another U.S. study group (the Panel on Integrated Environmental and Economic Accounting, chaired by William Nordhaus) recognised in its report that "non-behavioural approaches such as contingent valuation have not been thoroughly calibrated and tested to ensure that they are reliable proxies for actual behaviour". It went on to state that "although there are difficulties with non-behavioural approaches such as contingent valuation, work on the development of such novel valuation techniques will be important for developing a comprehensive set of production and asset accounts" (Nordhaus and Kokkelenberg, 1999). However, other expert panels like the German Scientific Council on Environmental Economic Accounting are more reluctant to see contingent valuation used in the context of environmental and economic accounting on a national level.

D Degradation crossing time and space

9.119. It has been noted above that the agent producing degradation is often not the agent who suffers the damage and equally the agent who incurs costs to mitigate degradation is often not the agent who benefits. Further, the time period in which the degradation takes place may not be the same as the period when the damage takes place and the country where the degradation takes place may not be the one where the damage is experienced.

The time dimension

9.120. In all the preceding sections, there has been the implicit assumption that degradation in this period leads to damage in this period and that damage in this period comes from degradation in this period. Clearly this assumption is not always valid. Pollutants cumulate in environmental media and may cause damage long after they were discharged from the economy. There is some limited discussion on the concept of "environmental debt" in Chapter 10.

Cross-boundary flows

9.121. The volume of residuals present in a country's atmosphere, say, does not necessarily coincide with the amount of residuals generated by that country since there may be movements of residuals in both directions across the borders. The territory of a country does not necessarily coincide with discrete ecological areas. Some issues may pertain to a watershed or river basin which forms a country boundary. Taking account of these imports and exports of residuals is important politically as well as in terms of estimating the costs to avoid damage. A discussion of the cross-border flows in physical terms appears in Chapter 3.

9.122. There is no exact way of estimating the value of the damage caused by the domestic country in another country because in general the necessary information (the local dose-response functions for example) will not be available. Usually allowance is made based on volume measures. If the amount of residuals generated locally accounts for 80 per cent of the residuals present in the country, 20 per cent of the damage is assumed to be caused by imported residuals. It is not possible to distinguish damage caused by the same residual according to the country of origin; the damage suffered is related to the level and not the source of the pollutant. If, on the other hand, the residuals present in the country are only 80 per cent of those generated, clearly some have been exported. Evaluating the damage caused in a foreign country may be problematical.

The exact costs will depend on the local conditions which may be very different from those of the residual-exporting country.

9.123. As part of the GARP project estimates have been made of the damage transfer between the countries of the European Union for 1995. These are shown in Table 9.1. The first column shows the value of the damage from residuals as generated in each country in billion ECUs. The next column shows in percentage terms how much of the damage is inflicted on the economy where it is generated. Only in Germany, Greece, Italy and the United Kingdom is this more than half the total. For all the other countries, more than half the total is "exported". The second column shows the export proportions. For the European Union as a whole the proportions retained and exported are each close to half the total. Smaller landlocked countries tend to export more than those with larger land areas and sea coasts. This is not a general rule though. France, which satisfies both these conditions, exports two thirds of the damage generated because a lot of heavy industry is in the east of the country near to borders with others and the prevailing winds are westerly.

9.124. There is no symmetry between the export and import of damages except at the total level. The column for imports shows how much the imported damage is in terms of what is generated domestically. For Austria, for example, just over twice as much is imported as generated making it one of the largest net importers of damage. The other net importers are Belgium, Denmark, Finland, Germany, the Netherlands and Sweden. The other eight countries are net exporters.

9.125. These figures concern flows only between the European Union countries. Figures for flows to and from the rest of the world are not available but important, especially for those countries to the east of the European Union boundaries.

Table 9.1 Transfers of damage between European countries

	Billion ECU	Percentage of domestic generation			
	Generated	Retained	Exported	Imported	Received
Austria	1 204	28.4	71.6	204.3	232.6
Belgium	4 392	12.6	87.4	89.8	102.4
Denmark	1 207	17.5	82.5	173.1	190.6
Finland	242	48.7	51.3	116.5	165.2
France	23 152	33.5	66.5	59.0	92.4
Germany	34 375	64.1	35.9	54.9	119.0
Greece	2 026	77.1	22.9	21.6	98.7
Ireland	747	10.1	89.9	43.5	53.6
Italy	15 829	58.3	41.7	38.4	96.7
Luxembourg	287	0.6	99.4	34.3	34.8
Netherlands	4 880	19.8	80.2	123.6	143.5
Portugal	1 572	27.5	72.5	48.9	76.3
Spain	13 526	34.0	66.0	31.7	65.8
Sweden	536	31.7	68.3	360.2	391.9
UK	24 727	52.1	47.9	26.3	78.5
EU total	128 700	47.3	52.7	52.7	100.0

Source: Commission of the European Communities, 1999.

E Summary and conclusions

1 Methodological reservations

9.126. An objective often put forward by economists for environmental cost-benefit analysis is to compare the costs of obtaining further environmental improvement (or avoiding further damage) with the benefits obtained. The situation where the cost of reducing by one extra unit the environmental damage is equal to the value of the extra benefits obtained is an economically optimal level of goods and damages production. This optimisation approach requires monetary estimates of the "marginal benefits" and the "marginal costs" of the environmental protection or enhancement action.

9.127. Unfortunately, none of the methods for valuing unpriced environmental services and assets reviewed in previous sections is ideal for this purpose and several drawbacks must be noted when these methods are used at the sectoral and national scale and under the consistency requirements of the national accounts. These drawbacks refer to issues such as coverage (some methods can only be used to value a very limited sub-set of environmental services or assets), incompatibility with the valuation principles of national accounts in terms of the time they refer to or the values they generate and the difficulties and costs of obtaining and interpreting the basic data (physical and monetary) needed for these valuation methods.

9.128. Quite apart from estimation difficulties, it is important to note that cost and benefit considerations usually arise separately and do not automatically balance. In particular, in order to link cost-of-supply figures to "environmental value" as such, it would be necessary to introduce the proposition that the (marginal) cost of supply is equal to the (marginal) environmental benefit. Since this is not automatically true (and, indeed, will usually not be true in any real situation), it is important to assess the extent to which and under what circumstances this proposition is likely to be approximately valid or can be considered as a policy reference point.

2 The suitability of pricing techniques

9.129. The valuations of the environment obtainable through observation or inference of people's actual choices fall into four main categories:

real costs incurred due to legally binding avoidance, compensation or restoration obligations;

expenditure voluntarily undertaken to avoid or limit damage;

people's "revealed" preferences for obtaining specified environmental services or amenities;

people's "stated" or hypothetical preferences as elicited through contingent valuation (that is, willingness to pay or willingness to accept enquiries).

9.130. Monetary estimates of environmental benefits and damages can have a clear policy-relevance but the "prices" are not necessarily comprehensive in the sense of taking into account all environmental benefits and harms.

9.131. The level of costs incurred, whether imposed by regulation or by choice, are seldom strictly determined by the level of any benefit which may be result. The absence of a clear link can be due to either estimation difficulties, because the full costs and benefits are not known when the estimates are made or, simply to the fact that not all of these are taken into account.

9.132. Travel cost and hedonic pricing methods reveal preferences from the behaviour of consumers in markets. Figures obtainable through both these sorts of analyses put a monetary value on the specified individuals' or agents' preferences for environmental goods and against damages relative to other uses of their own time and money. These payments most often relate to tangible use values of the environment over which the user has some power of choice. They cannot be expected to cover the value that might be attached to the feature or amenity by others or in the future.

9.133. The same remarks apply, generally, to the stated willingness to pay (or the demand for compensation). Individuals may state a willingness to pay for an environmental amenity. A commercial firm may express one for access to a needed input or environmental service such as timber or volumes of water of a particular quality or use of a river or sea as a receptacle for waste. The absence of any real market for the goods or damages in question makes it impossible to demonstrate that contingent valuation establishes "correct" prices, which inevitably leaves the figures obtained open to controversy.

9.134. On the benefits side, it is generally agreed that there can be estimation difficulties. Some of these relate to "non-capture" of identifiable categories of benefits or damages in the valuation. Others relate, however, to difficulties of the subject matter. The national accounts studiously avoid placing values on externalities and the pricing techniques applied in national accounts are not well suited to their inclusion. However, the application of environmental cost-benefit valuation techniques involves the attempt to extend and transpose traditional economic valuation methodology into this area.

3 Data limitations

9.135. As the descriptions of the valuation methods show, physical data sets and accounts are a crucial precondition for valuation in various respects. Physical quantities such as stocks of environmental assets, volumes of flows of environmental services, volumes of residual flows, extent of environmental damage in physical terms, etc., are necessary to determine the total values. In addition, for some methods detailed inter-linked physical accounts are necessary to enable valuation and to support the analytical applications of the environmental accounts. Cases in point are the avoidance-cost calculations where detailed data on the technologies used by different industries and households, on the residual flows generated by industries and households, etc., are necessary, as they are for damage valuation *via* dose-response functions.

9.136. Using the described valuation methods in the SEEA context imposes certain conditions. It is essential to avoid double counting and to be careful that the valuations are compatible when using different valuation methods simultaneously. When valuing the benefit/damage side, it is often necessary to use several valuation methods to capture as many affected values as possible, since the available methods cover different aspects of the benefit/damage. On the cost side, avoidance and restoration costs can also be overlapping.

9.137. In the case of pollution, the damage-side and the cost-side valuations are incompatible if a significant part of the pollutants deposited come from abroad since the avoidance costs refer to domestic emissions. Further, if the damage valuation is limited to a few of the effects, as is often the case when applying market price methods, it should be underlined that the valuation is only a lower bound for the damage costs.

9.138. A popular view amongst environmental economists is that it is (relatively) straightforward to make estimates of the economic costs of avoiding particular categories of damage or natural resource depletion but it is much more speculative to obtain monetary estimates for the benefits of such action. In fact detailed empirical work on firm-level environmental expenditures and statistically based sectoral estimates of abatement cost curves suggests that cost-side information is very heterogeneous and often somewhat speculative, even for well-defined investment and technology choice situations. Consequently, even though more firmly based than damage estimates, robust "supply-side" valuation information is not as easy to come by as one might like to hope. An illustration of this can be seen in the GREENSTAMP project (Brouwer *et al*., 1998).

Chapter 10 Making environmental adjustments to the flow accounts

A Chapter overview

1 Introduction

10.1. Chapters 3 to 9 describe various aspects of environmental accounting as currently practised. They cover physical accounts and some aspects of monetary accounts either alone or in combination. All the techniques discussed there are relatively new. There is some, but very little, history of these types of accounting going further back than a decade. When the SEEA 1993 was published, it was in a real sense a blue-print of what might be done rather than a discussion of what had been done.

10.2. Significant progress has been made in the last decade. Instead of environmental accounting being an occasional one-off exercise in a developing country, many of the techniques described in the earlier chapters have become embodied in statistical work programmes, particularly in the countries of the European Union thanks to the leadership and financial assistance provided by Eurostat. Even so, those countries involved in this process would be among the first to recognise that much remains to be done. Accounts for environmental protection expenditure may be established, but those for resource management are much less well developed. Hybrid supply and use tables for air emissions are now almost commonplace but similar accounts for water use and waste disposal are still in their early stages. Thus, while noting the enormous strides made in environmental accounting over the last ten years it is a legitimate question to ask what has not been done.

10.3. The largest question is can we calculate a measure of GDP that adequately accounts for demands placed on the environment? The simplest and most honest answer is that there is no consensus on how "green GDP" could be calculated and, in fact, still less consensus on whether it should be attempted at all. Instead of reviewing current best practice, this chapter is more tentative and thus less consensual. It tries to be deliberately two-faced. On the one side, it aims to look at the very edge of the present developments in environmental accounting and to describe what may be potential ways forward to some measure of a "greener" GDP. On the other, it tries to spell out exactly what are the risks of pushing the techniques beyond their statistical and theoretical underpinnings. It is for each reader to make a considered choice, based on both sets of information, of his or her own view about whether a measure of green GDP is desirable, practicable or feasible. This handbook deliberately makes no value judgement on the issue. It aims simply to say this is how you might proceed and this is why you may decide not to do so. The whole of this handbook is likely to be subject to significant revision in the short to medium term and that applies in particular to the present chapter.

2 Objectives of the chapter

10.4. The theme in this chapter is how the conventional national accounts could be adapted to show the interaction between the economy and the environment in monetary terms. Proponents of making environmental adjustments to national accounts aggregates usually cite three areas where they feel the SNA does not pay adequate attention to the use of the environment. The first is that when environmental assets, such as oil, are "used up" an adjustment should be made to show that the conventional measure of domestic product is overstated because no allowance has been made for the ***depletion*** to the stock of the asset. The second argument is that measures to protect the environment, ***defensive expenditure***, only correct some harm done by an activity measured elsewhere in the accounts and that it is incorrect to count both the harm done and the correction. The third concern is that despite the fact that some defensive expenditure takes place, there is more harm done to the environment which is not remedied and that the resulting ***degradation*** should also be treated as a decline in the environmental wealth of the nation and taken into account in similar ways to the decline in other stocks of wealth.

10.5. One section of the chapter is devoted to each of these topics. Within each section, there is discussion of the theoretical considerations for and against bringing the issue into the satellite account measure of macro aggregates.

Depletion

10.6. Section B is concerned with measuring depletion. It starts from the discussion in Chapter 7 about how to estimate the value of the stock of a natural resource and considers how changes in the value of the stock might be considered to affect the value of national income. Depletion of cultivated livestock has always been accounted for in the calculation of GDP and, since the introduction of the 1993 SNA, so has depletion of cultivated plants. Economic accountants have long been aware that the SNA does not treat consumption of fixed capital and depletion of natural resources in a parallel manner. Section B discusses how non-cultivated biological resources, land and subsoil deposits might be handled in a similar way to their cultivated biological counterparts. It also discusses the possibility of treating those natural resources which are the subject of activities such as exploration that add value to the resources (oil and gas for example) as fixed capital.

10.7. The theoretical and practical issues discussed in this chapter echo those described in Chapter 7 since the possibility of determining the impact of depletion on income depends crucially on being able to estimate the changes in value of the stock of an asset and the reasons for these changes.

10.8. Natural resources have owners and, as well as considering the possible impact on national income, Section B also discusses the impacts on income at a sectoral level. This may be of particular interest when the user of the resource is not the same unit as the owner so that the benefit accrues to one sector and the cost falls on another.

Defensive expenditures

10.9. Defensive expenditure is the subject of Section C. This term is widely used by commentators on environmental accounting but seldom by national accountants. It can be used in respect of various types of expenditure including, for example, defence expenditure; the concern here is with expenditure undertaken to combat environmental degradation. Even here it is difficult to be entirely specific about what constitutes defensive expenditure. Environmental protection expenditure is one clear candidate. Other examples include the administration necessary to establish and monitor fishing quotas or health expenditure related to atmospheric pollution.

10.10. In much of the discussion in Section C environmental protection expenditure will be used as the prototypical example of defensive expenditure. Environmental protection expenditure is already measured in the economic accounts. The means by which this is done are discussed in detail in Chapter 5. The problem is that some commentators perceive an asymmetry between current environmental protection undertaken by government which adds to the measure of economic activity and that undertaken by private industry which on the whole does not. The reasons for this asymmetry are discussed and the reasons to reject the simplistic proposal to simply omit all environmental protection expenditure from GDP.

10.11. Just as a better measure of total environmental protection activity can be obtained as explained in Chapter 5 by changing the SNA conventions on measuring ancillary activity, so a similar adjustment to the conventions is proposed which would lead to the symmetric treatment of all environmental protection expenditure in the accounts.

Degradation

10.12. Both depletion and defensive expenditures are measured in the national accounts. What is for discussion is the conventions by which they do or do not affect the conventional aggregates. In contrast, most degradation is not measured in the conventional accounts. A notable exception is degradation of land but this is usually encompassed under the heading of depletion. Degradation of air and water is not measured directly though some consequences may be captured indirectly; for example, health expenditures associated with atmospheric pollution. Section D discusses how the accounts can be used and extended to reveal a measure of domestic product and income which pays attention to the qualitative state of environmental media as well as to quantitative stock of natural resources.

10.13. There are two main ways to approach the problem. One is *via* the wealth approach to explore how far the stock of assets is damaged by a fall in the quality of environmental media. The other is an income approach which tries to quantify the income available for use when environmental standards are upheld. When discussing the alternative ways to place a valuation on degradation in Chapter 9, it was made clear that there is no guarantee that cost-based and damage-based estimates of degradation will be equal; indeed in general they will not be equal. Therefore, incorporating adjustments based on these valuation methods will not give alternative measures of macro-economic aggregates or, to be more precise, a measure of stocks and one of income which are perfectly coherent. This lack of coherence as well as an approach to restore it are also discussed in Section D.

10.14. Translating valuations of degradation into adjustments to macro-economic aggregates takes us beyond the realm of *ex-post* accounting into a much more hypothetical situation. It is the speculative nature of this sort of accounting which means that this is the area of greatest discomfort and strongest resistance for many accountants. Not only do the theoretical and practical problems of the techniques proposed have to be considered, so too does the institutional responsibility of the account compilers.

Completing the accounts

10.15. Chapter 7 discusses the basis of valuing natural resources and how the value to go into an asset account or balance sheet is related to the resource rent which accrues in an accounting period. It also discusses how part of the resource rent can be identified with a decline in the value of the resource stock and part taken as the return to the resource. This chapter builds on that analysis to show how the flows of resource rent carry through the whole of the accounting system and how the accounts might be extended to permit variations in the conventional macro-economic aggregates to be revealed.

10.16. No single alternative satellite account is recommended. In each of sections B to D a set of options is presented on possible approaches to the topic under discussion. Together they present a range of alternatives, some closer to the conventional accounts and some further away.

10.17. The final section of the chapter, Section E, looks at the sets of options available and considers which may be combined and which are internally inconsistent. It recapitulates the theoretical and practical issues involved. There is also consideration of the practical possibilities given the data needs and availability and a consideration of the quality of any possible adjustment. It contains example accounts for key resources consistent with tables in earlier chapters. It reaffirms the point made at the outset to this chapter that there are no recommendations of what should be done in this area, simply a set of options which might, at some point and by some people, be considered.

10.18. Just as there will be some readers who will ignore part or all of earlier chapters, there will be some who do not read this one. That should be expected in a book of this length. It should be acknowledged, though, that some of those who collaborated in the preparation of the handbook would prefer that this chapter were omitted from the book. A number of reasons underlie this position. Some people still have serious reservations from a theoretical point of view about incorporating the presumed effects of environmental flows into the well-established economic accounts. Some reservations have a practical rather than theoretical basis on the grounds that the data problems are still too formidably difficult to proceed at this time. Some statistical offices are constrained by institutional responsibilities to restrict their attention to the past and observed behaviour and it is often argued that in these circumstances, while staff of a statistical office can and should collaborate with external researchers to explore environmental accounting issues, it is not appropriate for the statistical office to undertake this work directly and alone. Set against these misgivings are the arguments that the proposals included here are the logical culmination of the work described in the preceding chapters and to omit the chapter would be to leave the work incomplete in an important respect. Readers interested in hypothetical accounting should be able to find some guidance here not only about the implications of the work described in previous chapters for proceeding towards adjusted aggregates but also warnings of the difficulties and uncertainties involved. This, and only this, is what the chapter aims to do.

B Depletion

10.19. Before addressing the question of how to account for depletion, it is useful to recapitulate the discussion on asset accounts and on the calculations associated with economic and resource rent from Chapter 7.

1 Asset accounts

10.20. Table 7.4 in Chapter 7 shows the format of the SNA asset account and Table 7.11 shows how the asset account interfaces with the flow accounts of the system. Opening stocks are subject to changes due to transactions (which are recorded in the capital and financial accounts) and to changes not due to transactions (which are recorded in the other changes in assets account) to reach a figure for closing stocks. Changes in produced assets appear in the flow accounts of the system unless they concern catastrophic losses, obsolescence, valuation changes or reclassification due to changes in ownership and structure.

10.21. Most of the items which appear in the SNA account for other changes in assets relate to the economic appearance and disappearance of non-produced assets. These assets are recorded in the flow accounts only when they are the subject of transactions, as with their purchase or sale. Many of these non-produced assets are environmental assets; specifically natural resources and land.

10.22. Table 7.5 and the discussion around it show how the SNA asset account can be slightly reformulated to a SEEA account for environmental assets. The idea of additions to and deductions from stock levels was introduced which included the SNA items in the other changes in assets account relating to economic appearance and disappearance of environmental assets but allowed for physical appearance with no monetary valuation and excluded monetary disappearance when there was no corresponding physical disappearance.

Other than these two main groupings of items, the same three items are left as other changes in assets as in the SNA account for produced assets: catastrophic losses, valuation changes and reclassification due to changes in ownership and structure.

10.23. The heart of the discussion about integrating environmental issues within standard economic accounting is about incorporating additions to and deductions from the stock of natural resources within the flow accounts. The rationale for this is a change in the primary focus of the economic accounts from a concentration on production itself to see how economic production affects measures of wealth which include environmental assets and measures of income which are concerned about maintaining the levels of these assets as well as of produced assets.

2 *Economic rent and resource rent*

10.24. There is a general understanding that the use of natural resources could be measured in a way that is broadly consistent with the use of fixed capital. This assumption underlies the discussion in Section D of Chapter 7 of how stocks of mineral resources should be valued. Just as with fixed capital, the stock value can be estimated, at least theoretically, as the net present value of the future stream of benefits coming from the use of the resource. The benefits are equated with economic rent which is embodied in gross operating surplus of an enterprise. This can be partitioned into two parts, one part relating to the economic rent coming from the use of produced assets (fixed capital) and the other part due to the use of non-produced assets (natural resources). The term resource rent is used for this second element, that part of gross operating surplus of the enterprise using the resource which is not attributable to the fixed capital at the unit's disposal.

10.25. Further, as also explained in Chapter 7, the economic rent arising from the use of a fixed asset can be partitioned into an element representing the decline in value of the asset, the consumption of fixed capital, and the remaining element which is taken to be the income arising from the use of the asset and which is incorporated in the net operating surplus of the unit. Similarly, the resource rent can be partitioned into an element showing the decline in value of the natural resource and the return to its use. The algebraic derivation of this partition is given in the following paragraph.

10.26. In Chapter 7, the notation RR_t for the resource rent was introduced to represent a unit resource rent in period t (denoted by rr_t) times the level of extraction E_t. As before, r represents the discount rate, and n the life length of the asset. $RV_{t-1,}$ the value of the asset at the end of period t-1 (that is, at the start of period t), can be written as:

$$RV_{t-1} = \frac{1}{(1+r)} RR_t + \frac{1}{(1+r)^2} RR_{t+1} + \frac{1}{(1+r)^3} RR_{t+2} + ... + \frac{1}{(1+r)^n} RR_{t+n-1}$$

This formula assumes that the rent is paid at the end of the year and thus even the first year's rent needs to be discounted. Transforming the equation leads to:

$$RV_{t-1} - \frac{RV_t}{(1+r)} = \frac{RR_t}{(1+r)}$$

By manipulation of this equation, the resource rent RR_t can also be written as:

$$RR_t = (RV_{t-1} - RV_t) + rRV_{t-1}$$

The first of these terms shows the difference in the value of the asset between the start and end of the period in question. The second term represents the income element in year t and represents the return to the capital asset in question.

10.27. At this point a decision has to be made about the way natural resources are regarded. Box 10.1 describes three options on how to identify the income element of the resource rent. One view is that the resources are so abundant that the whole of the resource rent can be regarded as income. As pointed out in Chapter 7, this was the assumption in the 1968 SNA. This is equivalent to saying that the term $RV_{t-1} - RV_t$ is zero; that is, that there is no decline in the value of the stock of the resource.

10.28. Another assumption is that the value of the resource in the future would be the same to future generations as it is to present generations today. There is thus no applicable rate of discount (r=0) and the second term in the last equation becomes zero leaving the whole of the resource rent to be treated as the decline in the value of the stock of the natural resource. Another interpretation of this view is simply that revenues obtained from selling natural assets are not income from production and thus all should be excluded from NDP, even those coming from the sustainable use of a renewable asset. This is the view advanced, for example, by Vanoli (1995).

10.29. This last view is equivalent to saying that natural resources should not be regarded as factors of production in the same way that fixed capital and labour are, because they were not produced. Although land is a natural resource, it has traditionally been regarded as a factor of production and income arising from its use as part of income from production. Most commentators would extend this treatment to all natural resources and so choose to partition the resource rent between an element which is regarded as income and one which is regarded as the using up of the asset. The solution, though, has to be generalisable to the case when the income element is either zero per cent or one hundred per cent of the resource rent.

10.30. There is extensive economic literature on this topic. One way of partitioning the resource rent into a perpetual income stream and a depletion element was put forward by El Serafy (1989) as the “user cost approach”. The resource rent (RR) in any period is split into an income element (X) and a depletion element (RR-X). The assumption is that the resource would provide an equal economic rent for each of n years, so its value is the net present value over n years of RR. The income element has to be such that the net present value of X over an infinite period has to be the same as the net present value of the resource. The net present value of the resource is:

$$NPV(RR) = RR\frac{1-\frac{1}{(1+r)^n}}{1-\frac{1}{1+r}} = RR\frac{(1+r)}{r}\left\{1-\frac{1}{(1+r)^n}\right\}$$

The net present value of the income stream is simpler since it is an infinite sum:

$$NPV(X) = X\frac{1}{1-\frac{1}{1+r}} = X\frac{(1+r)}{r}$$

Setting these equal, the proportion of each year’s resource rent which should be treated as income can be derived as:

$$\frac{X}{RR} = 1-\frac{1}{(1+r)^n}$$

Other methods include Hotelling (1931) and Hartwick (1990). Whichever method of splitting income and extraction is used, the longer the life length and the higher the interest rate, the greater will be the share of income. If a zero rate of interest is used as a social discount rate, which assumes that the benefit of resources to future generations has the same value as the benefit today, then there is never an income component to the economic rent; it is all regarded as extraction.

Box 10.1 Options for identifying the income element of resource rent

Option A1. All resource rent represents income. In this case $RR_t = rRV_t$ because RV_t is equal to RV_{t-1}.

Option A2. No resource rent represents income; it is all a decline in the value of the resource. Thus $RR_t = (RV_{t-1} - RV_t)$ because the rate of return, r, is taken to be zero.

Option A3. Part of the resource rent represents a decline on the value of the asset and part is income. In this case $RR_t = (RV_{t-1} - RV_t) + rRV_{t-1}$.

Consumption of fixed capital and depletion

10.31. The first term in the expression for resource rent given in paragraph 10.26, $RV_{t-1} - RV_t$, represents the value of the decline in the asset under consideration. For produced assets, this corresponds to consumption of fixed capital. For non-produced assets, or natural resource in this case, it may instead be called the depletion of natural assets.

10.32. The word "depletion" is commonly used with different meanings. It is sometimes used to denote the total volume of extractions of natural resources times the unit resource rent. It is sometimes used to represent the effect of extractions on the value of the stock of the resource, once the return to natural resources has been taken into account. In this text, the word "extractions" (sometimes "harvest", sometimes both) is used in the first sense and is synonymous with resource rent. Depletion is used, as in the SNA, in the second sense to mean the change in value of the stock of the resource.

3 Accounting for changes in the stock levels of environmental assets

10.33. Any use of an environmental asset raises the possibility of some deductions from stock levels so this item is discussed before the recording of additions to stock levels. It is also useful to look into the difference between recording gross deductions and deductions net of additions. First, however, we review the derivation of rent in the accounts.

Deductions from the stock of environmental assets

10.34. The generation of income account in the SNA is very simple. Under resources, it shows gross value added as generated in the production account and, under uses, compensation of employees and payment of taxes on production less any subsidies received, leaving gross operating surplus as the first balancing item. From this, consumption of fixed capital is deducted to leave net operating surplus as shown in Box 10.2.

10.35. For simplicity, taxes less subsidies on production are assumed zero in this section and are not included in each representation of the derivation of various measures of operating surplus. Compensation of employees is included not only because it is always a large item but as a reminder that in an industry with self-employed producers, a deduction for compensation of labour must be made to convert from "mixed income" to a measure equivalent to "gross operating surplus".

Box 10.2 The SNA generation of income account

Generation of income account Gross value added *less* compensation of employees *equals* gross operating surplus *less* consumption of fixed capital *equals* net operating surplus.

10.36. It is demonstrated in Chapter 7 that we can express gross operating surplus as the sum of two items, the economic rent on fixed capital and resource rent. If we deduct the economic rent on fixed capital (the value of the capital services they render) from gross operating surplus we derive resource rent explicitly. If we then add back the returns to fixed capital we again derive net operating surplus as measured in the SNA because the returns to fixed capital are equal arithmetically to the economic rent less consumption of fixed capital. Thus an extended form of the generation of income account can be developed as follows.

Gross value added
less compensation of employees
equals gross operating surplus
***less* value of capital services rendered by fixed capital**
***plus* returns to fixed capital**
equals net operating surplus.

10.37. This account contains nothing which is not implicit in the SNA account; it simply partitions gross operating surplus into conceptual components. There are those who find the techniques involved too far from direct observation to be quite comfortable but they are the same sort of techniques used to calculate consumption of fixed capital itself. This extended account provides information needed for productivity studies and a more comprehensive identification of the returns to natural resources. It also gives information on the value of total abstractions of natural resources.

10.38. Just as the consumption of fixed capital can be expressed as the services of fixed capital less the returns to fixed capital, so the impact of depleting assets can be expressed as the extraction of natural assets less the return on natural assets. If in addition to the derivation of net operating surplus, the impact of depletion (the value of the extractions less the return to natural resources) is deducted, then another balancing item can be derived which may be called depletion-adjusted operating surplus.

Gross value added
less compensation of employees
equals gross operating surplus
less value of capital services rendered by fixed capital
plus returns to fixed capital
equals net operating surplus
***less* extraction of natural resources**
***plus* returns to natural resources**
***equals* operating surplus adjusted for the depletion of natural resources.**

10.39. Because we are using depletion in the sense of a net change in the stock of an asset, "depletion-adjusted" extends the concept of net [of consumption of fixed capital] as applied to balancing items to mean less the effect of usage of both fixed capital and natural resources.

10.40. The version of the account given here is the most general one where it is assumed that the resource rent is partitioned into a depletion and an income element. If option A1 from Box 10.1 is used, there will be no depletion and therefore there will be no difference between net operating surplus and depletion-adjusted operating surplus. If option A2 from the same box is used, then there will be no returns to the natural resource and depletion-adjusted operating surplus will be equal to the value of net operating surplus less the whole value of the resource rent from extraction.

10.41. In principle such an account could be compiled for an enterprise, an industry (possibly at a disaggregated level such as oil extraction rather than all subsoil asset extraction) or for the economy as a whole. Before considering this sort of disaggregation, though, it is necessary to consider what adjustments, if any, should be made for additions to the stock of natural assets.

Increases in the stock of cultivated biological assets

10.42. Biological assets, being renewable, are somewhat trickier to account for than strictly non-renewable assets. Let us first consider produced or cultivated biological assets such a herd of dairy cattle. The analysis developed so far holds for each individual animal existing at the beginning of the year. By the end of the year, the dairy cow is a year older and the potential future milk yields will be lower than at the beginning. However, for the herd as a whole, it is likely that some of the cows will have had calves which will be retained for milk production in future. Equally some of the cows alive at the beginning of the period may have died or been sent to slaughter. The herd of cows at the end of the period, therefore, is not necessarily the same as the herd at the beginning but one year older. While our analysis of the value of each individual cow fits the model we have developed, we cannot apply it to the herd in a collective sense without making allowance for the regeneration which takes place in a year.

10.43. The SNA makes clear that the correct way to measure this regeneration is to measure the decline in the value of the cows extant at the start of the year and treat this as consumption of fixed capital while at the same time measuring the addition of new stock as new fixed capital formation, very possibly produced on own account. In many cases, though, this will be a counsel of perfection and consumption of fixed capital will be calculated on the basis of the net change in the herd. (This may be so particularly in developing countries where the only information regularly available is of the total stock of animals at given points in time.) If there is no change in the size of the herd, and if the age composition of the herd does not change from one year to the next, there will be no change in its value. In such circumstances, in practice there may be neither gross fixed capital formation nor the exactly offsetting consumption of fixed capital recorded. When the composition of the herd does change, only a net figure may be recorded. Unless special adjustments have to be made for extraordinary events such as drought or devastating disease, the net figure will appear as net fixed capital formation if positive and consumption of fixed capital if negative. Although recording only net changes in capital formation gives net measures of income which are correct, conceptually some income and some consumption of fixed capital is missing from the accounts.

Additions to the stock of non-cultivated biological resources

10.44. Non-cultivated biological resources also, of course, benefit from regeneration. As noted before, it is the assumption that there is no net reduction in the stock of natural resources which leads to the conclusion that there is no need to make an allowance for its depletion. This assumption is clearly unjustified in a number of cases; for example, concerning tropical rainforests and wild fish stocks of many species.

10.45. The first adjustment which is helpful to the elaboration of the generation of income account is to separate extraction of natural resources into two elements, one relating to biological (regenerating) resources and the other to non-renewable resources. For the moment we consider non-produced biological resources only and return to non-renewable resources below.

10.46. In the SNA, and the SEEA, gross operating surplus includes the resource rent from extractions or harvest of non-produced biological resources. In the SEEA the desire is to identify this explicitly. It is also desired to establish the impact on the stock levels of these resources. This may be done in two stages, by first calculating the impact on stock levels of the extractions and then allowing for the additions to the stock levels coming from natural growth. Alternatively, a single net effect on the level of the stock can be calculated which combines the effects of extractions and natural growth.

10.47. The previous version of the generation of income account can thus be amended to accommodate these extensions.

Gross value added
less compensation of employees
equals gross operating surplus
less value of capital services rendered by fixed capital
plus returns to fixed capital
equals net operating surplus
less **gross** extraction of non-produced biological resources
plus returns to non-produced biological resources
plus **natural growth of non-produced biological resources**
equals operating surplus adjusted for the depletion of non-produced biological resources.

10.48. The relationship between depletion-adjusted operating surplus and net operating surplus depends on the relationship between the physical measures of harvest and natural growth. If they are exactly equal, there is no net depletion and so depletion-adjusted operating surplus is identical to net operating surplus. When the harvest is greater than natural growth, the depletion-adjusted operating surplus will be less than net operating surplus. The wider the gap between the two, the less sustainable is the harvest. But what is recorded if natural growth exceeds the harvest?

10.49. In the case of a product where there is no restriction on regulatory harvesting, it should be assumed that it is harvested up to the point where demand for the item is satisfied and that for any quantity in excess of this amount the marginal economic rent has fallen to zero. If the harvest exceeds this level, the price of the product will fall so that the harvester will not even cover his costs. Since the value at which non-cultivated assets enter the balance sheet is the economic rent, there is no extra value to be added even when there is a physical addition to the stock of the item over the year.

10.50. Suppose on the contrary that there are restrictions on the harvesting of the product; for example, the existence of fishing quotas to prevent the ultimate extinction of species. The increase in physical stock levels would have a monetary value since the harvest was truncated before the marginal economic rent sank to zero. On the other hand, unsatisfied demand may have increased the economic rent of those fish harvested by increasing the price for the landed fish. In this case, the outcome will depend on the market conditions.

10.51. What this does reinforce again, though, is the need to have both quantity and value information available to fully assess what is happening to the stock of an asset. The analysis in the last few paragraphs assumes that the composition of the stock in terms of species and age composition is unchanged by repeated periods of harvest and natural growth. If the stock in question is not homogeneous, then it is necessary to look at the harvest and natural growth by species and cohort separately.

Additions to the stock of other natural resources

10.52. Before considering the case of mineral and energy resources, it is useful to review briefly the treatment of major repairs and improvements to produced assets in the SNA. A major repair to an asset such as an aeroplane is defined as one which increases it efficiency or prolongs its life. It is treated as gross fixed capital formation. This adds to the current value of the asset and slows, or at least prolongs, the decline in the future. Thus, there is an immediate impact not only on the value of the asset but also of the capital services it renders, the return to it and the value of consumption of fixed capital to be associated with it.

Land improvement

10.53. A particular case of interest is that of land improvements. These are described in the SNA as follows.

> The total stock of land is not fixed. For example, it may be marginally increased or decreased by reclaiming land from the sea or by erosion by the sea. Its quality may also be improved by clearing forests or rocks and by building dykes, irrigation channels, or windbreaks, etc. Similarly, its quality may be damaged by inappropriate agricultural use, pollution, natural disasters, etc. Activities that lead to major improvements in the quantity, quality or productivity of land or prevent its deterioration are treated as gross fixed capital formation and are shown separately in the classification. These activities represent productive activities that add to the value of land. (1993 SNA paragraph 10.122)

10.54. The appearance of new land is recorded as gross capital formation and not as economic appearance because it is the result of productive activity. In the balance sheet, though, the value of the produced part of land is aggregated with the much larger value of non-produced land into a single aggregate which is classified as a non-produced asset At the same time, however, the value of the land improvement is subject to consumption of fixed capital in the same way as other fixed capital formation; that is, the consumption of fixed capital is the change in value of the enhancement to the land. Where it is a question of structures such as dykes, the life length and decline in value may be obvious. For other improvements affecting the soil fertility directly, it may be that there is little if any deterioration.

Mineral and energy resources

10.55. Occasionally there is complete and exhaustive knowledge about the extent of mineral or energy deposit even before extraction starts. However, because by their nature most such deposits occur below ground level this is seldom the case. Initial estimates of the extent of the deposit must be made and verified before it is economic to start extraction. Once extraction has started, it is common for the estimates to be revised, often but not always upwards. The question to be addressed now is how to record the initial discoveries and subsequent revisions.

10.56. There is extensive discussion of the process of delineating mineral exploration from the valuation of the subsoil deposit itself and of the valuation options in Section B of Chapter 8. For convenience, the options given in Box 8.1 are reproduced here as Box 10.3. They are now qualified by the letter B to distinguish them from other options in this chapter.

10.57. Options B1 and B2 are consistent with the SNA which states that the value of mineral exploration should be recorded as gross fixed capital formation in the form of an intangible produced asset while the valuation of the deposit is recorded as a tangible non-produced asset.

10.58. Unless separate valuations of each is available (option B1), the process of valuing the deposit using net present value techniques means that the higher the costs of exploration the lower the value of the non-produced asset and *vice versa* (option B2).

10.59. An alternative recording, option B3, records a single asset incorporating the value of the exploration activity as well as that of the deposit itself. The combined asset, described as a developed natural resource, is recorded as a tangible produced asset and allows additions to these sorts of natural resources to be treated in the same way as capital formation. This process of combining produced and non-produced assets into a single entry in the balance sheet is similar to that adopted for land, but in this case, since it is assumed that the produced element predominates, the single combined asset is treated as produced whereas land remains non-produced.

Box 10.3 Options for recording mineral exploration and mineral deposits

Option B1 is to record values for both the mineral exploration and the mineral deposit which come from independent sources, neither depending on a calculation of the resource rent of the deposit. There is no guarantee in this case that the sum of the assets will exactly match the net present value of the stream of resource rents; the total may be either greater or smaller than this depending on the assumption underlying the valuation of the deposit.

Option B2 is to record the value of mineral exploration based on either market prices or costs (depending on whether it is carried out by a contractor or on own account) and to base the value of the mineral deposit on the net present value of the resource rent calculated to exclude the value of mineral exploration.

Option B3 leads to identical values as option B2 but treats the sum of the two values as attributed to a "developed natural asset" which would be recorded as a tangible produced asset. By contrast, in the SNA mineral exploration is classified as an intangible produced asset and the mineral resource as a tangible non-produced asset. There is no impact on the asset account or on the balance sheet of this change (except for headings used) but there are changes implied for the flow accounts as explored below.

10.60. There is an analysis in Chapter 7 of the effect of a number of factors on the stock of mineral and energy resources. These were discoveries and reappraisals, extractions, the change in the extraction rate and the change in the resource rent. Changes due to price changes are treated in both the SNA and the SEEA as revaluation and are recorded in the other changes in assets account. Changes in the unit resource rent come into this category. Changes in the extraction rate affect the level of the stock; the faster the extraction, the higher the value of the stock because the value of extraction in future years is discounted less. On the other hand, the decline in the value of the stock will be greater in each year of the shorter life length.

10.61. The impact on the accounting entries of a decision to extract faster or more slowly than in the past is determined by the actual level of extraction in the period in question. The higher the level of extraction, the higher the resource rent; the faster the extraction, the higher the depletion element. The other factor influencing the calculation of any change in the value of the stock is the item of discoveries and reappraisals.

Combining additions and deductions to stock levels

10.62. The options for recording the effect of additions to and deductions from the stock levels of non-produced biological assets separately or on a net basis are discussed above. For mineral and energy resources, the position is somewhat more complex because of the option to merge the recording of mineral exploration and mineral deposits into a single "developed natural asset". Three options are given in Box 10.4 (C1 to C3) to show how changes in non-produced biological assets and mineral deposits can be recorded in combination in the generation of income account.

10.63. Option C1 records harvest of non-produced biological resources and extraction of mineral deposits as deductions from net operating surplus.

10.64. Option C2 offsets some or all of the effect on the value of the stock level of extraction by the value of the additions to stock due to natural growth of non-produced biological resources and the discoveries and appraisals of mineral deposits coming from the activities of mineral exploration. Natural growth is included in this measure of operating surplus on the grounds that although it is outside the production boundary of the SNA, it is a natural process which an economic agent can reasonably rely on to support rational economic behaviour. Natural growth is likely to exceed harvest only when active steps are being taken to rebuild stocks of a resource previously threatened and over-exploited. Discoveries and reappraisals are included because they are the direct result of economic production. They can exceed extractions in any year but are unlikely to do so consistently for a very long period, if only because once a certain level of stocks has been confirmed exploration is likely to be suspended. The value given to discoveries of mineral deposits will depend on the options chosen to value mineral exploration and, in general, the larger the element of operating surplus attributed to this production activity, the lower the resource rent for the deposit discovered. Note that under option C2 there is no economic rent and so no addition to gross operating surplus coming from the additions to stock from natural growth or mineral discoveries. They simply reduce the amount by which economic rent has to be offset by an allowance for the consumption of natural capital.

10.65. There was discussion above that, in practice, information on the stock of biological resources may sometimes be available only on a net basis with harvest and natural growth not available separately. This may sometimes be true also for subsoil deposits. In such circumstances only a form of net recording of the effect on the value of the stock levels of extractions less discoveries will be possible. This is treated as a variation on option C2.

Box 10.4 Options for recording the additions to and deductions from the stock of environmental assets

Option C1 records the consequences of extraction of natural resources in the extended generation of income account leading to a depletion-adjusted operating surplus, but the corresponding increases in resources are shown in the other changes in assets account.

Option C2 records both the consequences of extraction and additions to natural resources in the extended generation of income account. Additions cover both the natural growth of biological resources and discoveries and reappraisals of subsoil deposits.

Option C3 is one where there are no entries for extraction and addition to natural resources in the extended generation of income account of those assets which have been reclassified as developed natural assets and which are therefore recorded in the same way as produced assets.

10.66. It is assumed here that it is logical to either include additions to the stocks of all natural assets or to exclude them all. Obviously, though, further variations are possible such as including natural growth but excluding mineral discoveries.

10.67. Option C3 concerns the case where option B3 is chosen for the recording of mineral exploration and the mineral deposits as a combined developed natural asset. This is then recorded as a produced asset and the consequences are included in net operating surplus. The adjustments to be recorded leading to a depletion-adjusted operating surplus are only those related to environmental assets which are not treated as developed natural assets.

4 A set of depletion-adjusted accounts

10.68. We are now in a position to see how the whole set of SNA accounts could be adjusted to allow for depletion of natural assets. This means looking at both the flow accounts and the accumulation accounts.

The sequence of accounts

10.69. Because of the ease of identifying the link between operating surplus and the use of capital, this section has been illustrated in terms of adjustments which could be made starting with the generation of income account where operating surplus is recorded. In principle, though, since the depletion adjustment parallels that for consumption of fixed capital, a figure for depletion-adjusted value added could be shown in the production account consistent with the entries shown below for the generation of income account.

An extended generation of income account

10.70. Bringing together the discussions on the extractions of natural resources and the different ways in which additions to the stock of biological resources and subsoil deposits could be made, as summarised in Box 10.4, a single extended generation of income account can be presented in line with the versions presented earlier in the text for non-produced biological resources only. This is shown in Box 10.5.

Box 10.5 An extended generation of income account

Extended generation of income account
Gross value added
less compensation of employees
equals gross operating surplus
less value of capital services rendered by fixed capital
plus returns to fixed capital
equals net operating surplus
less extraction of non-produced biological assets
plus natural growth of non-produced biological assets
plus returns to non-produced biological assets
less extraction of subsoil resources
***plus* enhancement to the value of subsoil resources**
plus returns to subsoil resources
equals depletion-adjusted operating surplus.

10.71. The same qualifications apply to this extended version as to the earlier version given above before considering additions to stocks. It is phrased in terms of the most general case where it is assumed that the resource rent is partitioned into a depletion and an income element. If option A1 from Box 10.1 is used, there will be no depletion and therefore there will be no difference between net operating surplus and depletion-adjusted operating surplus. This is the SNA option, according to which all the additions and deductions shown in Box 10.5 following net operating surplus appear in the other changes in assets account. If option A2 from Box 10.1 is used, then there will be no returns to the natural resource and depletion-adjusted operating surplus will be equal to the value of net operating surplus less the whole value of extractions.

Other current accounts

10.72. The adjustments made to the balancing item of operating surplus carry through the following balancing items of the successive accounts up to and including the use of income account where the resulting balancing item, carried forward to the capital account, becomes a depletion-adjusted measure of saving.

An extended capital account

10.73. The adjustments included to bring net saving to a depletion-adjusted basis all concern the measurement of capital and thus corresponding adjustments are needed in the capital account to show how depletion-adjusted saving is affected by transactions and other flows to reach net lending or net borrowing. Just as consumption of fixed capital appears as a use of funds in the current accounts and a negative use of funds in the capital account, so the other adjustments have to be similarly recorded. An example of the resulting extended capital account is shown in Box 10.6. Obviously, the entries in this account must match those in the generation of income account and so the options selected in respect of that account will carry through to the capital account also.

Box 10.6 An extended capital account

Extended capital account	Notes			
Depletion-adjusted saving	1			
less gross fixed capital formation other than land improvement		2		
less land improvement		2		
less changes in inventories		2		
less (acquisitions less disposals) of valuables		2		
less (acquisition less disposals) of non-produced non-financial assets		2		
plus the value of capital services rendered by fixed capital			3	
less returns to other fixed capital			3	
plus extraction of non-produced biological resources				4
less natural growth of non-produced biological assets				4
less returns to non-produced biological resources				4
plus extraction of natural resources				4
less enhancement to the value of subsoil resources				4
less returns to natural resources				4
equals depletion-adjusted capital formation	5			
plus capital transfers receivable		2		
less capital transfers payable		2		
Equals net lending(+)/net borrowing(-)		2		

Notes 1. Bears the same relation to net saving as depletion-adjusted operating surplus does to net operating surplus.

2. Standard SNA entry.

3. Together equal consumption of fixed capital as shown in development of extended generation of income account. Since gross fixed capital formation is a deduction from saving, these items have their signs reversed to produce net fixed capital formation.

4. Adjustment items from extended generation of income account. As with the previous items, the signs are reversed in this account in order to add to depletion-adjusted saving.

5. Algebraic sum of all the items above between gross fixed capital formation through to returns to natural resources inclusively.

10.74. Note that a depletion-adjusted measure of capital formation is available from this account by aggregating the adjustment items with the entries for capital formation. This is then the measure of the impact of the total stock of produced and non-produced, non-financial assets caused by economic activity in the period in question.

10.75. The figure reached for net lending or borrowing is identical with that in the standard SNA tables. Nor is there any change in the entries in the financial account up to the present.

The accumulation accounts

10.76. Returning to a consideration of the asset account given in Table 7.4, we can see that all the entries concerned with additions to and deductions from the stock of environmental assets can be incorporated into the capital account by choosing the appropriate options from the various sets of choices presented. The only entries left for inclusion in the other change in assets account then relate to catastrophic losses, price revaluation and changes in classifications and structure.

Illustrations of options A, B and C

10.77. Table 10.1 shows illustrative data for the options described above for the recording of adjustments to operating surplus in the case of oil and gas extraction. Basically they show how entries in the other changes in assets account may be moved and included in the extended generation of income account to change the balancing items representing income in the flow accounts. Since these changes do not affect net lending or borrowing, the same entries appear with the opposite sign in the capital account representing a reduction in wealth.

Table 10.1 Illustrations of options for recording adjustments to operating surplus

Billion currency units

Options	A1 =SNA	A2	A3		
			B1		B2
			C1	C2	C3
Extended generation of income account					
Gross operating surplus	104.1	104.1	104.1	104.1	104.1
Consumption of fixed capital	24.9	24.9	24.9	24.9	24.9
Depletion of developed natural assets					12.8
Net operating surplus	79.2	79.2	79.2	79.2	66.4
Extraction (resource rent)		-58.3	-58.3	-58.3	
Return to natural resources			28.9	28.9	
Discoveries				16.6	
Depletion adjusted net operating surplus	79.2	20.9	49.8	66.4	66.4
Capital account					
Extraction (resource rent)		58.3	58.3	58.3	
Return to natural resources			-28.9	-28.9	
Discoveries				-16.6	
Other changes in assets account					
Depletion	-29.4				
Discoveries	16.6	16.6	16.6		
Revaluation	22.9	51.8	22.9	22.9	22.9

Source: SEEAland data set.

10.78. Under option A1, which is the SNA option, the whole of the resource rent is treated as income. There are no adjustments in the generation of income account or capital account and there are three entries in the other changes in assets account, one for depletion, one for discoveries and one for revaluation.

10.79. Under option A2, none of the resource rent is treated as income; it is all taken to be depletion so net operating surplus is reduced by this amount. In the entries in the other changes in assets account, the amount for revaluation increases by the amount of the return on natural resources leaving the same net effect on reserves as under option A1.

10.80. Option A3 allows for some but not all of the resource rent to be treated as income and is the underlying assumption for the next three cases.

10.81. Columns three and four show the changes in the extended generation of income account when the resource is still treated as a non-produced asset but both extraction and discoveries are recorded in the year. Under option C1, resource rent and the return to natural assets are shown as the only two elements of depletion. Under option C2, discoveries are shown as the third component of the depletion adjustment. As items are included in the extended generation of income account, they are also included in the capital account and removed from the other changes in assets accounts.

10.82. The last column refers to the options where mineral exploration and the deposits are recorded jointly as a developed natural asset. Here the depletion adjustment as calculated under option C2 (12.8) is shown together with the consumption of fixed capital for (other) produced assets. There is thus no difference between net operating surplus and an adjusted version, though it has the same value as the depletion-adjusted operating surplus under option C2.

Attributing accounting entries to sectors

10.83. While these tables may be satisfactory at the level of the total economy, it is also necessary to investigate how the extra entries suggested would affect the accounts of various sectors. In particular, this means identifying what should be recorded when the owner of the asset and its exploiter are different; in whose balance sheets are the assets recorded and how are the payments from the user to the owner recorded?

Is the owner also the user?

10.84. When it is the owner who is also the extractor of the natural resource, the accounts as described above can be implemented for that unit exactly as for the economy as a whole. However, there are many cases where the owner is not the unit undertaking the extraction activity. Often government is regarded as the owner on behalf of the nation as a whole. Even in cases where the extraction is undertaken by a wholly public corporation, this will be shown within the non-financial corporate sector of the national accounts and thus separate from the accounts of government as legislator and administrator.

Owner and user different

10.85. Here also we must have recourse to a number of options which can be chosen in a number of combinations. One set of options concerns the balance sheet in which the asset is to be recorded. This issue is discussed in Section B of Chapter 8 and the options given there in Box 8.2 are repeated here for convenience, prefixed by the letter D. The second set of options relates to where the flows are recorded under each of the options in Box 10.7 for recording the ownership of the stock. This is discussed next.

Box 10.7 Options for recording the ownership of mineral-related assets

Option D1 shows mineral exploration in the balance sheet of the extractor and the value of the deposit in the balance sheet of the legal owner. If the agreement between the owner and the extractor allows for the extractor to retain some of the resource rent coming from the asset, the ownership of the asset should be partitioned consistently.

Option D2 shows both the mineral exploration and deposit as being in the *de facto* ownership of the extractor. In addition the extractor has a financial liability towards the owner corresponding to his share of the resource rent. This amount is also shown as a financial claim in the balance sheet of the owner.

Assets recorded in the legal owner's balance sheet

10.86. This is the default case and the one which the SNA assumes. Payments from the user to the owner are recorded as property income. Property income is defined in the SNA as,

> The income receivable by the owner of a financial asset or a tangible non-produced asset in return for providing funds to, or putting the tangible non-produced asset at the disposal of, another institutional unit. (1993 SNA paragraph 7.88)

10.87. Property income is sub-divided into a number of components all of which except one relate to financial assets. The exception is rent which is further subdivided into rent on land and rent on subsoil assets. Although only these two are mentioned explicitly, it seems clear that in principle payments for the use of natural forests for logging or wild fish stocks for fishing would also be covered by the heading of rent.

10.88. Rent is recorded in the distribution of primary income account and represents a charge on the operating surplus of the institution paying the rent. As suggested by the name of the account where it appears, it is not a form of income generation but of redistribution from the unit which has generated the income by the use of the asset back to the owner of the asset.

10.89. As long as the asset suffers no depletion in the course of its use, this recording of the payment from the user to the owner is satisfactory for both the SNA and the SEEA. However, if the asset has suffered some measure of depletion, this may not be adequate. (Given the special characteristics of land, it is easiest to treat degradation of land as a special form of depletion.)

10.90. The problem is that while it is the user who benefits from the capital services the natural resource yields and it is his activity which causes the degradation, it is the owner who suffers the decline in wealth caused by the depletion. One way to show this would be to partition the payment from the user to the owner into two parts, one corresponding to the return on the asset and one to the decline in the value of the asset. The first could be recorded as rent and the second as a form of capital transfer from the user to the owner as recompense for the decline in the asset's value.

10.91. A summary of the options for recording depletion when the assets are recorded in the balance sheet of the legal owner is given in Box 10.8.

10.92. These three options, all of which assume that option D1 regarding the ownership of assets is followed and that the asset is recorded in the balance sheet of the legal owner, are illustrated in Table 10.2. The consistency, or lack of it, with the earlier options can be seen by comparing the entries remaining in the other changes in assets account.

10.93. Option E1 is strictly consistent with the SNA. Option E2 gives aggregate balancing items which are consistent with the SNA but the sectoral allocation differs from option E1 since part of the transfer of resource rent is recorded in the capital account.

10.94. Options E3 and E4 are the analogues of options C1 and C2. Options E3 and C1 both make a deduction for extraction from balancing items; options E4 and C2 include an adjustment for discoveries as well.

Box 10.8 Options for recording depletion – asset recorded in the legal owner's balance sheet

Option E1 is consistent with the SNA. This records the value of the depletion in the other changes in asset account.

Option E2 partitions the actual payment into two elements. The part which corresponds to the decline in value of the asset is recorded as a capital transfer from the user to the owner as recompense for the decline in the asset's value; the rest is recorded as property income (rent) payable from the user to the owner in the distribution of primary income account.

Option E3 maintains the recording of the actual payment from the user to the owner as property income in the distribution of primary income account but treats this as rent gross of depletion. An element for the consumption of natural capital is shown in this account for the owner also to reduce the rent to a value net of depletion.

Option E4 is similar to option E3 but assumes that the consumption of natural capital allows for the discoveries made during the year as well as the extraction.

Table 10.2 Illustration of options for the payments of rent

Billion currency units

Option	E1		E2		E3		E4	
	Extractor	Owner	Extractor	Owner	Extractor	Owner	Extractor	Owner
Distribution of primary income account								
Gross rent	-49.7	49.7			-49.7	49.7	-49.7	49.7
Consumption of natural capital						-29.4		-12.8
Net rent			-20.3	20.3		20.3		36.9
Capital account								
Capital transfer			-29.4	29.4				
Other changes in assets account								
Depletion		-29.4		-29.4				
Discoveries		16.6		16.6		16.6		
Revaluation		22.9		22.9		22.9		22.9

Source: SEEAland data set.

Assets recorded in the user's balance sheet

10.95. In the case of financial leasing, a produced asset is recorded not in the balance sheet of the legal owner but of the user. The conditions are that the legal owner, usually a financial institution, has no productive activity for which the asset would be relevant. Nor does the legal owner assume any responsibility for the use of the asset nor its care and maintenance. All these are assumed by the user. The view is that there is a *de facto* transfer of ownership to the user in return for which there is a financial claim and liability established between the owner and the user. Payments from the user to the owner are treated as being in part the repayment of the financial claim and in part the payment of property income, but in this case treated as interest, for the use of the asset by a unit other than the owner. More detail on financial leasing can be found in 1993 SNA (paragraphs 6.118, 6.119 and 11.31).

10.96. It has been suggested that there are cases where non-produced assets are put at the disposal of the user in conditions similar to financial leasing and so a similar form of recording would be appropriate. An obvious case is where an extractor of a subsoil deposit is given the right to exploit the deposit to exhaustion or at least for an extended period of time. It is the extractor who makes the decision about the rate at which the stock is depleted and is responsible for all aspects of the extraction process. The return to the deposit and its depletion are recorded in the extractor's accounts in accordance with the case when the extractor is the owner.

10.97. If adopted, the consequences for the flow accounts are that the actual payment from the user to the owner has to be partitioned as in option E2 above, but now the capital part is regarded as a financial transaction rather than a capital transfer and the property income flow is of interest rather than rent.

10.98. One unsatisfactory aspect of this option is that the changes to the value of the deposit resulting from changes in relative prices, from new discoveries and from changes in the extraction rate all affect the level of the financial claim and liability as well as the value of the mineral deposit itself. This is a most unusual situation for financial assets which are usually clearly specified at the time they are acquired and not subject to such fluctuations. These fluctuations also have implications for the partitioning of payments into a capital and income element.

10.99. Table 10.3 gives an example of how the changes in the financial liability might be calculated. The starting point is to calculate the level of the financial liability at the start of the year. This is assumed to be the fraction of the stock of the resource (estimated as described in Chapter 7) represented by the owner's share in the resource rent in the previous year. The value of the stock at the end of the year is calculated in the same way as before. A new value of the financial liability is calculated according to the owner's share of the current year's resource rent. The change in the financial liability over the year is then calculated as the difference between the start and end year figures.

Table 10.3 Illustrative example of imputing change of ownership for a financial liability

Billion currency units

	Total	Extractor	Owner
Stock at end of previous year	698.8		
Resource rent allocation previous year	49.1	3.7	45.4
Financial asset/liability end of previous year		-646.2	646.2
Change in resource stock due to:			
Extraction	-29.4		
Discoveries	16.6		
Revaluation	22.9		
Stock at end of current year	709.0		
Resource rent allocation current year	58.3	8.6	49.7
Financial asset/liability end of current year		-604.9	604.9
Change in financial asset/liability			-41.3

Source: SEEAland data set.

Assets shared between the owner's and user's balance sheets

10.100. The possibility exists of treating the asset as being part owned by more than one unit which may fall in different institutional sectors. If this is so, then there will be two sets of entries, one relating to the user in respect of his share of ownership of the asset and one relating to his payments to the owner in respect of the owner's share of ownership. These latter may follow any of the options described above for outright ownership of the asset.

Stock level and owner unknown

10.101. The procedure just described where there is full balance sheet accounting and the owner is known is difficult to apply in cases such as uncultivated fish where there may be little firm evidence of the level of the stock and even if government is the nominal owner, it may not always receive a "royalty" or "rent" payment for the right to fish.

10.102. An alternative procedure suggested by Vanoli (1995) is to introduce a quasi sector for nature. Natural growth is shown as a resource of nature and adds to depletion-adjusted saving, though without affecting the depletion-adjusted saving of any other sector. In the balance sheet, this addition to stocks offsets some or all of the harvesting of fish which is shown as a gross extraction under the fishing industry.

Example accounts

10.103. Table 10.4 shows a more complete set of flow accounts than the earlier illustrations. It covers the whole economy consistent with option C2 and shows how the consequences of the adjustments to operating surplus affect subsequent balancing items up to saving. Because of the adjustments in the capital account, however, net lending and borrowing is not altered by the changes in the recording of depletion. Net lending for the whole economy remains 40 billion currency units which is the excess of exports over imports in the SEEAland data set.

10.104. The only items for property income flows and transfers included in the table are those necessary to maintain the integrity of the goods and services account. The accounts for each of the resource industries are consistent with the SEEAland accounts shown in Chapter 7.

10.105. What is most striking about the table in comparing the various options is that the only decisions which affect the value of the macro aggregates are firstly the decision on whether to have some adjustment for depletion and secondly whether to show additions to stock levels in the transaction accounts. Once these decisions are made, although there are differences sector by sector in subsequent balancing items, for the economy as a whole differences cancel across sectors. Thus, the consequences for the economy-wide balancing items – from balance of primary income onwards up to and including saving as well as domestic product and income measures – are the same whatever precise option is used to record the various flows.

Table 10.4 Illustration of depletion-adjusted flow accounts

	Flow accounts	Extraction of oil and gas		Forestry		Capture Fishery		Aquaculture	
		Use	Resource	Use	Resource	Use	Resource	Use	Resource
	Production account								
1.	Output		133 167		2 444		6 642		6 434
2.	Intermediate consumption	19 124		826		2 863		5 438	
3.	**Gross value added**	**114 043**		**1 618**		**3 779**		**996**	
	Taxes less subsidies on products								
	GDP at market prices								
	Extended generation of income account								
4.	**Gross value added**		**114 043**		**1 618**		**3 779**		**996**
5.	*less* compensation of employees	6 738		413		1 390		431	
	less other taxes less subsidies on production	3 193		- 19		71		0	
6.	***equals* gross operating surplus**	**104 112**		**1 224**		**2 318**		**565**	
7.	*less* services of produced biological fixed capital								
8.	*less* services of other fixed assets	45 858		668		1 486		368	
9.	*plus* returns to produced biological fixed capital								
10.	plus returns to other fixed capital		20 938		290		516		128
11.	***equals* net operating surplus**	**79 192**		**846**		**1 348**		**325**	
12.	*less* harvest of natural biological resources			242		82			
13.	*less* extraction of subsoil assets	58 254							
14.	*plus* returns to natural biological assets								
15.	*plus* returns to subsoil assets		28 870						
16.	*plus* natural growth of biological assets				0		0		
17.	*plus* discoveries of subsoil assets		16 631						
18.	***equals* depletion adjusted operating surplus**	**66 439**		**604**		**1 266**		**325**	
	Distribution of primary income account, Secondary distribution of income account, Use of income account								
19.	**Depletion adjusted operating surplus**		**66 439**		**604**		**1 266**		**325**
20.	Compensation of employees								
	Taxes less subsidies on products								
	Other taxes less subsidies on production								
21.	Property income	45 500							
	Specific taxes on income from extraction	4 200							
22.	Consumption expenditure								
23.	**Depletion adjusted saving**	**16 739**		**604**		**1 266**		**325**	
	Capital account								
24.	**Depletion adjusted saving**		**16 739**		**604**		**1 266**		**325**
25.	Gross fixed capital formation	30 778		269		1 087		304	
26.	Consumption of fixed capital	-24 920		- 378		- 970		- 240	
27.	Change in inventories			- 120				311	
28.	Land improvement			0					
29.	Harvest of natural biological resources			- 242		- 82			
30.	Depletion of subsoil resources	-29 384							
31.	Natural growth of biological assets								
32.	Discoveries and reappraisals of subsoil resources	16 631							
33.	**Net borrowing or lending**	**23 634**		**1 075**		**1 231**		**- 50**	

Notes:

Row	Equals or is counterpart to row
3	1-2
4	3
6	4-5
11	6-7-8+9+10
18	11-12-13+14+15+16+17
19	18
23	19+20 plus (resources) or minus (uses) 21-22
24	23
26*	7+8-9-10
29*	12-14
30*	13-15

* By convention, these items are shown as negative uses rather than positive resources

Source: SEEAland data set.

Million currency units

Other industries		Owner of subsoil assets (government)		Households		Nature		Total		
Use	Resource	Use	Resource	Use	Resource	Use	Resource	Use	Resource	
	1137 713								1286 400	1.
635 749								664 000		2.
501 964								**622 400**		**3.**
								70 000		
								692 400		
	501 964								**622 400**	**4.**
324 453								333 425		5.
755								4 000		
176 756								**284 975**		**6.**
140								140		7.
193 118								241 498		8.
	140								140	9.
	115 226								137 098	10.
98 864								**180 575**		**11.**
								324		12.
								58 254		13.
										14.
									28 870	15.
							263		263	16.
									16 631	17.
98 864						**263**		**167 761**		**18.**
	98 864						**263**		**167 761**	**19.**
					333 425				333 425	20.
			70 000						70 000	
			4 000						4 000	
			45 500						0	21.
			4 200						0	
		159 000		347 400				506 400		22.
98 864		**-35 300**		**-13 975**		**263**		**68 786**		**23.**
	98 864		**-35 300**		**-13 975**		**263**		**68 786**	**24.**
112 300								144 738		25.
-77 892								-104 400		26.
1 071								1 262		27.
								0		28.
								- 324		29.
								-29 384		30.
						263		263		31.
								16 631		32.
63 385		**-35 300**		**-13 975**		**0**		**40 000**		**33.**

Row	Equals or is counterpart to row
31	16
32	17
33	24-25-26-27-28-29-30-31-32

C Defensive expenditure

10.106. The issues of defensive expenditure and degradation are closely linked since the former helps to prevent the latter. It is helpful to have a clear view of how defensive expenditure is and might be identified in the accounts before proceeding to consider the same issues for degradation.

10.107. As discussed in the introduction to the chapter, defensive expenditure is a term which can be interpreted in quite a wide sense. The main discussion here concerns environmental protection expenditure which is an obvious candidate for inclusion. Other possible candidates for inclusion are regulatory bodies charged with protecting and managing natural resources and health costs incurred to mitigate the effects of atmospheric pollution.

1 Current and capital environmental protection expenditure

10.108. Measurement of environmental protection expenditure is discussed in Chapter 5. Expenditure which will help combat environmental degradation in both the current and future periods is classified as fixed capital formation. Regardless of what type of unit undertakes the expenditure, it forms part of final demand and adds to the level of GDP. As with all fixed capital formation, it is necessary to adjust for consumption of fixed capital in order to reach a value of net domestic product or net national income.

10.109. Expenditure by producers which affects the level of environmental degradation only in the accounting period in question is treated as current expenditure, essentially compensation of employees and intermediate consumption. For all producers, expenditure not contributing to value added is recorded as intermediate consumption. However, when the producer is within the government sector and the production is for collective consumption, the environmental protection expenditure automatically adds to the level of government consumption and thus to the level of GDP. By contrast, for a producer who sells his products in the market place, intermediate consumption does not appear to add to GDP directly. This apparent asymmetry bothers a number of commentators who suggest that all (current) environmental protection expenditure should be excluded from GDP.

2 Environmental protection expenditure by government and industry

10.110. Gross domestic product can be measured by any of three routes and the accounting system in the SNA is such that each will give the same answer. The production measure counts all the goods and services which are produced, less those used for intermediate consumption. The expenditure measure counts the acquisition of the same goods and services to satisfy human wants. The income measure shows how the income generated in production is used to fund this acquisition of the goods and services produced. There is no automatic equality between all three measures for a single activity or group of activities; it holds in the aggregate only.

10.111. It seems relatively easy to consider excluding environmental protection expenditure by government since it can be identified within output and expenditure without problem. However, it is difficult to make a case to exclude the wages and salaries earned by, say, street cleaners and to classify these workers as unemployed on an "environmentally adjusted" basis. Their earnings are used to acquire goods and services for their families and there is no reason or obvious accounting means of excluding these purchases and the subsequent consequences from the accounts. Simply omitting activities and preserving a closed accounting system is not an option.

10.112. Goods and services acquired by industry are not themselves part of final demand. They are incorporated into other products which fulfil this function after one or more further steps. Cotton is made into fabric which is made into shirts, for example. However, the purchase of the shirt includes the cost of the raw materials which went into its manufacture. Firms which undertake environmental protection expenditure rarely if ever simply swallow the costs and take a drop in profits to pay for this. The usual market mechanism is to pass the costs on to their customers. Thus those buying seemingly unrelated products will be paying an element which covers the cost of the environmental protection expenditure just as the shirt-buyer covers the cost of the raw materials that went into it. It is thus an inaccurate simplification to think that because a firm's environmental protection expenditure is counted as intermediate consumption, it does not add to GDP.

10.113. The accounting system makes no judgement about the moral worth or physical necessity of production. It simply records those products which are the subject of transactions in the market place and ensures that when these transactions are completely and consistently covered, the three measures of GDP will give the same answer.

10.114. The suggestion to remove the easily identifiable elements of defensive expenditure (environmental protection expenditure in this example) from the expenditure side of the accounts is not tenable within a coherent accounting system. There is no way, if this were done, that exactly compensating deductions could be made from the other means of calculating aggregate GDP. Nor would this remove the whole of the designated activity.

3 A possible symmetric treatment

10.115. A symmetric treatment of environmental protection expenditure by government and industry cannot be achieved by simply omitting some part of the accounting system. However, we can achieve a form of symmetry by reclassifying some of the existing transactions.

10.116. Roads represent fixed capital formation. They are subject to extensive repairs and maintenance to keep them in a good state. The 1968 SNA took the position that repairs and maintenance would be sufficient to ensure a road lasted for ever and thus there was no consumption of fixed capital allowance for roads in that version of the system. Gross capital formation was taken to be also a measure of net capital formation and all repairs and maintenance were treated as intermediate consumption[1]. There is another possible way to reach a similar position though, one which was in use in a number of Scandinavian countries before they adopted the 1968 SNA. This was sometimes known as the "gross gross" method of recording capital formation (Aukrust, 1994). Under this, all repairs and maintenance were recorded as part of gross capital formation and that part which would otherwise be counted as current repairs were treated as a form of consumption of fixed capital thus eliminating the double counting just introduced.

10.117. The gross gross approach to recording of current environmental protection expenditure is one way to achieve a symmetric treatment of such expenditure by government and industry. If the expenditure undertaken by an industry is treated as both capital formation and consumption of fixed capital, the level of output of the industry on its other products will not alter. GDP will increase by the amount of the environmental protection expenditure but net domestic product will not change. The change in classification of government environmental protection expenditure will not affect GDP, though some final consumption will now appear instead as fixed capital formation. On the other hand, net domestic product will fall by the amount of this expenditure just reclassified. In this way we have a symmetric recording of environmental protection expenditure between industry and government and the gap between GDP and NDP is increased by

[1] This position was changed in the 1993 SNA recognising that even with regular maintenance roads eventually need complete renewal. This is not the present point at issue though.

the whole amount of this expenditure, by increasing GDP by the current expenditure by industry and reducing NDP by the current expenditure by government.

Environmental protection expenditure by households

10.118. As indicated in the example from Chapter 5, households also purchase environmental protection products. Simply reclassifying this household consumption to be a form of capital formation seems to introduce quite a new concept in the SNA, the idea of capital formation without any associated production process. However, several types of collective consumption, including the environmental protection expenditure carried out by government, could be described as comprising capital formation not directly linked to production processes. At present in the SNA, only government undertakes collective consumption, but if the guidelines were relaxed to permit other sectors to finance collective consumption, this would allow household consumption on environmental protection expenditure to be reclassified as capital formation also[2].

10.119. An illustrative example, based on the data for environmental protection expenditure given in Chapter 5, is shown in Table 10.5.

4 *Implications at constant prices*

10.120. It is important for policy analysis that the national accounts not only give a relevant measure of expenditure in current prices but also portray the pattern of economic growth in an analytically useful way. We therefore need to consider what happens to measures of growth when new environmental protection expenditure is undertaken.

Table 10.5 Illustrative table of adjustments to GDP and NDP for defensive expenditure

Billion currency units

	Output	Intermediate consumption	Taxes on products	GDP	Consumption of fixed capital	NDP
SNA totals	1 286.4	664.0	70.0	692.4	104.4	588.0
Ancillary production - addition	4.0	4.0				
Reallocations						
Intermediate consumption		- 9.5			9.5	
Government final consumption					1.8	
Household final consumption					3.6	
Capital formation					0.1	
Defensive adjusted totals	1 290.4	658.5	70.0	701.9	119.4	582.5

	Final consumption of government	Final consumption of households	Gross capital formation	Exports	Imports	GDP
SNA totals	159.0	347.4	146.0	403.0	363.0	692.4
Ancillary production - addition						
Reallocations						
Intermediate consumption			9.5			
Government final consumption	- 1.8		1.8			
Household final consumption		- 3.6	3.6			
Capital formation						
Defensive adjusted totals	157.2	343.8	160.9	403.0	363.0	701.9

Source: SEEAland data set.

[2] This idea is further elaborated by Harrison (1999). It provides for a similar mechanism for reclassifying environmental protection expenditure by industry which is an alternative to the "gross-gross" recording suggested above.

10.121. Although measures of national accounts at constant prices are sometimes referred to as being in "real" terms, they are in fact somewhat hypothetical. They attempt to measure the level of activity in one accounting period at the prices prevailing in another period. This only makes sense if the changes are fairly modest. If there has been a radical change in the structure of the economy or of relative prices, asking what the level of activity would have been at the other set of prices becomes a silly question and so does any answer other than "that type of activity would not have taken place at that set of prices".

10.122. Properly speaking, the expression "constant prices" is shorthand for a set of conditions. Not only price levels but the quality of goods, the technology of production and the tax structures are also supposed to remain constant. The issue of constant quality is discussed in Chapter 4, where it is explained why volumes in the constant price terms of the national accounts are not necessarily the same as physical quantities.

10.123. If between period t and t+1 new environmental regulations are introduced which lead to significant new environmental protection expenditures, what is the effect in constant price terms? This depends on whether the increase in the current price value is seen as being purely a price increase or is seen as a quality increase. In practice, there are some such innovations which are generally treated as quality increases. The introduction of catalytic converters on motor engines is one such case which is frequently quoted. In some instances, though, and especially when environmental protection expenditure is undertaken as an ancillary activity not identified as suggested in Chapter 5, it is quite possible that the increases in costs appear as price increases. A discussion of some of the practical difficulties in identifying the difference between price and quantity effects is given in Steurer *et al.* (1998).

10.124. For some analyses, it may be desirable to take the idea of constant prices one stage further and specify explicitly both the base year for the constant prices and also the base year for the environmental standards. Measuring growth between year t and t+1, when there are different environmental standards in the two years does not illustrate the impact on growth of perpetuating a given environmental standard. It may be more useful to consider a two step approach. A comparison between year t at the prices and environmental standards of t and year t at the prices of t but the environmental standards of year t+1 would give the impact of changing environmental standards; then a comparison between year t assuming not just the environmental standards but also prices of year t+1 and year t+1 would give a measure of growth at constant prices and constant environmental standards. For more on this see Harrison (1997).

10.125. As pointed out by Steurer *et al*. (1998), it may well be price statisticians who have made the decisions about when to treat environmental protection as a price increase so that national accountants and environmental accountants may not be able to determine what has been done. However, an option whereby all environmental protection expenditure was treated as gross capital formation would open the way to making adjustments to explore the option of treating more of this expense as a quality change rather than as just a price increase.

D Degradation

1 Alternative approaches

10.126. Incorporating the effects of degradation into the conventional economic accounts is more difficult, less certain and more controversial than making adjustments to the accounts for either depletion or defensive expenditure. This section is therefore more tentative, longer and contains more radically different alternative options than the preceding sections.

10.127. If we have an asset which will last forever, providing the same services year after year, then the whole of the value of that service may be regarded as income. If there is deterioration in the asset so that either the level of the services declines or the life length of the asset ceases to be infinite, then the decline in the value of the asset must be regarded as a deduction from income.

10.128. In the case of the environment, there are services provided every year which are not currently given a money value. Until recently, the supposition was that these services would continue to be provided year after year without a decline in quality or quantity of the service. This is now put in doubt and the precautionary principle is invoked to protect the level of services the environment can provide in the future by restricting the extent to which the environment is used as a sink for residuals.

10.129. It should be recognised explicitly at the outset that information about degradation, even at a physical level, is much less well established than information about other environmental phenomena. Ways of documenting quality decline have still to be further developed and budgetary resources to measure it are not sufficient. There are not only theoretical but also serious practical problems in the way of assessing the impact of degradation reliably.

10.130. An ideal situation might be to consider that it is possible to value all environmental functions and to devise an eco-environmental aggregate which included the value of all economic products and all environmental functions. Impairment of environmental functions would then represent a deduction from a state where all environmental functions were preserved. Unfortunately, it is not possible even to specify all environmental functions exactly in quantified terms, let alone put a monetary valuation on each. A somewhat simpler and less ambitious target has therefore to be formulated.

10.131. Chapters 7 and 8 deal with accounting for resource functions in both physical and monetary terms. Chapter 3 describes how physical flows of residuals can be associated with production and consumption processes. It is assumed here that it is the excessive generation of residuals which impairs the quality of environmental media and hence of the environmental functions they provide. Unfortunately the exact links between specific residuals and a given environmental function are not always established and seldom precisely quantified. However, although we cannot value the environmental functions directly, we can investigate whether we can value the deterioration in air and water quality on the assumption that if this were reversed, the environmental functions clean air and water convey would be restored.

10.132. Alternative methods of valuing degradation were discussed in Chapter 9. These were characterised as damage-based and cost-based. The consequence of having two valuation principles for measuring degradation is to have two sets of accounting adjustments, one flowing from each.

10.133. Damage-based estimates answer the question "how much damage is caused by environmental degradation". Cost-based estimates answer variations on the question of "how much would it cost to avoid environmental degradation". Both questions have their foundation in the Hicksian concept of income as being dependent on preserving the value of one's wealth[3] but one estimate is formed by looking at what has happened to the stock of assets (the damage-based estimates) and the other is based on a measure of income (the cost-based estimates). Both types of estimates incorporate hypothetical valuations into the economic accounting system and thus are less firmly based than measures depending solely on observation. Both are crucially dependent on the adequacy of the data on generation of residuals and environmental quality in physical terms as described in earlier chapters.

[3] "Thus we may say that income is the amount a man can spend in a week and still be ***as well off*** at the end of a week as at the beginning" (Hicks, 1946).

10.134. The consequences of degradation on the stock of assets are easy to recognise in deforestation due to air pollution and land degradation caused by over-logging, for example. Similarly it is possible to visualise damage to produced assets; for example, the damage caused to buildings and equipment by acid rain. More controversial in accounting terms is the damage done to human health since this is not presently regarded as an asset within the accounting system. In broad terms, damage-based adjustments follow the logic of depletion type adjustments discussed in Section B and are discussed first.

10.135. The cost-based alternative is more like an extension of defensive expenditure and is essentially an income approach. When this is associated with the notion of maintaining environment services within the existing economic structure this is called the maintenance cost approach.

10.136. The maintenance cost approach implies imputing values of costs and activities which either do not take place in fact or have zero market value. Instead of wrestling with the accounting implications of this inherent inconsistency, one important alternative is to suggest this approach starts from the wrong place. Instead of asking how much the value of GDP would be affected if the accounting system were changed to reflect the use of environmental media, it assumes the accounting system is quite satisfactory as it stands and the problem is to know how economic activity itself should be altered to reduce environmental degradation. This approach has come to be known as "greened-economy modelling".

10.137. Just as there was no automatic equality between damage-based and cost-based pricing techniques so there is none between the alternative adjusted aggregates coming from the damage-based and cost-based approaches. Only by coincidence do the costs equal benefits or avoided damages. If we realise the links of the two with the wealth and income approach, we realise that what we have is an accounting inconsistency between the measurement of stocks and flows in the system. However, comparing the two estimates is useful. For example, by assessing the cost of achieving given environmental targets, the goals can be adjusted according to what is considered as a reasonable estimate of benefits. The consistent application of these two approaches leads to two different environmentally adjusted macroeconomic aggregate measures which are to be interpreted differently. They serve different policy purposes and lead to different analyses. Rather than making a choice between them, they should be seen as complementary and often are developed in parallel.

2 Damage-based methods to derive macro-aggregates

The measurement of damage within the SNA

10.138. A cost-benefit analysis of the impact of environmental pollution would suggest that costs to avoid pollution would be incurred up to the point where the benefits are at least as great as the costs. One problem is that often the costs would be incurred by one set of economic units and the benefits accrue to another set. Typically, therefore, the users of environmental resources continue to regard these as "free" and thereby impose dis-benefits or damages on other units. (These are the effects economists refer to as externalities.) Chapter 9 examined how damages actually incurred and benefits foregone might be valued[4]. This section examines how these values might be brought within the flow accounts to derive "damage-adjusted" aggregates.

10.139. Damage from environmental degradation may manifest itself in a number of ways. It may result in or affect actual transactions which are recorded in the accounts leading up to the calculation of GDP or in subsequent adjustments to reach depletion-adjusted domestic product (dpNDP). For simplicity these are referred to here as damage-affected transactions. Environmental damage may affect the conditions and thus

[4] In the 1993 SEEA, these damage costs were referred to as "repercussion costs".

the value of man-made assets and environmental assets, both those within the economic asset boundary of the SNA and those added in by the SEEA. These are described as damage-based valuation adjustments. Environmental degradation may also have detrimental effects on human health and on living organisms more generally. The impact on human health is probably the issue which has the highest profile in terms of the effects of environmental degradation. Most of this section is concerned with how a valuation might be placed on this. Damage to other living organisms is noted but not directly addressed in the adjusted aggregates presented here.

Damage affected accounting entries

10.140. Agriculture is the industry most obviously affected by environmental degradation. Livestock may have reduced growth rates due to water pollution; forests and crops may suffer because of acid rain or reduced productivity of the land because of acidification. If plants or animals grow more slowly, reproduce less or die earlier because of environmental pollution, then this should in principle be reflected in the accounts and show up as lower increases (possibly decreases) in the stock of these assets. If these are cultivated biological assets, the value of output and value added will implicitly record this fall without further adjustment. If the biological assets are non-cultivated, the figure for natural growth of non-cultivated biological assets and the value of dpNDP will be lower than if there had been no environmental degradation.

10.141. More controversial is the possible treatment of disasters. Usually in national accounts, floods, droughts and forest fires are treated as exceptional events whose cause is not due to human activity. In some of the more spectacular disasters recently, human culpability can be traced. Excessive deforestation upstream exacerbates the ability of heavy rains to lead to disastrous floods; uncontrolled slash and burn techniques may lead to major forest fires; overgrazing leads to desertification. The possibility exists to consider the damage caused by such events also as environmental damage, along with the effects of ship-wrecked oil tankers, for instance. This issue is not pursued further here but left as a marker for consideration to set against the cost of trying to combat the causes of these disasters.

Damage-based valuation adjustments

10.142. When market prices for the assets do not exist the values are determined as the net present value of future income streams. When market prices do exist, they are supposed to be consistent with this hypothesis. In so far as damage caused by environmental degradation affects the services to be rendered by assets, whether produced or non-produced, and is likely to continue to affect these services in the future, in principle this should be reflected in changes to the value of these assets.

10.143. The simplest example is the value of agricultural land. If the crop yield has declined because of degradation and is expected to be lower than its potential in future for the same reason, the market value of the land should fall to reflect this. Buildings and structures may suffer damage due to acid rain and pollution. Urban residential buildings may lose value because of increasing noise due to urban congestion. If the damage done to buildings or equipment is such that their efficiency is reduced or their useful life is shortened, then the changes in the value of the assets in the asset accounts should reflect this. The SNA recognises this and includes mention of this as "degradation of fixed assets not accounted for in consumption of fixed capital" which is part of the item for other volume changes to be recorded in the account of the same name (1993 SNA paragraph 12.45). Within the SEEA it would seem logical to treat this in a similar way to the consumption of natural capital discussed in Section B.

10.144. One position is that these changes should be noted and recorded as part of consumption of fixed capital since this represents the decline in value of the asset during the year in question. An alternative view is that the decline in value is due to an external event not directly related to the use of the asset, and thus should be recorded separately. If this is done, it should be recorded in the other changes in assets account. In drawing up environmental accounts, the compiler should find out whether these effects are already counted in consumption of fixed capital and, if not, whether an estimate is already made and included in the other changes in assets account or whether a new adjustment needs to be calculated. If the latter, it should also be incorporated in the regular SNA accounts since it affects the articulation of the accumulation accounts from opening to closing balance sheets. Note that if environmental standards are improving, it is possible that historically based life lengths and efficiency factors may be too pessimistic and a reduction in consumption of fixed capital would be appropriate.

Damage to human health

10.145. The present SNA has no means of taking the damages caused by pollution to human health into account through the consideration of assets. One possibility is to consider introducing human capital into the balance sheet and thus regarding the health damage as another form of reduction in the nation's net worth. While this approach has some appeal, it is not wholly satisfactory. At best one could estimate the change in human capital due to changes in health but not the total value of human capital. Placing a monetary value on the damage caused by disease does not necessarily lead to valuation of a healthy life. Nor is health the only factor affecting a valuation of human capital; education is another obviously relevant factor. If human capital is taken to be the people employed in production, how useful would a measure of environmental damage be that ignored damage done to children and the elderly because they are not of working age?

10.146. The alternative route is to revert to the question of welfare. This is by no means intended to be a comprehensive measure of welfare but simply one that says that a deterioration in health represents a deterioration in welfare that many people would be prepared to pay to avoid if possible. In this sense, therefore, we may say that from the income generated from production we should deduct not only the allowance for depreciation of fixed capital which is part of conventional national accounts, and the allowance for depletion of natural capital discussed in Section B, but also a sum representing the decline in welfare caused by environmental damage.

10.147. This approach introduces concepts and practices which are major innovations to the SNA as presently articulated. The benefits we receive from a good state of health are not recorded in NDP, yet we suggest recording a decline in those benefits due to environmental degradation as a decline in NDP. If we were to suppose that a (restricted) value of welfare could be estimated as being the sum of NDP plus a health benefit H, then we could more easily say that the decline in welfare due to environmental degradation was the decline in the original sum NDP+H. This is not possible as long as we have no robust estimates of H. However, it means that in looking at the impact of degradation it is advisable to relate it to year to year changes (when the unknown value of H may be fairly constant) rather than to just a simple comparison with the absolute level of NDP.

10.148. This problem is not new and has frequently been commented on in the controversy over whether so-called defensive expenditures should be deducted from NDP. If damage occurs and is remedied, the cost of the remedy forms part of the economy and the activity involved directly or indirectly adds to national income. Preventive services, such as fire services, also contribute to national income because they provide employment even though the goal is not to have to fight fires, or, if fires occur, to minimise the damage caused. What is presently included in GDP for these services is the cost of providing them, not a "welfare" value of the protection they provide. Before deducting the damage caused by a fire, in principle the benefit of a "fire-free" economy should be included.

10.149. In Chapter 7 there was discussion of the various services provided by the environment and a distinction made between use and non-use values.

> ***Use values*** refer to the ***direct or indirect use values*** of environmental goods; for example, timber revenues or recreation. Use values also include the ***option values*** that express the preferences that individuals have for an asset or service they might use in future as well as ***bequest values*** that signal preferences for preserving an environmental asset or service for others, including future generations.
>
> ***Non-use values*** cover only ***existence values*** (or intrinsic values) that signal preferences individuals have for some good they may never actually or potentially use; for example, the preservation of some species, ecosystem or habitat.

10.150. As can be seen, the damage-cost approach does not attempt to put a value on the total services rendered by the environment. All existence values and many indirect use values are left out, though some of the techniques described in Chapter 9 could in principle be used to extend the extent of the services covered to, for example, the recreational services provided by the environment and other services.

Damage-adjusted product and income

10.151. In the absence of property income flows to and from the rest of the world, net domestic product and national income are the same. Since at the moment the flows with the rest of the world are not our main concern, we consider the move from production to income assuming these flows are zero.

10.152. Damage-adjusted income is the damage-based income measure coming from the SEEA. It is derived as follows.

GDP (gross domestic product)
less consumption of fixed capital
equals **NDP** (net domestic product)
less any damage adjustments to asset valuation not included in consumption of fixed capital
less depletion of natural resources
equals **dpNDP** (depletion-adjusted NDP)
equals depletion-adjusted national income
less pollution damage to human health
equals **daNNI** (**damage-adjusted national income)**

10.153. ***Consumption of fixed capital*** is the standard national accounts measure. As explained above if it does not include the effects of pollution damage on economic assets, a separate adjustment should be made for this damage.

10.154. ***Depletion of natural resources*** should be calculated as explained in Section B. It should measure net depletion of biological resources which have an economic value. It could include a net increase in the value of subsoil assets if the increase in economic rent of those assets through discoveries exceeds the higher economic rent of the amounts extracted in that year. A key point is to avoid counting losses in current production as a change in asset value. For example, acid precipitation may produce a loss in agricultural production in a given year but this loss is already captured in GDP in the sense that agricultural output is lower than it would have been in the absence of the pollutant. However, if this acid precipitation reduced soil fertility in a permanent (or at least long-lived) manner, then this should show up in also in the asset accounts as present values of lost land rents.

10.155. ***Pollution damage to human health*** covering both pollution-linked morbidity and excess mortality needs to be valued (using combined dose-response and willingness to pay methods as described above Chapter 9).

10.156. Damage-adjusted income clearly says something about the country's revenue-creation capacity under prevailing conditions (including market, political and institutional as well as environmental conditions). This figure of Hicksian income for a country, as for any firm, is basically an accounting result in the sense that it gives an evaluation of the performance of the firm (or country) during the current year, calculated with current year prices.

10.157. Analysts should resist the temptation to use this Hicksian income as a hasty estimate for "sustainable national income" (SNI). If we continue with the analogy of a firm, the Hicksian income for a firm is "sustainable" only if the prevailing prices and external conditions for the firm do not change for the time horizon of interest. But, if the conditions change in any ways that are not already "internalised" into these prices and asset valuations, then the Hicksian income as defined for the current period does not provide a reliable guide as to future viability (for better or worse) of the enterprise.

10.158. Damage-adjusted income can give a useful impression of the direction in which a country is headed and may be very powerful in identifying problematic trends. However, this "diagnostic capacity" does not, in itself, tell where a remedy might be found. This issue and a potential solution are discussed further below.

Damage-adjusted saving

10.159. Hicksian income is usually defined as the maximum consumption obtainable while maintaining the total capital stock intact. Since income is equal to consumption plus saving and net new investment equals saving, income will only be a measure of Hicksian income if saving is positive or at least not negative. Just as we defined damage-adjusted income above, we may define damage-adjusted saving. It is either

damage-adjusted saving = damage-adjusted income
less final consumption by households and government

or it can be derived from saving as measured in the national accounts less the same adjustments made to reach damage-adjusted income from GDP[5].

10.160. Damage-adjusted saving is a particularly intuitive indicator since a value less than zero gives a clear warning that stocks of assets are being run down and that the economic situation cannot continue in the long run without a reversal of this position.

10.161. Obviously, the figures for both damage-adjusted income and damage-adjusted saving are sensitive to the categories of assets included. It is essential, in order to avoid misunderstandings, to have a clear presentation of what is, and is not, included in the set of economic and environmental assets being considered. What is or should be included in a country's damage-adjusted income may be determined by the circumstances of what is deemed most important or what it is feasible to estimate. As the set of assets included changes, then the "damage-adjusted" aggregates will change. In particular, attempts to include climate change, biodiversity, land cover change or other aspects of environmental services not yet monetised

[5] "Damage-adjusted saving" as used here is closely related to the concept of "genuine saving" as used by the World Bank. Note though that the World Bank's use of the term "genuine saving" includes reclassifying current education expenditures as investment rather than consumption. This is not an issue of environmental accounting *per se,* but plays an important role in informing decision-makers about the total change in the asset base underpinning development.

might be key cases where there could be very fruitful explorations of the policy applications of the SEEA 2000 framework.

Environmental debt

10.162. In making adjustments to current period production or income measures for degradation it is clearly only appropriate to adjust for degradation caused in the present period. This should include an allowance for pollutants generated this period even though the effects may not be felt until later. It should not include the costs of restoring damage caused in an earlier period. As noted earlier, unremedied degradation which carries forward to a future period is sometimes referred to as "environmental debt". Knowing the extent of this "debt" is obviously useful, but it is a stock value rather than a flow. As with asset accounts it is possible, in theory at least, to track this through time, seeing how much debt is ameliorated in a year and how much is added to the debt. As with other entries in the balance sheet, the costs of restoration are likely to increase over time also so there is a type of "holding loss" associated with environmental debt.

10.163. For additions to environmental debt, increments to stock pollutants should be valued as the present value of damages resulting from these increments over their lifetime in the environment. This is the methodological basis for the damage figures that are estimated for CO_2 emissions, for instance, where a 200 year residence time in the atmosphere is assumed.

10.164. In looking at the value of existing environmental debt, it should be noted that not all environmental assets can be restored because of irreversibility. Available restoration methods often restore the environmental asset, or reduce the environmental debt, only to a certain extent.

"Repaying environmental debt"

10.165. If the level of environmental protection in a year is not only sufficient to keep the level of residual generation within the assimilative capacity of the environment but actually goes further and improves the situation by countering some of the past activities, this excess should be regarded as a form of capital expenditure offsetting part of the previous level of environmental debt.

Importing environmental damage

10.166. If one is thinking of making adjustments to the production measure of output in respect of damages, the correct figure to take is that corresponding to the damage due to generation in the national economy. If, on the other hand, one wants the effect on income, it is the net amount received which is relevant. Just as national income departs from national product by the amount of net income flows to and from the rest of the world, so this is the appropriate adjustment to make in respect of damage costs.

3 Cost-based methods to derive macro-aggregates

10.167. Actions which may be taken to prevent environmental deterioration or to restore environmental quality include:

(a) reducing, or halting, harmful economic activities;

(b) producing and consuming less harmful products;

(c) changing to more environmentally benign technologies of production;

(d) reducing the effects of current technologies by, for example, installing end-of-pipe scrubbers; and

(e) restoring environmental quality.

10.168. The ways of measuring the costs associated with these actions were described in Chapter 9. The heading of avoidance costs covers structural adjustment costs (corresponding to (a), (b) and (c) above) and abatement costs (d), while the heading of restoration costs covers (e). This section considers how these costs, if incurred, would be reflected in the macro-economic aggregates. The method suggested in the 1993 SEEA, and implemented in a number of countries since then, relies on the maintenance cost approach.

10.169. As noted above, there are accounting inconsistencies implicit in the maintenance cost approach and a number of countries have adopted an alternative, modelling, approach to the question, usually called "greened-economy modelling". This assumes that the problem of degradation should be addressed not *via* the accounting system but *via* economic behaviour. Each of these approaches is discussed in turn below.

The philosophy of maintenance costing

10.170. Increasingly more and more firms are incurring actual costs to mitigate their impacts on the environment, either as a result of governmental legislation or simply pressure from the general public favouring producers seen to be "green". For example, as the negotiations related to the Kyoto protocol on climate change have illustrated, corporations, with or without government intervention, are taking increasingly many initiatives in reducing CO_2 emissions either in anticipation of future market intervention, to improve their image or to realise resource-saving potentials. These actual costs are captured in the type of accounts discussed in Chapter 5. The present section is concerned with trying to evaluate the costs associated with environmental degradation which is not, or not yet, being controlled.

10.171. The philosophy of the maintenance cost approach is to try to estimate what the accounting entries would have been for the same level of activity if all the costs associated with environmental degradation had been incurred and internalised within market prices. That is, it is an attempt to put a value on environmental sink functions which are currently free. As such it is a hypothetical exercise and should be interpreted as such rather than, as is sometimes portrayed, as a "correction" to the standard national accounts. Indeed, various levels of adjustment can be calculated depending on how much or how little degradation is to be permitted under the hypothetical scenario. It is sometimes unrealistic to assume no degradation at all takes place and this is unnecessary in any case when there are natural assimilation processes at work to absorb some of the emissions.

10.172. Maintenance cost is sometimes interpreted as a proxy for the value of the environmental functions which are used up. Under this latter assumption, allocating the costs to those who cause the deterioration in the function is in accordance with the polluter pays principle and may suggest the level at which market instruments for cost internalisation could be set.

10.173. Another possibility is to regard maintenance cost as a proxy for the environmental damage caused by economic activities during the accounting period. This is behind the assumption that the value of the maintenance cost represents the "wear and tear" on the environment just as the consumption of fixed capital represents the wear and tear on produced assets, and like consumption of fixed capital, should be deducted from GDP to reach a measure of net domestic product or income.

10.174. Under either scenario, maintenance costs could be held to provide a snapshot of the immediate environmental impacts of economic activity without entering the realm of modelling. This assumption is more likely to be valid at the micro level than the macro level and when the decline in environmental quality in question is modest. The further the economy is from the desired environmental standards, the larger the adjustment and the less realistic this snapshot will be.

Measuring maintenance costs

10.175. The 1993 SEEA first defines maintenance costs as those that "would have been incurred if the environment had been used in such a way as not to have affected its future use" (1993 SEEA paragraph 50). In fact, this position is somewhat modified just a few paragraphs later when the calculation of maintenance cost is described in a manner parallel to the consumption of fixed capital; that is, maintenance cost is set to the value of the costs which would have had to be incurred to remedy the environmental degradation that current production and consumption practices in the year caused. If the environment had been in a perfect state at the start of the year, these two formulations would correspond. If, however, the environment is already impaired at the start of the year, the initial definition is over-stated.

10.176. Maintenance costing is the only method described in the 1993 SEEA and in the associated operational manual (United Nations, 1999) for deriving alternative macro-economic aggregates. In those manuals the term EDP is used for the concept described here as eaNDP (environmentally adjusted NDP). Although the definition used implies that no environmental degradation is allowed when using maintenance cost methods, in fact it can also be applied to a given environmental standard which may be less than perfectly clean.

10.177. The different ways of combating degradation imply different costs and different accounting impacts for each.

10.178. ***Avoidance costs - structural adjustment option.*** One example might be to stop using fertilisers and pesticides, which would lead to a reduction in intermediate consumption but a greater reduction in output. GDP would therefore be lower than previously. Further, if the fertilisers and pesticides are domestically produced, there are likely to be second round effects further reducing GDP. Another possible means of reducing environmental damage is to change from environmentally damaging products and technologies to more environmentally benign ones. Here the impact on GDP will depend in the main on the relative cost of the more benign products as compared with the former ones.

10.179. ***Abatement and restoration costs***[6]. These do not involve cessation or change in activity but embarking on new activity to either inhibit the production of pollution or to clean it up once it has taken place.

10.180. In general, structural adjustment costs lead to decreases in NDP while those for abatement and restoration costs lead to increases. Restoration costs may arise from a variety of causes, including natural events, domestic economic activities in the past or economic activities in other countries. They may also be spread over several time periods if actually carried out. Avoidance costs refer to the present emissions and to domestic economic activity. (Either, if actually carried, out may bring benefits in the future.)

10.181. In preparing estimates of costs, the choice of activities for calculating the maintenance costs depends on relative costs and efficiencies; that is, on best-available technologies. Avoidance costs of industries should thus be based on the most efficient methods for not degrading the environment or for meeting environmental standards. Such standard setting is in line with the more practicable approaches to approximating optimal tax rates for cost internalisation (see notably Baumol and Oates, 1971). Restoration costs need to be carefully

[6] The 1993 SEEA used the expression "repercussion costs" to cover costs due to environmental damage which has not been restored. In this manual, such costs are treated under damage-based estimates as described in Chapter 9.

attributed to the current emissions and the anticipated effects of emissions discharged during the current accounting period. This is to ensure that environmental costs refer to the current wear and tear of natural capital and not to past environmental degradation.

10.182. In practice, even the best-available technologies applied to current production and consumption processes may not always be capable of abating all the emissions generated during the accounting period. The remaining emissions would have to be "tolerated" as their removal would be sub-optimal (owing to marginal costs exceeding social standards) in simulated markets. It is often assumed, or simply hoped, that these remaining emissions are safely absorbed by the environment, or are within the set standards. If this is not acceptable, the cost of avoiding the polluting activity altogether, in order to meet a given standard, has to be estimated.

10.183. Care must be taken not to use both avoidance and restoration costs which refer to the same environmental damage, such as reducing acidifying pollutants at the source and counteracting the acidifying effects of this year's emissions by liming.

Accounting for maintenance costs

10.184. A maintenance cost-based measure of eaNDP can be described as the attempt to answer the question

> *What would the value of net domestic product be if hypothetical environmental standards had been met using current costs and current technologies?*

10.185. Box 10.9 shows in schematic form a number of variations on the production account. The symbols used in the box are defined as follows:

P - production (output);
IC - intermediate consumption;
M - maintenance costs;
CFC - for consumption of fixed capital;
D - depletion;
dpNDP - depletion-adjusted NDP;
eaGDP - environmentally adjusted GDP; and
eaNDP - environmentally adjusted NDP.

Box 10.9 Options showing the derivation of domestic product measures

	Gross domestic product	Net domestic product
Option F1	GDP = P - IC	NDP = GDP - CFC
Option F2	GDP = P - IC	dpNDP = GDP - CFC - D
Option F3	eaGDP = P - M - IC = GDP - M	eaNDP = eaGDP - CFC - D = GDP - CFC - D - M
Option F4	eaGDP = P - (IC + M) = GDP - M	eaNDP = eaGDP - CFC - D = GDP - CFC - D - M
Option F5	eaGDP = P + M - IC = GDP + M	eaNDP = eaGDP - CFC - D - M = GDP - CFC - D

10.186. The row for option F1 in Box 10.9 shows the standard SNA derivation of gross and net domestic products with no allowances for either depletion or degradation of environmental assets. GDP is defined simply as output (P) less intermediate consumption (IC). NDP is equal to GDP less consumption of fixed capital (CFC).

10.187. The row for option F2 corresponds to the elaboration of accounts in Section B where depletion is taken into account in the difference between GDP and NDP but no allowance is made for degradation.

Depletion here includes the effects of extraction, natural growth, discoveries and return to natural capital as detailed in Section B.

10.188. The rows for options F3 and F4 cover avoidance costs (M) and seem identical but option F3 is predicated on the assumption that production falls because some environmentally harmful activity is halted. In option F4 it is assumed that intermediate consumption increases to mitigate the environmental damage which would otherwise result. In both cases, as a result of these measures, it is assumed that no degradation takes place so that GDP and NDP both show the same decrease.

10.189. Option F5 is an example of restoration costs; that is, degradation occurs but is remedied in the same period by undertaking new "clean-up" activity. Initially this leads to an increase in GDP but this is offset by the extra deduction made for degradation actually occurring. This approach is consistent with that proposed for the treatment of defensive expenditure given in the previous section.

10.190. Although options F3 and F4, on the one hand, and F5, on the other, result in different values of gross and net product, the difference between them in all three cases is equal to CFC + D + M; that is, the consumption of fixed capital due to produced assets (as in the SNA), depletion as in Section B and maintenance costs.

10.191. All these options are schematic. None leads to balanced national accounts because the effects of changes to output and intermediate consumption on the final use categories are not shown. Nor are any second round or subsequent effects allowed for.

10.192. More importantly, none of the options F3, F4 or F5 reflects economic behaviour in the light of changed circumstances; they are purely (incomplete) accounting constructs. Option F4 assumes that the producer bears all the costs, passing none on to the purchaser. Option F5 assumes the reverse, that the producer absorbs none of the costs but passes them all on. In neither is there a true internalisation of the costs with consequences for changing production patterns and prices. In option F5 there is no apparent change in demand in the face of higher prices. Neither allows for changing technology in the face of higher costs. Neither option explains where extra demand comes from and whether the economy has the capacity to provide it without running into capacity constraints. Neither option adequately allows for residuals generated by households in terms of a production account except by creating a notional industry with maintenance cost and negative output of the same size.

10.193. For an analysis to calculate the maximum impact of increasing environmental protection, these problems may perhaps be temporarily overlooked. When national accounts are calculated at constant prices, the prices of one year are applied to the volumes of another without any assessment of change in supply and demand; the whole of the reconciliation of any inherent inconsistency falling to the measure of value added at constant prices. In some ways, therefore, this seems a similar situation. However, constant price calculations are made when the difference in prices cause only marginal changes in the patterns of demand between the current and base year. For non-marginal changes, the correct response might well be "at those prices, that pattern of demand simply would not have existed". For maintenance cost for environmental protection, a similar situation prevails. It is a technique which can be used to estimate the maximum total impact of a marginal change in environmental standards but extreme caution should be exercised if it is used to estimate the impact of a change so large as to trigger major behavioural change. It is more suited for estimating the effect of fine-tuning environmental standards than trying to calculate the effect of removing all causes of degradation.

Maintenance costing in practice

10.194. Since the publication of the first version of the SEEA in 1993, a number of studies have been conducted using this technique. Some of these are referred to in Chapter 11 and a detailed account of work carried out in the Philippines is included there.

The philosophy of greened-economy modelling

10.195. One motivation behind many of the calls for "green GDP" in the past was the belief that alerting policy analysts, by means of adjusting standard macro-economic aggregates, to the fact that the economy was damaging the environment would be sufficient to provoke policy change to avoid this damage. There were, and are, many analysts who feel that this is unlikely to be sufficient and is not in fact the most helpful sort of information to make available to those policy makers concerned to protect the environment. Rather than a green GDP, what is needed is a blueprint for a green economy. It is not the accounting conventions which need to be changed but economic behaviour itself.

10.196. This ties up directly with the criticisms of the maintenance cost approach articulated in the previous sub-section. If environmental functions actually had a price on them instead of a hypothetical value, economic behaviour would change in a way which made more prudent use of functions now no longer free. This would lead to preferring economic activity which was increasingly more responsible in environmental terms. The means of achieving this change in behaviour are, as before, abstaining from damaging activities, making structural adjustments to behaviour, using abatement techniques or restoring damage done. The pricing techniques available are the same; it is the context in which they are applied which is different.

10.197. The search is not for a different, greener, value of GDP for the same economy (eaGDP) but a value of GDP, derived according to normal economic accounting practices, which relates to a different economy, one which is "greener" in that it is on a more environmentally benign path. The value of GDP for the greener economy is called "greened-economy GDP" or geGDP. Moreover interest is concentrated on the time series of geGDP rather than point-in-time estimates, since improved environmental standards take time to implement and require continual review and adjustment even when reached.

10.198. The information from the maintenance cost approach may form the starting point for such an exercise but the accounting framework is used as a basis for modelling rather than for making one-time adjustments to a limited number of aggregates. The model is used to determine the responses to extra demand for environmental protection goods and services and to look at the consequences of increasing prices. It can also be used to investigate the effects of achieving environmental standards by reducing activities with a high environmental burden in favour of those with less. An important feature is that all aspects of the accounts are utilised so that as far as possible all feedbacks are captured in the model.

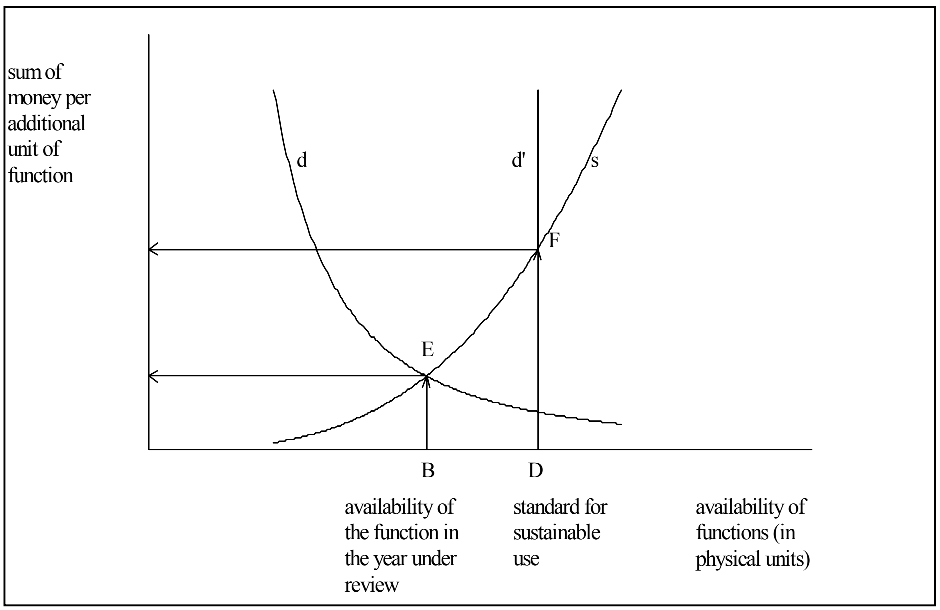
National income and greened-economy modelling

10.199. Much of the initiative to look for an alternative path for the economy rather than a different measure of the existing economy came from the work of Hueting in the late 1960's and early 1970's. He introduced the concept of environmental function referred to throughout this manual, explaining how pressure on functions leads to scarcity or competition for these functions. As with any economic good or service, this scarcity gives rise to an economic value due to the opportunity cost involved in their use or appropriation. The concern is then to define aggregate indicators to characterise a sustainable economy which ensures the maintenance of key environmental functions in perpetuity. Such an economy may be described as a "greened" version of the existing economy where typically an increase in national income is secured at the expense of worsening environmental degradation. Interest then focusses not on the new aggregates themselves but in the gap between the existing economy and the greened version.

10.200. The availability of functions for achieving a given end depends, on the one hand, on the quality, quantity and spatial extent of elements such as water, soil and life support systems, including ecosystems. These are largely amenable to measurement in physical units. On the other hand, a choice among availability of functions depends on the strength of subjective preferences, which are not directly measurable. These considerations can be expressed in a graph showing the availability of functions expressed in terms of a physical parameter on the x axis and the strength of the revealed and unrevealed preferences as well as the costs associated with restoration and maintenance of functions on the y axis (see Figure 10.1).

10.201. The marginal benefit curve in Figure 10.1 can in principle be constructed from the total of all expenditures, actually made or yet to be made, resulting from the loss of functions and of expenditures people are prepared to make to regain these functions.

Figure 10.1 Translation of costs in physical units into costs in monetary units



Key to the figure:

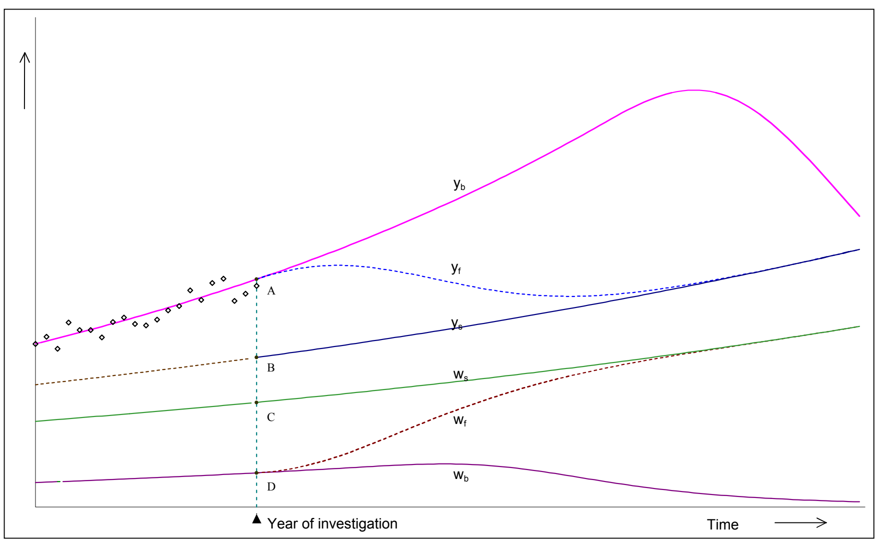
s: supply curve or marginal avoidance (or elimination) cost curve of the function
d: incomplete demand curve or marginal benefit curve based on individual preferences (revealed from expenditures on compensation of functions, etc.)
d': "demand curve" based on assumed preferences for sustainability
BD: distance that must be bridged in order to arrive at sustainable use of environmental functions
BDFE: costs of the loss of functions, expressed in monetary units
The arrows indicate the means by which the loss of environmental functions recorded in physical units is translated into monetary units.

Source: Hueting and de Boer, 2001.

10.202. Hueting postulated a partial measure of welfare which was derived from the conventional measure of income arising from economic activity by recognising the dis-benefits caused by scarcity of environmental functions. It refers to the maximum attainable national income given a set of assumed preferences expected to lead to the restoration and conservation of environmental functions. This indicator is called a greened-economy net national income (geNNI) using the terminology of O'Connor (2001). The concepts and their policy relevance have been explored in the context of the GREENSTAMP project (Brouwer *et al.*, 1999). Applying proposed environmental standards as constraints on the national economy leads to the derivation of "greened" aggregates such as domestic product and national income using either comparative static or dynamic scenario modelling. Comparisons of these aggregates with the values actually measured in the economy as currently operating leads to measures of opportunity costs in the sense of consumption or investment options that would be necessary to pursue the chosen environmental standards. These standards may correspond to a measure of full sustainability or to a less stringent set of circumstances.

10.203. Over time, as environmental pressures increase, the gap between conventionally measured economic welfare (as measured by national income) and the composite economic-environmental measure of welfare would increase and eventually and inevitably national income would decrease. This scenario can be seen in the top and bottom curves in Figure 10.2 which represent income (y_b) and welfare (w_b) respectively. Corresponding to this pair of curves, one can envisage another pair where the absolute level of income (y_s) is lower and the level of welfare (w_s) correspondingly higher under the assumptions made, but where income and welfare continue to increase without suffering the downturn of the first pair. The upper of these two curves corresponds to the notion Hueting called sustainable national income (SNI). It is the maximum income in a year in the past that can be sustained with the technology of that year, without assuming technological development except in respect of non-renewable resources. At a given point in time, national income is observed to be A and the corresponding welfare D. The corresponding SNI is B and matching welfare C. Further details on this approach can be found in Hueting and de Boer (2001).

Figure 10.2 National income and welfare on three paths



Source: Hueting and de Boer, 2001.

10.204. The two income lines passing through points A and B are so different that it is clear that they share few characteristics. Prices and levels of output differ and it is only possible to determine the parameters of the economy at B by applying a fairly complex model. It is obviously not possible in other than an analytical device to move instantaneously from A to B. One goal of the work is to derive an indicator for a given year in the past showing the extent of the environmental problems raised by production and consumption patterns of that year. Another goal is to project a transition path (y_f) from the non-sustainable income path to the sustainable one with a corresponding upwards convergence (w_f) from the present welfare path to the sustainable one. A strategy to reach this path must take account of the institutional behavioural and information factors which mean that the desired environmental standards are currently breached. Planning this evolution in such a way as to manage a soft landing is at the heart of successful environmental policy.

10.205. Greened-economy modelling is a generalisation of the SNI approach just described. As noted above, it is possible to specify less stringent environmental standards than those of full sustainability. Depending on how these are expressed, there is therefore an almost unlimited number of possible greened-economy paths and corresponding lines of income, each of which is sustainable only in certain environmental respects.

10.206. Just as it is possible to calculate a variety of income paths for different environmental standards, corresponding to generalisations of the pair of lines y_s and w_s, so it is possible to estimate a variety of transition paths to move from the existing economy lines (y_b and w_b) to any of these desired lines.

10.207. Greened-economy estimates may be calculated on the basis of historical data (*ex post* estimates such as SNI) or using future projections (*ex ante*). They may be produced using a comparative static solution so that the estimates for each time point are derived independently from each other or using a dynamic model which computes a continuous time path on the basis of changing stock variables. Together with the flexibility available on the degree of implementation of sustainability to be applied in a greened-economy solution, there are three choices to be made about how a greened-economy solution is to be estimated. A description of a number of applications making different use of these three dimensions can be found in O'Connor (2000).

10.208. What distinguishes a greened-economy model from a more general economic model is the emphasis given to achieving environmental improvement *via* economic processes. To achieve this, the following inputs are necessary.

10.209. The first is to establish standards for the use of environmental functions such as those of vital natural resources, environmental waste absorption capacities and life-support systems, biodiversity, air, soil and water quality and the ecological dimensions of sustainability. This is done by means of modelling in physical terms as a result of which environmental standards are determined for use in succeeding stages of the model. These are specified through non-monetary targets relating to maintaining key environmental functions. Physical accounts are essential to organise information concerning the state of the environment and key economy-environmental interface measures or environmental use or "pressure" indicators relative to estimates of environmental carrying capacities.

10.210. The next step is to identify the measures that would have to be carried out to secure the desired environmental quality level or measures for restoring environmental deterioration which actually occurred. Some specific examples are:

expenditures by production sectors to use resources more efficiently or to reduce polluting emissions per unit of output through changes in technologies;

shifts among different natural resources (for example, the use of wind power to replace the use of fossil fuel);

changing physical locations of environmental exploitation to make better use of local assimilation capacities;

replacing products or activities by alternatives less damaging to the environment, which involves changes to production and consumption patterns.

When the target path, such as a sustainable development path, is far away from the actual development path, the possibility of taking a lower human population into account has to be considered as well.

10.211. The third step is to calculate the costs necessary to implement these measures. Data on emissions, technology and costs are required to estimate aggregate abatement and restoration costs. An important source of raw data is databases of technologies held by research institutes. Governments also increasingly collect physical characteristics and cost data of best-available technologies for administrative purposes, such as the granting of authorisation to operate installations (permits). An example of this trend is the reporting and information exchange mechanisms set up in Europe through the European Union's Council Directive 96/61/EC of 24 September 1996 concerning Integrated Pollution Prevention and Control (IPPC). Data from such sources contribute the first step towards standardisation and increased comparability of environmental costing.

10.212. As explained, "greened-economy" indicators can be estimated using scenario modelling *ex post* for a series of years in the past or *ex ante* for years in the future. As shown in Figure 10.2, *ex post* figures show a gap between geGDP which conforms to the assumed environmental standards in the year in question and the observed GDP. *Ex ante* projections start from a geGDP which is assumed to be already on a transition path. The figure for geGDP which results from the model will depend on the environmental standards chosen and also on demographic assumptions, hypotheses about preferences for future consumption patterns and the technological options being explored. A whole-economy approach must make explicit hypotheses about the timing of various policy and investment responses and the inter-dependence of the variables measured in the accounts. The aim is to model a scenario where the production and consumption of products generating high levels of residuals is reduced. This will have consequences for other industries related to high-residual producers and possibly on employment and household income. The scenario framework makes it clear that more than one "greened-economy GDP" figure or time series might be calculated, each connected to a different set of assumptions. There is no uniquely "correct" geGDP. On the contrary, different geGDP figures, or time series, give far more information to policy makers than one geGDP, provided that the assumptions underlying each of the variants are made explicit.

10.213. The definition and estimation of greened-economy GDP and NDP figures is intended to inform debate about alternative possible national economic development paths and trade-offs between output growth, final consumption and environmental performance objectives. Where the purpose is to investigate sustainability prospects, a robust and transparent approach is needed to develop *ex post* and *ex ante* scenarios based on explicit propositions about consumption, technological change, and environmental performance requirements.

10.214. In practice, it may often be the case that a definitive level of what is sustainable is very uncertain. However, the techniques above can be used to estimate the cost of reaching a given target; for example, those established under the Kyoto protocol. In such cases, the costs calculated have a clear meaning (the cost of achieving the target). However, they cannot be interpreted strictly as the "cost of being sustainable" in absolute terms, only of sustaining a given, pre-determined, level.

Greened-economy modelling in practice

10.215. Some experience exists for making greened-economy estimates. Box 10.10 gives an indication of such experience in Germany. The extent of the data requirements was such that the researchers turned to modelling as a cost-efficient way of pursuing their objectives.

E Summary

10.216. This section examines the consistency of the various options presented, discusses theoretical, practical and institutional considerations, and assesses the impact in terms of quantification of making adjustments for each of depletion, defensive expenditure and degradation.

1 Depletion

Theoretical considerations

10.217. The section on depletion concerns the use of natural resources within production. By extension, it may include reductions in the value of land and non-cultivated biological assets as well as reductions in value of produced capital brought about by the effects of environmental degradation.

10.218. Section B describes various means of measuring depletion-adjusted income and depletion-adjusted capital formation in such a way that these two concepts are strictly consistent with one another. The changes in capital stock are consistent with those recorded in an SNA asset account. By situating some items appearing in the SNA other changes in assets account within the income accounts instead, a matching measure of income can be calculated.

Box 10.10 German experiences in implementing the maintenance cost approach

As a member of the European Commission-funded Greenstamp project, the German Federal Statistical Office applied and tested the maintenance cost approach of the 1993 SEEA during 1995-1997. The aim was to clarify the theoretical background of imputed abatement or avoidance costs, to develop a calculation procedure consistent with the statistical framework of national accounting and to test the concept empirically by calculating abatement costs for the German economy for different nitrogen compounds (reporting year 1990 for former Germany). The final report discusses definitional, conceptual and empirical difficulties in the calculation of abatement cost curves. A multi-stage calculation procedure was developed allowing the aggregation of physical and cost data at the technical level in successive steps; first to the micro-economic level, then to the industry level and finally to macro-economic abatement costs.

Within the project, reliable abatement costs were calculated for the industry level, reflecting direct abatement costs at an industrial branch level for certain technical measures reducing emissions of nitrogen. Indirect physical and monetary effects were not calculated. Empirical experience gained through the project underlined the need for econometric modelling procedures to integrate such important indirect effects, mainly monetary, and arrive at comprehensive abatement costs in a macro-economic perspective consistent with the framework of national accounts.

In a subsequent step, following the Greenstamp philosophy, econometric model calculations were conducted in Germany by research institutes in collaboration with the Federal Statistical Office in 1997-1998. The macro-economic consequences of meeting predefined environmental performance standards (for example, certain CO_2 reduction rates) were estimated. In that context, the database of the Pantha-Rhei model of Osnabrück University was substantially enlarged by incorporating the detailed emission accounts of the Statistical Office and the abatement cost data of the Greenstamp project.

Another research project examined the suitability of five major German econometric models to analyse changes aimed at a better environmental interaction. The general task was to determine the extent to which models are suitable to describe the actual state or pathways of a national economy while meeting given environmental targets or standards.

Sources: Radermacher *et al*., 1998; Riege-Wcislo and Heinze, 1998; Frohn *et al*., 1998.

10.219. Measures of gross and net domestic product with the same values as in the SNA remain in the accounts but an additional item, called depletion-adjusted domestic product (dpNDP) is also presented.

Consistency of options

10.220. The key decisions to be made about whether to calculate a depletion-adjusted value of income are twofold. The first decision is whether to recognise any of the income arising from the use of assets as actually a reduction in national wealth which should be deducted from income. If not, there is no further deduction from NDP to be made to reach dpNDP. The second decision is whether to include any of the benefits from using natural assets as income from production. If not, then dpNDP is less than NDP by the whole of the value of the natural resources brought into the economy. The more general case lies between these two positions with some but not all of the value of the resource being treated as income and some as consumption of natural capital.

10.221. The global estimates for macro-economic aggregates are unaffected by issues of ownership of the assets but Section B spells out various possible alternatives for recording the flows between the user and the owner. These are summarised in Boxes 10.7 and 10.8.

Practical considerations

10.222. All the calculations necessary for incorporation in the flow accounts are included in the steps necessary to calculate an SNA asset account for the natural resource in question. A summary of the parameters need is given in Box 7.2.

10.223. It is worth noting that the size of any addition to or reduction in a reserve with a life length over 20 years and a discount rate greater than five per cent is relatively small and becomes even less significant as the life length increases and the discount rate increases.

Institutional considerations

10.224. Since the basic steps of the calculations are required to implement the SNA, there are no institutional considerations beyond deciding whether the use of natural resources is sufficiently important for the country to warrant making alternative presentations available to the general public. For some resources, there may be a question mark over the accuracy of the estimates which would caution against publication but in these cases the SNA cannot be fully implemented either.

Impact of adjustments on macro-economic aggregates

10.225. The example for the SEEAland data given in Table 10.4 shows a figure for GDP of 692.4 billion currency units. This is reduced by 104.4 billion currency units in respect of consumption of fixed capital to give a figure for NDP of 588.0 billion currency units. If an adjustment is made in respect of extraction only, this figure reduces by a further 58.6 billion currency units to 529.4 billion currency units. If discoveries and natural growth are set against extraction, then the adjustment to NDP to reach a figure for depletion-adjusted domestic product is 12.8 billion currency units giving a total of 575.2 billion currency units.

10.226. The magnitude of the data entries in the SEEAland data set are thought to be realistic for a country well-endowed with natural resources. On this basis, while adjustments for depletion are significant, they are not startlingly large, especially if discoveries are taken into account. Whereas NDP is approximately 85 per cent of GDP, depletion-adjusted domestic product is only about 2 per cent lower.

2 Defensive expenditure

Theoretical considerations

10.227. Identifying environmental protection expenditure within the SNA involves identifying some ancillary activity and identifying its output separately. This increases the value of both output and of intermediate consumption but leaves the values of GDP and NDP unaltered. Under the "gross gross" treatment suggested in Section C, GDP is higher than in the conventional SNA and NDP lower. The difference between the two is increased by the total current expenditure on environmental protection. The same accounting identities are used to calculate the aggregates but these can be designated as being "defensive adjusted".

10.228. Both treatments of defensive expenditure relate to income measures only with no consequences for the state of environmental media explored.

Consistency of options

10.229. If the "gross gross" approach to environmental protection expenditure is adopted, it would be logical to extend this to other current repairs and maintenance also. This could provide a way to address similar issues such as the treatment of research and development expenditure and education expenditure, for example, though these considerations are beyond the scope of this handbook.

10.230. These options for defensive expenditure are entirely consistent with the options presented for the treatment of depletion and can be cumulated in any combination.

Practical considerations

10.231. Once the basic data needed for a satellite account showing environmental protection expenditure as described in Chapter 5 are available, all the necessary information is available for incorporating explicit reference to environmental protection expenditure in the flow accounts of the complete system.

Institutional considerations

10.232. If there is no institutional objection to showing a satellite account for environmental protection expenditure, it is difficult to see there would be any for the identification of this form of defensive expenditure in satellite flow accounts.

Impact of adjustments on macro-economic aggregates

10.233. The figures in Table 10.5 take account of environmental protection expenditure only. On this basis they show an increase in GDP of just over one percent and a decrease in NDP of about one per cent also. On this revised basis, NDP is 83 per cent of GDP compared (as before) with a ratio of the SNA aggregates of 85 per cent.

10.234. The environmental protection expenditure data are not as carefully estimated as those relating to natural resources but assuming they are broadly realistic, this might suggest that an adjustment for defensive expenditure could be of the same order of importance as an adjustment for depletion.

3 Degradation

Theoretical considerations

10.235. The theoretical considerations are different for each of the main approaches described.

Damage-based estimates

10.236. Damage-based estimates of degradation are broadly consistent with the concept of consumption of natural capital deriving from the asset-based approach to depletion. This allows damage to both produced and non-produced assets to be incorporated in the flow accounts in a parallel manner. The major extension is to treat damage to human health in a similar way as a decrease in welfare, rather than wealth, and a matching decrease in income. The problem with this approach is that there is no absolute value to be placed on welfare so any resulting analysis should be conducted in terms of changes in welfare rather than absolute levels.

10.237. Because the damage falls on units other than those causing the environmental degradation, this adjustment can only be made globally and not at the level of the individual sectors. On the other hand, adjustments for "environmental debt" can be made to show the carry-over effects from one period to another and also the effects of damage caused by cross-border flows of residuals.

10.238. Under this option, a new macro-aggregate, daNNI (damage adjusted national income) is introduced which is lower than dpNDP by the amount of estimated damages.

Maintenance cost estimates

10.239. This approach is similar to the treatment of defensive expenditure. It makes adjustments to income without any corresponding consideration of the stock of environmental assets. It suffers a major conceptual weakness in that it assumes that a new set of prices or production changes can be introduced without consequences for the rest of the economy. At best it can be seen as a snapshot or upper estimate of the value of degradation.

10.240. Under this option a new macro-aggregate, eaNDP (environmentally adjusted NDP) is introduced. Its relation to dpNDP and maintenance costs will depend on the exact nature of those costs, as explained in Box 10.9.

Greened-economy estimates

10.241. These estimates are entirely consistent with the theoretical structure of the SNA but not with the existing economy which the current SNA estimates measure. Macro-economic aggregates are prefixed by "ge" under this option but this does not signify an accounting difference from their SNA equivalents.

Consistency of options

10.242. The three approaches are not consistent with one another, though the greened-economy estimates can be seen as growing out of the maintenance cost approach. Damage based estimates focus on (negative) benefits and a stock approach where maintenance cost estimates focus on costs and income flows. There is no market mechanism to bring the costs and damages into line with one another except under the greened-economy alternative which is a modelling and not an accounting solution.

10.243. Any of the three approaches can be combined with the depletion and defensive expenditure options, but care must be taken that damages and costs are counted only once.

Practical considerations

10.244. All approaches present practical difficulties and may be resource intensive to implement. In all implementations, there is the question of whether all degradation is to be valued (and hopefully avoided or restored) or whether the exercise is rather to explore the impact of improving environmental standards by only a given amount. When the techniques are to be used to make forward projections of (more) sustainable paths for the economy, questions arise about the degree of technical progress to be assumed and how far consumption and production patterns will change to be more environmentally benign. Not all these changes may be driven by explicit concern over the environment. Fears about diseases linked to meat consumption may lead to greater consumption of less agriculturally intensive products; fear over terrorist activities may reduce air travel and thus the emissions from spent fuel.

10.245. The damage-based method assumes that the value of damage done is equal to the fall in value of environmental services provided. There is a question over how much damage can be measured in this way. The techniques described assume that a causation can be made between particular illness and specific pollutants and calibrated to an acceptable degree of accuracy.

10.246. An ideal dataset for damage estimates would include emissions by industries in a hybrid accounting framework (by region), linked to physical distribution models for the pollutants, ambient concentrations in a geographical breakdown and the population affected. Dose-response functions could then be applied to estimate the physical impacts and damages (respiratory diseases, damages to buildings, etc.) which could then in turn be valued in monetary terms. In analytical applications, this linked dataset would allow the monetary value of damage estimates to be linked to the initial causes (domestic and foreign). It would also allow the effects of alternative policy options, distributed geographically and by industry, on the damage estimates to be modelled. The hybrid accounting framework allows the avoidance cost calculations to be directly linked to the damage estimates so that for each policy option a cost-benefit comparison can be performed.

10.247. The maintenance cost approach can be very resource intensive to apply. In principle, if a reduction in emissions can be brought about by one of several ways, the relative costs of each should be estimated and the least expensive chosen. Not only is there a need to identify the appropriate solution to the given problem, the question of the interaction between the cost level and improvement in pollution prevention must be calibrated. This is an area where the macro-economic figure is not necessarily a simple aggregate of numerous micro-studies and further work is necessary to move from one level to another.

10.248. The greened-economy solution faces these problems, as well as the usual considerable problems of specifying how an economy will react to changes in prices and demand.

Institutional considerations

10.249. There are several reasons why a statistical office may decide not to pursue degradation-adjusted accounts. One reason is that several institutions are formally inhibited from undertaking modelling or projection work and the exercise therefore falls outside their work programme. A second reason may be reservations over the theoretical basis for the work. A third reason may revolve around the trade-off between resource cost and accuracy. Making such estimates is inevitably resource intensive, both in terms of staff numbers and elapsed time, and the accuracy and timeliness of the results may not seem to justify this. Even with access to very considerable databases of relevant information, estimates of the value of degradation across the economy as a whole are likely to remain subject to significant margins of error for some time to come.

Impact of adjustments on macro-economic aggregates

10.250. The SEEAland data set is not sufficiently elaborated to permit estimates of damage adjusted aggregates. The research results available for a number of countries give a very wide range of proportionate adjustments. Not only is the range wide, but the robustness of the estimates would generally be held to be less than for the other two adjustments.

4 Conclusion

10.251. The possibilities of incorporating adjustments for depletion and defensive expenditure into the flow accounts are much more promising for a statistical office at this time though even here there may be reservations about proceeding with the work on theoretical or practical grounds. By contrast, it seems that work on degradation will stay mainly in the research field for some time.

10.252. Users should be advised that robust and fully comprehensive environmentally adjusted accounts are unlikely in the very near future. Depending on individual circumstance, though, some partial estimates may be prepared; for example, covering depletion for mineral rich economies and damage to human health for those countries with serious problems arising in large conurbations.

10.253. Many of the values estimated for the SEEA will ideally be site-specific, increasing the estimation burden. Again, concentrating on the largest problems first can help to reduce the effect this has on the accounts, and benefits-transfer methods offer a possible means to fill gaps where precise local estimates are unavailable.

10.254. Even so, economic aggregates from the SEEA will be necessarily less precise than those coming from the SNA. Collaboration with users as new versions of the accounts are developed is important to allow external review of the techniques adopted and the quality of the results and also to avoid raising unrealistic expectations among users.

10.255. One observation which should be noted for any policy maker concerned with a measure of income which preserves a given level of capital is that the first and most important adjustment to take into account is that which transforms GDP to NDP by allowing for the depletion of the stock of produced assets. This adjustment runs at between 10 to 15 per cent for most countries and is potentially much greater than any adjustments made for either depletion or defensive expenditure.

Chapter 11 Applications and policy uses of the SEEA

A Chapter overview

1 Objectives

11.1. This chapter attempts to give examples of the various applications and policy uses for which the sort of tables and analyses described in this handbook can be used. It does not aim to be exhaustive or prescriptive but rather aims to introduce the reader to potential uses and to encourage him or her to develop other applications imaginatively.

11.2. Broadly speaking, there are two sorts of applications described. The first of these is closest to statistical tradition and concerns the development of sets of indicators and descriptive statistics drawn from the different subject areas covered.

11.3. The second set of applications shows how specific policy analyses can be based on the techniques covered in the handbook. Policy analysis usually requires more specialised expertise in the techniques of economic analysis and modelling. The statistical offices in only a few countries extend their analyses into these areas. Consequently, in many countries, further use of the SEEA will require extensive cooperation between statistical offices and those agencies that have responsibility for and expertise in policy analysis and recommendation. The distinction between monitoring and policy analysis in this chapter is made to help statistical offices identify what they can reasonably do alone and what it may be preferable to undertake in collaboration with other agencies.

11.4. The common theme running through all applications is a concern to monitor the pressures exerted by the economy on the environment and to explore how these might be abated. The order of the previous chapters is followed so that the questions of degradation, defensive expenditure and depletion are addressed in this order. There then follows a section where comprehensive analyses embracing all three concerns are considered.

11.5. Section B looks at the economic activities which lead to degradation of environmental media. It discusses the use of physical and hybrid flow accounts and draws on material on chapters 3 and 4.

11.6. Section C explores the existing responses to degradation through defensive expenditure and the development of economic instruments to tackle pollution at source. It draws on the material in chapters 5 and 6.

11.7. Section D discusses measures of national wealth and the changes in it due to depletion of the stock of natural resources. The techniques and analyses described here are particularly relevant for those who regard sustainability as a matter of maintaining wealth. It is based on the material described in chapters 7 and 8.

11.8. Section E examines how the application of prices to estimates of degradation in physical terms can be used to determine the cost-effectiveness of various strategies to combat degradation. The pricing techniques used are those described in Chapter 9.

11.9. Section F shows how the techniques for valuing degradation described in Section E can be combined with valuation of depletion described in Section D to make adjustments to the conventional macro-economic aggregates. As described in Chapter 10, on which this section draws, some of these techniques go beyond statistical accounting into the realm of economic modelling.

11.10. A last section, Section G, is included rather as an annex to the handbook to look at sets of indicators for sustainable development such as those being developed by various international organisations and individual countries. The relevance of different parts of the SEEA for the lists of indicators suggested by the United Nations is given as an example of the application of the SEEA in this field.

2 The examples cited

11.11. The examples quoted in this chapter are additional to those quoted in earlier chapters, in particular to those in Chapter 8 where extensive discussion is given to each of five environmental assets based in large part around data for individual countries. In general, the earlier examples help to explain the technical derivation of the tables as well as to show their analytical usefulness whereas the examples in this chapter concentrate on why to undertake various analyses rather than how to do so.

B Physical flow accounts and the causes of environmental degradation

11.12. The physical flow accounts described in Chapter 3 can be used to establish detailed time trends of the generation of residuals and to determine the most important sources of pollution. By linking information from the physical accounts with that from hybrid accounts, a judgement can be made about the relative importance of the sector generating the residuals to the functioning of the economy to set alongside the significance of the level of residuals generated. The accounts provide information and indicators (e.g., carrying capacity, total material requirements and “ecological footprints”) useful for monitoring progress toward the de-materialisation of the economy, or the de-coupling of economic growth from material throughput. Thus, together, the two sorts of accounts help set priorities for policy based on the volume of residuals.

1 Indicators and descriptive statistics

11.13. Several examples of the application of physical and hybrid flow accounts are given in chapters 3 and 4. Of particular interest are the environmental-economic profiles developed by Statistics Netherlands in connection with their work on hybrid flow accounts (that is, their NAMEA).

Tracking the structural causes of residual generation

11.14. In order to design effective environmental policy, one must understand the reasons for the large differences in the amounts of residuals generated by different industries. The first step in this process is to distinguish between the role played by an industry's technology and the role played by the level of output.

11.15. The impact of technology can be measured by the residuals intensity of production, measured by dividing total residuals from an industry by the output of that industry. These direct coefficients of residuals, material and energy intensity by industry can be used to rank industries in terms of their environmental impact. For industries with relatively large coefficients, even small changes in the levels of output can have a major impact on corresponding levels of residuals generation or material use. The coefficients can also be useful for benchmarking, to assess progress toward reducing residuals or material intensity of production within an industry over time, or to assess progress of one industry compared to another over time, or across countries.

11.16. It is important for policy-makers to understand not just the direct generation of residuals associated with production but also the driving forces that underlie the production patterns. In the Dutch example, a relatively small proportion of total residuals is generated by final consumers; most residuals result from industrial production. However, production takes place in order to supply other industries with inputs they need and, ultimately, to supply final users with products they want.

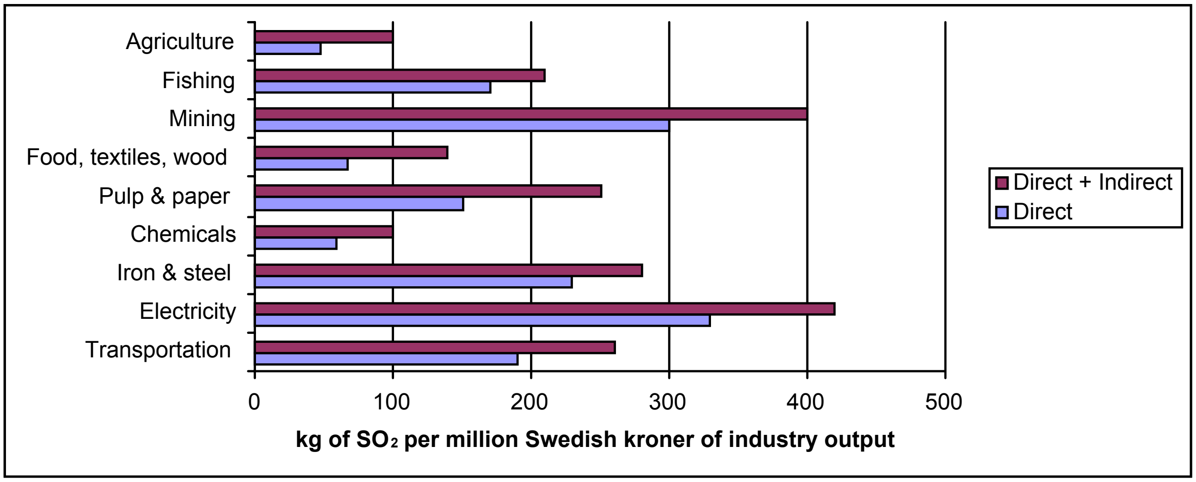
11.17. Each product purchased by final users requires an extensive web of "upstream" industrial production to supply it. Every stage of upstream production requires energy and material use and generates residuals; these are known as the indirect use of energy and materials and indirect residuals generation associated with deliveries to final users. Models based on hybrid input-output tables are used to measure the total impact of a given final use (that is, both the direct and indirect impact). In effect, this analysis redistributes emissions from industry to the driving force (final user) for which this production took place.

11.18. A comparison of the direct and total emissions of sulphur dioxide for each product delivered to final users in Sweden is provided in Figure 11.1. This shows, for example, that every purchase of one million kroner of agricultural output by final users results in the generation of nearly 50 kg of sulphur dioxide (SO_2) by the agricultural industry. An additional 50 kg of SO_2 (for a total of 100 kg) is generated by the production of all the inputs required for production by the agricultural industry, for the production of those inputs into agriculture and so on. Long experience with environmental input-output analysis has shown that the total impact is often much larger than the direct impact (Førsund, 1985; Miller and Blair, 1985; Pearson, 1989). Similar statistics have been constructed for a number of other countries such as the Netherlands (Keuning *et al*., 1999), Germany (Tjahjadi *et al*., 1999), Canada (Statistics Canada, 2001), Norway (Sørensen and Hass, 1998) and the UK (Vaze, 1999).

11.19. The ability to measure total residuals and direct plus indirect use of materials associated with given products, processes, or consumption patterns allows far more effective strategies for reducing the use and managing the disposal of materials than could be devised on the basis of direct use only. For example, Table 4.12 in Chapter 4 shows that public utilities, mainly electricity production, were responsible for 26 per cent of greenhouse gas emissions and 9 per cent of acidification emissions in the Netherlands. In attempting to reduce these emissions, policy-makers can try to bring about technological change in the electric power industry to reduce emissions, but they can also identify who is purchasing electricity and try to change the behaviour of those users as well. It is often necessary to design policy for both groups – the direct source of residuals as well as the users of products, whose demand drives the level of production and associated residuals.

11.20. The calculation of total emissions is particularly useful for understanding how the structure of an economy affects the levels of residual emissions and resource use. Final use can be disaggregated into its components, household consumption, government consumption, investment and exports to determine how much of the total residuals generated in the economy occur in order to meet the demands of each of these components. Because household consumption accounts for the greatest share of final demand, researchers have increasingly focussed on the composition of household consumption as a critical component for sustainable development. Strategies for sustainable development have examined the impact of alternative household consumption patterns, particularly in the wealthy industrialised countries where the need to identify "sustainable lifestyles" with corresponding consumption patterns has received a lot of attention.

Figure 11.1 Direct and total emissions of sulphur dioxide per unit of industrial output delivered to final users in Sweden, 1991



Source: Hellsten *et al.*, 1999.

Understanding changes over time through decomposition analysis

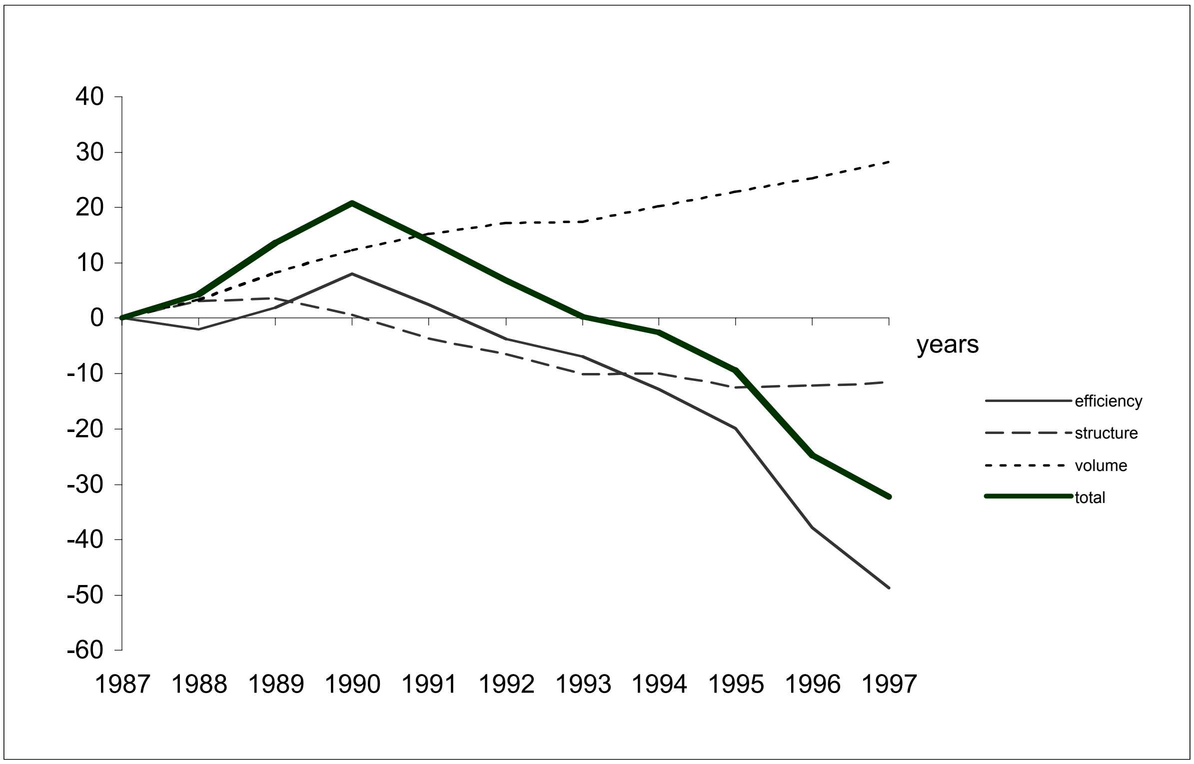
11.21. A formal and more thorough analysis of driving forces over time can be obtained by applying the technique of structural decomposition analysis to a hybrid input-output table. Over time, levels of emissions can change considerably and policy-makers need to know how much of this might be the result of environmental policies. Policies affect the choice of technology as well as the level and composition of final demand and it is not immediately evident how much of the change in emissions is attributable to each factor. Are emissions falling mainly because of changes in production technology (and in which industries) or because of changes in the composition of final demand to a mix of goods and services with lower (total) emission requirements?

11.22. Structural decomposition analysis is a technique developed to distinguish the different sources of change in the economy over time by decomposing differences in the direct plus indirect requirements matrices derived from the input-output tables. A recent application of decomposition analysis for residuals using the NAMEA for the Netherlands was carried out by de Haan (2001) for the period 1987 to 1998. The study addressed changes in the levels of greenhouse gas emissions, acidification emissions and solid waste. It distinguished three major factors affecting residuals: economic growth (volume of production), changing composition of final demand and changes in technology. A description of the results for greenhouse gas emissions is given in Chapter 4 comparing the figures for the Netherlands and the United Kingdom. For greenhouse gas emissions, economic growth outweighed the impact of improved efficiency and structural change, resulting in rising emissions over time. For acid emissions, economic growth tended to increase but this trend was outweighed by emission reductions brought about through technological change. The change in the composition of final demand had relatively little impact and the net effect was a decline in acidification emissions over the period.

11.23. Solid waste generation increased from 1987 to 1990 but thereafter declined due to substantial improvements in technology and, to a lesser degree, changes in the composition of final demand. With no gains from efficiency due to technological developments or changing structure, it would be expected that solid waste generation would have grown in line with the growth in the volume of production over the period (28 per cent). In the case of the Netherlands, reductions due to eco-effciency gains (48 per cent) and structural changes effects (12 per cent) resulted in an overall decrease of 32 per cent. These results are shown in Figure 11.2.

11.24. While only the aggregate figures for each of the three major factors are reported, each of the factors, in turn, can be disaggregated to the level of industrial classification used for the analysis. In some countries, this can be 500 industries or more, allowing an extremely detailed and complete analysis of the causes of changes over time.

Figure 11.2 Decomposition of changes in production-related solid waste generation in the Netherlands, 1987-1998



Source: de Haan, 2001.

11.25. In the conclusion to the study, de Haan stresses the importance of extending this analysis to the entire EU region in order to better account for intra-EU trade. A limitation of this analysis is estimating the residual content of imported products. Without environmental accounts for a country's major trading partners, one cannot accurately estimate the extent to which an environmental problem has improved (or worsened) simply because products are no longer produced domestically but are imported instead. Environmental management would certainly benefit from a consistent set of multi-country accounts that could be used for regional analysis.

11.26. The examples discussed above concern residuals. However, this kind of analysis is equally important for material flows as well. There is a long literature of this kind of analysis for energy use. The construction and analysis of flow accounts for water has also received attention especially in countries of water scarcity.

Water accounts are a priority component of the environmental accounts in France, Spain, Moldova, Chile, Namibia, Botswana and South Africa.

2 *Policy analysis and strategic planning*

11.27. So far, the discussion has focussed on analysis of the interaction between the existing environment and the economy, but policy-makers also need to look to the future and design effective instruments for environmental policy. Strategic analysis is conducted to explore the various possible alternatives in order to design a more desirable future. Countries typically identify the broad environmental objectives they wish to achieve in the future, such as more sustainable development or more sustainable lifestyles. Under these objectives, specific problems, such as air quality, are identified and more detailed strategies to address these problems are examined in a modelling framework. This analysis is often based on long-term models to explore alternative scenarios about paths of economic development.

11.28. Strategic planning addresses a relatively long time horizon (10-25 years or more) and fundamental changes in the structure of the economy that might be necessary to achieve society's environmental objectives. Examples of strategic planning include the Netherlands Environmental Policy Plan, a long-term plan for sustainable development or routine strategic macroeconomic planning models (for example, the Multi-Sector Growth Model of Norway's Ministry of Finance which has integrated environmental components for energy and residuals). Strategic planning often emphasises dynamic modelling instead of the static analysis commonly used for policy analysis. Dynamic analysis is important because it informs policy-makers about the transition path (that is, the process of adjustment to a different economy).

11.29. Once the possible overall strategies are determined, policy analysis involves choosing the best alternatives and preparing to implement them. This analysis considers different instruments policy-makers might choose (usually a small range of actions over a relatively short period of time, such as different values for a carbon tax) and provides policy-makers with the most likely outcome of these actions Policy models can be used to examine the economic implications of various environmental policy instruments, such as taxes, tradable permits, or emission standards, as well as macroeconomic policies, such as trade policy and its impact on the environment.

Examples of policy analysis

11.30. In parts of Australia, the United States and southern Africa, water scarcity is as critical an issue as water quality. Flow accounts for water have been used in a computable general equilibrium (CGE) model to address new water pricing policies in South Africa (Hassan, 1998). In the past, water prices were very low with little regard for cost or scarcity, especially for agricultural use. The proposed new pricing policy includes full-cost recovery tariffs with a guaranteed “lifeline” amount of water supplied to all households, as well as innovative pricing policies such as a user charge for the reduction of rainfall runoff caused by commercial plantations of exotic forest species.

11.31. A broad range of policy studies was undertaken in the Philippines, including an assessment of the environmental implications of rice self-sufficiency (land, water and residuals), a study of trade and environment linkages and a study of the environmental implications of alternative land use patterns (ENRAP, 1999).

11.32. Another application of the physical flow accounts is life-cycle analysis (LCA). Traditionally, LCA is a bottom-up process analysis based on linking the specific processes in a supply chain to trace the environmental impacts from “cradle to grave” of specific products or production processes. The advantage of this extremely detailed approach is its capacity to represent environmental impacts precisely. However, a major limitation of process-based LCA is the likelihood that important parts of the product systems are left out of the analysis, simply because it is difficult to follow the entire supply chain in such detail.

11.33. In some instances, practitioners have attempted to address this problem through the use of so-called hybrid life-cycle analysis or environmental input-output life-cycle analysis, in which the detailed, partial LCA is combined with economy-wide input-output analysis. Physical flow accounts for inputs of natural resources and outputs of residuals are combined with input-output analysis as a supplement to traditional process-oriented LCA (see the journal *Industrial Ecology* for regular articles on theoretical and empirical aspects of this topic). While input-output data, based on averages of intermediate consumption, natural resource use and residuals for industries, may be less accurate than process-level analysis, the input-output analysis ensures that all the indirect effects are taken into account. In hybrid analysis, process analysis is often used for the first few rounds, then input-output analysis for the remaining.

11.34. This method has been used to calculate the total CO_2 impact from Danish household consumption of 72 different commodities (Munksgaard, 2001). It has also been applied to examine the environmental implications of introducing fuel cell electric vehicles in the United States (Gloria, 2001). The combination of traditional LCA with input-output has been used in the United Kingdom to explore aspects of climate change policies, such as the development of a model for carbon emissions trading (Shipworth, 2000) and an analysis to identify the industries that would gain and lose the most from carbon taxes (Ecotec, 1999).

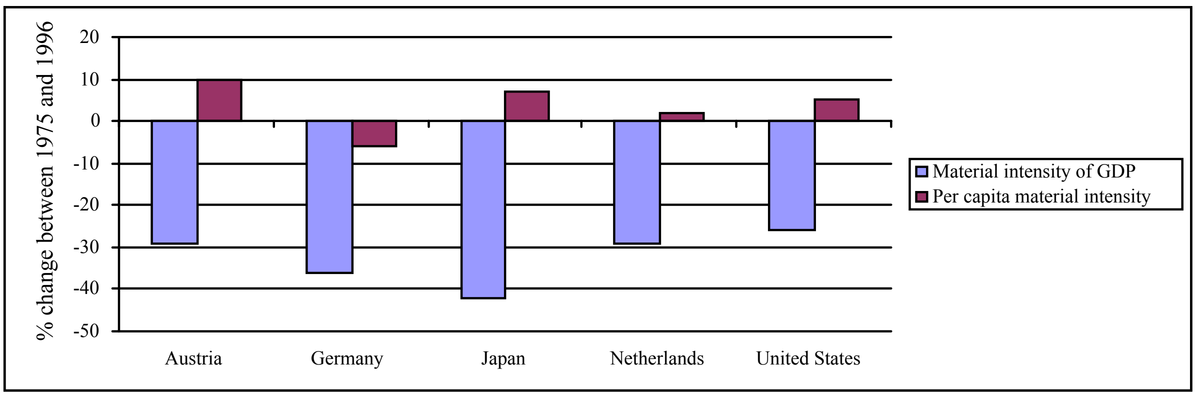
Material Flow Accounts

11.35. Material flow accounts (MFA), as explained in Chapter 3, attempt the comprehensive tracking of all material use into, through and out of the economy. In the words of two of their founders, "instead of regarding physical materials as essentially incidental to the system we now choose to regard the economic system itself as a material flow process" (Saxton and Ayres, 1976, p. 192). MFA were developed to address sustainability based on the ecological concept of de-materialisation, or de-linking economic growth from material use (Spangenberg *et al*., 1999). MFA are similar to the SEEA physical flow accounts in that they record the use of materials and the generation of residuals, although MFA are not always fully disaggregated by industry. The SEEA physical flow accounts can improve upon MFA by providing information about much of the material use disaggregated by industry. However, MFA also include the "hidden flows," which consist of materials excavated or disturbed along with the desired material, but which do not themselves enter the economy. Examples of hidden flows include mine tailings or soil excavated during construction. MFA also distinguish between dissipative use flows and flows which are embodied in products. Dissipative flows are materials which are shed from products during the normal course of use, such as fertiliser, or rubber worn from motor vehicle tyres.

11.36. MFA have been constructed by a number of countries. An ambitious project by the World Resources Institute compiled roughly comparable MFA for five industrialised countries: Austria, Germany, Japan, the Netherlands and the United States (Matthews *et al*., 2000). An important sustainability goal for environmentalists has been the decoupling of economic growth from material use, a concept popularised by the "Factor 4" movement which aims to halve total material requirements (TMR) while doubling wealth and welfare (von Weizsäcker *et al*., 1997). The World Resources Institute study shows significant de-coupling in the countries studied; since 1975 the material intensity of GDP in all five countries has declined by 20-40 per cent. This is shown in Figure 11.3, not in terms of TMR but as domestic processed output relative to GDP. This decoupling has been the result of efforts to reduce the volume of solid waste and the shift away from energy- and material-intensive industries toward knowledge-based and service industries. However, per capita material intensity has not declined in most countries over this time period; only Germany showed a decline (6 per cent). The authors attribute the general increase to economic growth and consumer choices that favour energy- and material-intensive lifestyles. The figures for Germany are strongly influenced by the effects of reunification and the subsequent closure of some heavy industries in the Eastern Länder.

11.37. The MFA do not differentiate materials by their environmental impact; highly toxic materials are simply added to materials like timber or gravel that may be much less environmentally damaging. Consequently, the sustainability goals set under this framework, such as Factor 4, appear rather vague for use as guides to policy on their own and require more detail to be interpreted correctly. Indicators created for certain categories of materials whose environmental impacts are more similar, such as the NAMEA theme indicators, may be more useful. Nevertheless, the relation between these indicators and total output or trends over time can provide insight into whether countries are working towards overall goals of reducing their impact on the environment.

Figure 11.3 Percentage change in material use in five industrialised countries, 1975-1996



Notes: Material intensity calculated as Domestic Processed Output/GDP.
Per capita material intensity calculated as Domestic Processed Output/Population.
Domestic Processed Output = Domestic extraction + Imports – Net additions to stock – Exports.

Source: Matthews *et al*., 2000; p 20.

11.38. A somewhat similar exercise has been carried out by Eurostat for the 15 EU member countries. Here the indicator of reference was material consumption. Unlike TMR, this does not include hidden flows (that is, material which is moved by economic activity but not absorbed by it, such as mining overburden and water for hydroelectric use). Material consumption relates to materials extracted domestically plus those imported less those exported. It is equal to the additions to material stock in buildings, infrastructure, machinery, etc., plus materials returned to the environment whether as emissions to air and water, waste sent to landfill or materials dissipated during use.

11.39. Material consumption is a useful indicator to track the changes in production and consumption and the level of production and consumption material use over time. In economic terms the indicator shows the dependence on physical resources and the efficiency with which materials are used. In environmental terms, it is a background indicator for the overall environmental pressures generated by the production and consumption of goods associated with material extraction and transformation, waste, land use and so on. Preliminary estimates for EU countries in 1990 and 1997 are shown in Table 11.1.

11.40. The applications of the flow accounts discussed so far in this section have been at the national level. However, a country trying to design a more sustainable economy can face two problems. First, it may find that although domestic emissions are low it still suffers environmental degradation because of emissions from other countries that are transported by air or water. Secondly, small open economies typically import many products and the pollutants associated with the imported products might be quite high. Such an economy may appear "clean" on the basis of its domestic emissions, but its imports may be responsible for causing emissions elsewhere.

11.41. Certain environmental issues are regional or global in nature and require international management. For example, acidification and eutrophication are regional problems in most parts of the world; climate change and ozone depletion are global problems. Construction of national-level environmental accounts may not be sufficient for effective policy design if much of a country's residuals are imported. In this case the accounts need to include the international transfers of residuals as discussed in Chapter 3.

Table 11.1 Material consumption in EU countries (preliminary estimates)

Country	Million tonnes			Tonnes per capita		
	1990	1997	% change	1990	1997	% change
Austria	143	158	10	19	19.5	3
Belgium/Luxembourg	184	193	5	18	18.3	2
Denmark	119	145	22	23.2	27.6	19
Finland	197	182	-8	41.3	35.3	-15
France	1 101	1 062	-4	20.4	18.2	-11
Germany	1 744	1 696	-3	22.3	20.7	-7
Greece	133	191	44	13.8	18.1	31
Ireland	136	147	8	40	40.3	1
Italy	720	791	10	12.8	13.8	8
Netherlands	229	240	5	16.2	15.4	-5
Portugal	117	124	6	12	12.6	5
Spain	645	868	35	17.2	21.9	27
Sweden	248	242	-2	29.8	27.3	-8
UK	832	925	11	14.7	15.7	7
EU total	6 545	7 025	7	18.4	18.8	2
Biomass	2 145	2 322	8	6	6.2	3
Fossil fuels	1 473	1 419	-4	4.1	3.8	-7
Minerals	2 927	3 284	12	8.2	8.8	7

Source: Eurostat, 2001c.

Extension from national to regional analysis

11.42. International trade has led to a dissociation of consumption in one country of products that cause environmental degradation from the source of production in another where the degradation occurs. For example, Australia appears to be a highly energy-intensive country. However, much of this energy is embodied in products that it exports to other countries. On the basis of their direct energy use, the countries to which Australia exports may appear to have achieved low energy intensities for their economies.

11.43. Attempts have been made (using the so-called "ecological footprint" for example) to take imports into account when assessing a country's total environmental impact. Ideally, for this purpose, information on the technologies in use in the countries of origin of the imports should be used to accurately determine the environmental content of imports. Often, however, these data are not available and more approximate methods must be used, sometimes assuming that the imports are made with the same technology as that adopted in the importing country and, therefore, have the same residuals and energy coefficients per unit of output. The construction of flow accounts by many countries would make it possible to substitute more appropriate information for this highly unlikely assumption. This would greatly improve the estimates of the true environmental burden of a country's consumption patterns.

11.44. Sweden undertook a pilot study to compare the emissions embodied in their imports using three alternative methods: 1) using Swedish industry-level emission coefficients for imports; 2) using national average emission intensity for all imports from each country based on emissions data for all EU countries plus other major trading partners (USA, Japan, Norway and Switzerland); and 3) using industry-specific emissions coefficients for each country, derived from their environmental accounts. Data for the first two methods were obtained for 1995; data for the third method were only available for 1993, so the results are not strictly comparable with results from the other two methods. The results are shown in Table 11.2.

11.45. The results for CO_2, SO_2 and NO_X emissions embodied in imports were extremely sensitive to the method used. The lowest estimate of CO_2 and SO_2 emissions occurred when Swedish emission coefficients were used; emissions using the other two methods were at least 50 per cent higher. The reverse occurred for NO_X. Swedish emission coefficients gave the highest level of NO_X emissions, although not much higher than the other two methods. The results reveal significant differences among countries in emission intensities. While there are a number of methodological and data improvements needed, this pilot study indicates the importance of obtaining environmental accounts for all major trading partners in order to evaluate correctly the emissions embodied in imports.

Table 11.2 Emissions embodied in Swedish imports under alternative assumptions about emission intensities of imports, 1995

	CO_2	SO_2	NO_X
Method 1: Swedish emission coefficients	20 800	43	128
Method 2: national average emission coefficients from exporting country	32 900	121	119
Method 3: industry-specific emission coefficients from exporting country	36 300	128	109

Note: Method 3 used data from 1993 and so is not directly comparable to the other two methods.

Source: Statistics Sweden, 2000.

C Combatting environmental degradation

11.46. This section describes the use of the SNA to identify the costs presently incurred to prevent environmental degradation and to explore means to discourage continuing residuals in the future. The first concerns the accounts for environmental protection expenditure and resource management described in Chapter 5 and the second the use of economic instruments such as eco-taxes and the issuing of licences described in Chapter 6.

11.47. As described in Chapter 5, the SEEA seeks to highlight information about defensive expenditures, making it more explicit and so more useful for policy analysis. This part of the SEEA is similar to other satellite accounts, such as transportation or tourism accounts, which do not necessarily add new information, but reorganise existing information. It provides the basis for exploring the consequences of the introduction of new levels of environmental protection expenditure whether they are introduced voluntarily or in response to government legislation.

11.48. Indicators of environmental protection attempt to identify some of the efforts by society to prevent or to reduce pressures on the environment. The interpretation of these indicators can be ambiguous because technological solutions to residuals sometimes result in joint reduction of production costs as well as residuals and this dual effect is not captured in the environmental protection expenditure accounts. Equally, increases in environmental protection expenditure may not keep pace with increasing levels of residuals generation. Thus increases or decreases in environmental protection expenditure cannot be interpreted unambiguously as showing whether the economy is becoming more sustainable or less so.

11.49. In addition to monitoring environmental protection expenditure, the accounts show the transactions related to the imposition of environmentally related taxes, the granting of subsidies which affect the use made of the environment and the ways in which environmental resources cease to be free by the requirement that users pay for their use either on a continuing basis or by the issue of a licence to authorise their use. Economic modelling can be used in connection with these accounting entries to examine how changes in these economic instruments would affect use of environmental resources in future.

11.50. The first part of this section addresses the construction of descriptive statistics and indicators from these accounts to use for monitoring environmental protection and resource management activities. The second section discusses the use of the accounts for analysis and policy modelling.

1 Indicators and descriptive statistics

11.51. Environmental regulation has been highly controversial in most countries and these accounts may help to address some of the important questions surrounding regulation; for example, whether the money spent on residuals abatement has been effective in reducing residuals and whether environmental regulation has affected productivity and international competitiveness. To understand the impact of environmental protection and resource management expenditures in the economy better, it is useful, in the first instance, simply to track some of these expenditures over time. A set of descriptive statistics provides policy-makers with information of the sort below.

- An overview of the magnitude of environment protection expenditures and economic instruments in the economy.
- How environmental protection expenditure is related to specific production activities and environmental concerns.
- Whether the costs are incurred by the public or private sector, by industries (and if so which) or by households.
- The extent to which environmental taxes match the environmental burden caused by each industry.
- How important the environment protection industry is to the economy in terms of, for example, employment.
- What the possibilities are for growth through specialisation in environmental protection and international trade.

11.52. Spending on environmental protection is a burden which needs to be monitored. Table 11.3 shows expenditures for environmental protection (called pollution abatement and control) in the United States from 1972 to 1994. Pollution abatement expenditures are by far the most important, accounting for over 90 per cent of all spending, with the remaining spent on monitoring and regulation and on research and development. All regulation and monitoring and most research and development is undertaken by government.

11.53. In 1972, most of the spending was for water pollution (43 per cent), followed by air pollution (39 per cent) and solid waste (19 per cent). The picture in 1980 was not significantly different but by 1994 priorities had changed and spending was more evenly distributed across environmental domains. Water pollution still dominated (35 per cent), but solid waste was nearly the same (34 per cent) and air pollution (31 per cent) was close behind. In 1994 businesses split their expenditures almost equally between the three categories while government spent almost half on both water and solid waste.

Table 11.3 Pollution abatement and control expenditures in the US, 1972, 1980 and 1994

	Percentage of total PAC	Percentage of category Air	Water	Solid waste
1972				
Pollution Abatement and Control	100.0	38.2	42.8	18.9
Pollution abatement	92.9	36.4	43.7	19.9
Personal consumption	8.1	100.0	0.0	0.0
Business	64.2	38.8	43.2	18.0
Government	20.5	3.5	62.9	33.6
Regulation, monitoring, RandD	7.2	67.3	28.6	4.1
1980				
Pollution Abatement and Control	100.0	43.1	39.8	17.0
Pollution abatement	94.1	42.7	40.5	16.9
Personal consumption	13.1	100.0	0.0	0.0
Business	59.1	44.3	37.6	18.1
Government	21.9	3.4	73.1	23.5
Regulation, monitoring, RandD	5.9	52.3	27.3	20.4
1994				
Pollution Abatement and Control	100.0	30.9	34.8	34.3
Pollution abatement	96.6	30.4	35.0	34.6
Personal consumption	8.0	100.0	0.0	0.0
Business	62.9	31.9	34.7	33.4
Government	25.6	4.6	46.7	48.7
Regulation, monitoring, RandD	3.4	49.0	28.6	22.5

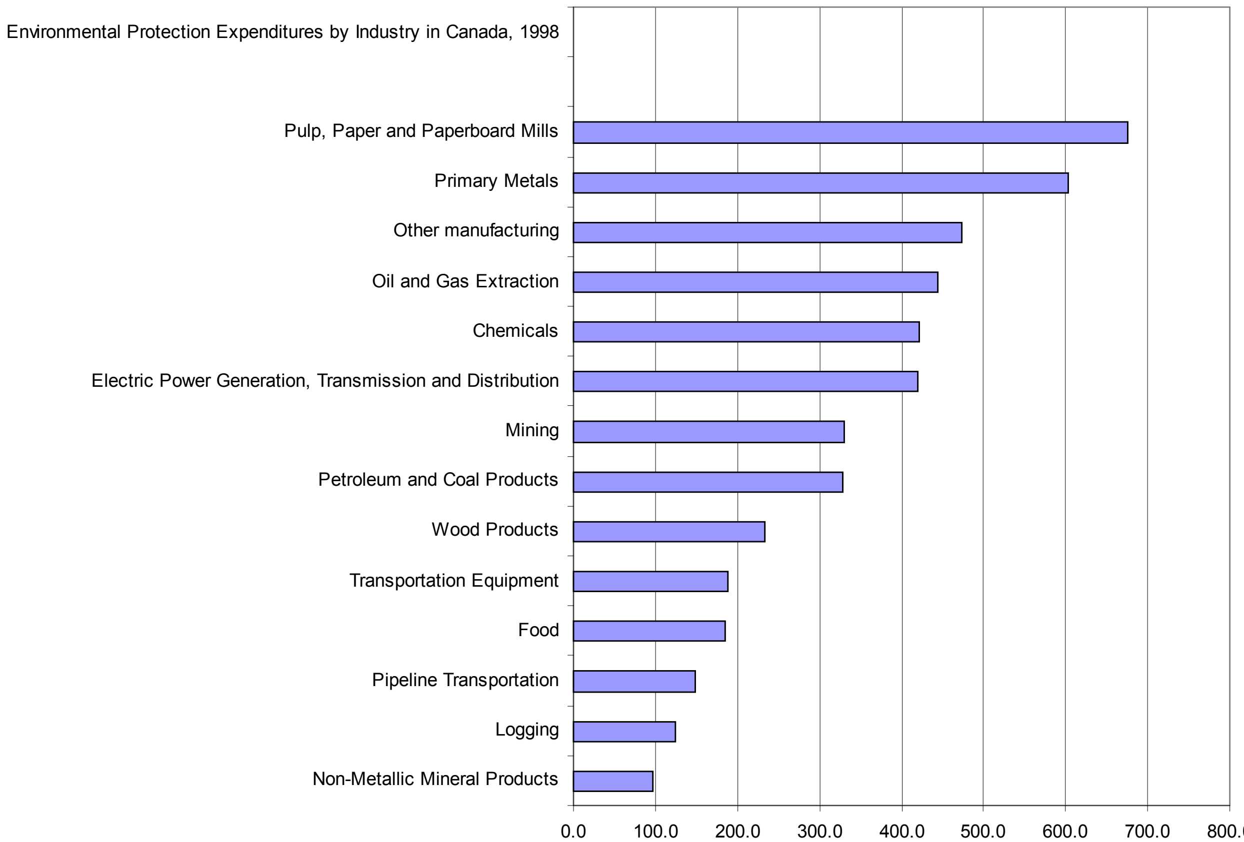
Source: Vogan, 1996.

11.54. As a percentage of GDP, US environmental protection expenditures have remained constant at between 1.7 and 1.8 per cent. About two thirds of the spending for pollution abatement and control is undertaken by the private sector. The share of spending by households, mostly for motor vehicle pollution abatement devices, has remained constant at around 8 per cent of the total. However, the share of spending by government rose between 1972 and 1994 from 25 per cent to 29 per cent, matched by a decline in private sector expenditures.

11.55. A more detailed breakdown of expenditures by industry can be used to identify which economic activities bear the greatest burden of environmental regulation. Figure 11.4 shows spending in Canada in 1998 by industry (Statistics Canada, 2000). Five industries accounted for 55 per cent of all environmental protection expenditure: electric power generation, chemicals, oil and gas extractions, primary metals and pulp and paper. The Canadian data also provide a breakdown by province. The industrial and geographic disaggregation allows policy policy-makers to identify the industries and communities that would be most affected by new environmental policies and to design measures to assist them if necessary.

Figure 11.4 Environmental protection expenditures by industry in Canada, 1998

Millions of Canadian dollars



Source: Statistics Canada, 2000.

11.56. The NAMEA constructed by Statistics Netherlands introduces the idea of environmental domains. The domains distinguished are water, air, soil, waste, noise and landscape. The main purpose of this breakdown is to provide a closer connection between environmental expenditures and the physical accounts in the NAMEA. The recent revision to the Dutch national accounts has been used to improve the data on environmental expenditure in their NAMEA. First of all, two new surveys on “Recycling” (NACE code 37) and on “Sewage and refuse disposal, sanitation and similar activities” (NACE code 90) were used and integrated in the NAMEA. Further, the ancillary environmental expenditures were updated and a more detailed breakdown among the environmental domains to which the expenditure is directed was established.

11.57. As a measure of economic burden, environmental protection expenditure can be calculated as a percentage of industry costs, as a percentage of household expenditures and as a percentage of government spending. These expenditures can also be disaggregated between current and capital expenditures. This more detailed picture of environmental protection expenditure may allow further analysis, such as investigation of the impact of environmental regulation on competitiveness and productivity. Table 11.4 provides a more detailed list of indicators of potential use to policy-makers.

11.58. There has been some criticism that the environmental protection expenditure accounts focus too much on the expenditure side which emphasises the extra costs imposed by environmental regulation. Possibilities for revenue and cost savings through implementation of process-integrated environmental measures have not received the same degree of attention. A Swedish environmental protection expenditure survey included questions about cost savings and found that a large share of companies were engaged in cost-reducing or revenue-enhancing measures that were not covered by the standard environmental protection expenditure survey instrument (Johansson, 2000). As companies adopt process-integrated pollution prevention instead of pollution abatement approaches, the conventional environmental protection expenditure accounts are less useful in analysing the economic impact of environmental regulation or the likely response to changes in regulation.

Table 11.4 Examples of policy issues and related indicators of environmental protection

Policy issue	Variables/indicators	Users
Net cost of environmental goods and services (net of any savings from environmental activity); cost/benefit analysis of environmental regulations and voluntary initiatives	Investment spending and current expenditures on environmental protection; cost savings, energy savings from environmental technologies or products	Industry, industry associations, environment departments and other government bodies, universities
Contribution of environment industry to economic growth, production and employment; potential for aid to industry	Relative yearly growth in turnover (revenues), value added, employment, type of jobs, etc.	Governments (environment, industry and finance departments in particular); industry associations (including environment industry associations); universities; marketing consultants
Contribution of environmental goods and services industry to international trade	Exports, imports (absolute amounts and as a percentage of total exports/imports), international direct investment, licensing agreements	Governments and industry associations, exporters and importers
Regional and structural differences in characteristics and importance of environment industry	Turnover, value added, employment, etc. by region, by industry structure, etc.	Regional governments, industry associations, national and regional
Environmental protection and R&D and innovation potential	Environmental R&D as a share of total R&D; new patents for environmental technology	Governments, industry, universities
Economic efficiency	Price per unit of environmental protection services (e.g., $ per ton of treated waste)	Governments, industry
Adequacy of environmental products and technologies to environmental protection goals (environmental efficiency)	Linkages of environment industry activities and characteristics to environmental quality indicators	Governments, industry, universities
Contribution of environment industry to sustainable development	Preventive activities (e.g., cleaner technologies and products) as a share of total environment industry output	Governments, industry, universities
Transfer of environmental technologies	Share of imports and exports of environmental capital expenditures	Governments, industry, intergovernmental organisations

Source: Modified from Drouet, 1997.

11.59. While environmental protection expenditures have imposed substantial costs, they have also created opportunities. Entirely new industries have arisen to fill the need for environmental services. The second part of the environmental protection expenditure accounts provides a clear description of this industry, its contribution to GDP, to employment and to exports. For some countries, the environmental services industry has become an important exporter, while other countries are large importers of these services. For example, in France, the environmental services industry accounted for 2.3 per cent of GDP and 1.4 per cent of employment on 1997. More than half the employment was in solid waste and waste water management (Desaulty and Templé, 1999).

Environmental taxes

11.60. Environmental taxes and subsidies are important policy instruments for implementing the "polluter pays principle" that has been adopted by many countries. The tax component of the environmental protection expenditure accounts can be very useful in assessing whether the tax regime is promoting sustainable development. Eurostat has compiled a time series of environmental taxes for its 15 member countries (Steurer *et al*., 2000). As a share of total tax revenue, environmental taxes constitute a small but increasingly significant portion, growing from 6.7 per cent of total tax revenue in 1980 to 7.6 per cent in 1997. Among the different environmental taxes, taxes on energy, transport, pollution and resources, energy taxes dominate and presently account for about three-quarters of environmental taxes.

11.61. To determine whether environmental taxes have been successful in implementing the polluter pays principle, further analysis of the environmental protection expenditure tax accounts is needed. The Swedish Environmental Protection Agency undertook such a study, the results of which are shown in Table 11.5. Environmental taxes rose from 49.7 billion Swedish kroner in 1993 to 61.6 billion Swedish kroner in 1998 and are dominated by energy taxes, which include carbon taxes.

Table 11.5 Environmental taxes in Sweden, 1993-1998

(Millions of Swedish kroner in current prices)

Taxes on:	1993	1994	1995	1996	1997	1998
Energy	39 017	42 043	44 161	49 733	49 352	52 652
Pollution	582	566	682	753	551	508
Transport	8 119	5 852	5 798	6 721	6 451	6 336
Resources	-	-	-	70	131	142
Total	49 711	50 455	52 636	59 273	58 482	61 636

Source: Sjölin and Wadeskog, 2000.

11.62. Linked with the physical accounts for energy, the tax accounts show the extent to which the polluter pays principle is being followed. The share of CO_2 emissions and the carbon taxes paid for five groups of industries and private consumption in Sweden in 1997 is shown in Figure 11.5.

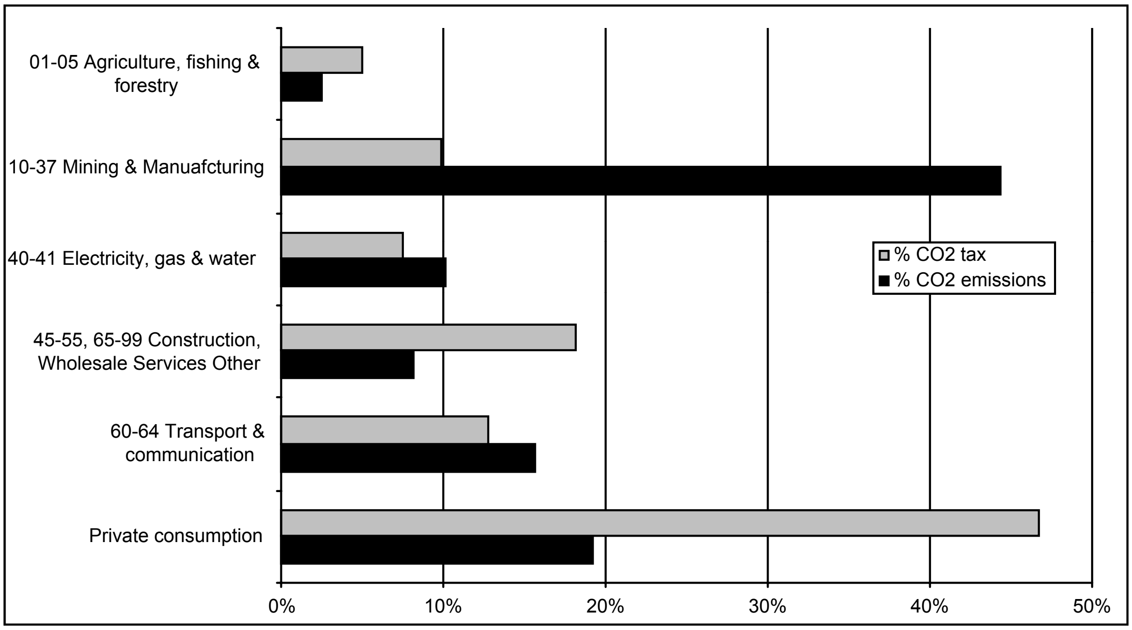
2 *Policy analysis and strategic planning*

11.63. There are now quite a few examples of the use of environmental protection expenditure for policy analysis and strategic planning; in particular, for the design of economic instruments when the accounts are linked to economic models. The applications cover four broad topics: the economic impact of environmental regulation, the economic impact of environmental taxes, the assessment of the costs of regulation relative to their benefits in terms of reduced levels of pollution and the impacts of recycling and reuse.

11.64. One way of using environmental protection expenditure accounts is to model the effects of assumed changes in environmental protection measures in order to estimate the way such changes will affect, both directly and indirectly, environmental pressure, economic activity, growth and employment in the future. A particular use of such models may be to construct the abatement cost curves whose use was discussed in Chapter 9.

11.65. The economic impact of taxes on resources and residuals is a major policy issue. Several countries have looked at the structure of taxation with particular reference to taxation of labour relative to the taxation of natural resources, environmental goods and services, emissions and discharges and so on. Policy-makers need to know how high to set taxes to achieve a certain reduction in residuals, but they also need to know what the economic impact of these taxes would be compared to an existing tax structure, a subject discussed earlier in this chapter. Impacts include domestic restructuring of the economy and its impact on specific industries and communities, as well as effects on international competitiveness.

Figure 11.5 Carbon dioxide emissions and taxes in Sweden, 1997



Source: Sjölin and Wadeskog, 2000.

11.66. Norway has used the flow accounts to assess a policy that many countries are considering; that is, changing the structure of taxes to increase taxes on emissions and/or resource use while simultaneously reducing other taxes by an equal amount in order to remain fiscally neutral – the so-called "double dividend" (Statistics Norway, 1998). Norway used its multi-sector general equilibrium model to look specifically at increasing the carbon tax to Norwegian kroner 700 per ton of CO_2 and decreasing its payroll tax. Policy-makers in Norway wanted to know what effects this tax reform would have on economic welfare.

11.67. Using a multi-sector, general equilibrium model of the economy, Norway initially found that employment and economic welfare would increase while carbon emissions declined. However, closer analysis of the results indicated that the tax reform would result in significant structural change in the economy. Certain energy-intensive industries in the metal, chemical and oil refining industries were particularly hard hit by the tax and would reduce output and employment considerably. Furthermore, these industries were disproportionately located in small towns where an industry might be the only major employer. It is reasonable to assume that, at least in the short term, people would be reluctant to move to new towns in search of new jobs. By including this element of labour immobility, the model showed that although emissions would still decline, the economic improvement disappeared and economic welfare actually declined slightly.

11.68. In considering environmental taxes, another issue policy-makers must consider is the impact such taxes might have on the international competitiveness of their domestic industries. This is an especially important issue for very open economies like that of the Netherlands. A study addressing this issue for the Netherlands was undertaken using the flow accounts for energy as well as for carbon emissions, other greenhouse gas emissions, acidification and eutrophication emissions (Komen and Peerlings, 1999). The study quantified the relative sensitivity of the different industries to changes in environmental taxes.

11.69. A major concern of policy-makers has been the evaluation of the costs of environmental regulation relative to the benefits in terms of reductions in residuals. With integration of environmental protection accounts and the physical flow accounts, it may be possible to trace the relationship between expenditures (or taxes) and changing levels of resource use, residuals emissions and solid waste. For example, linking accounts for actual emissions to water (or for water quality) with the accounts for waste water management expenditures (or effluent taxes) provides an indication of the effectiveness of spending in reducing residuals However, there are difficulties in interpreting this relationship because there is a time differential between the expenditure and the environmental benefit resulting from that expenditure. Also, interpretation may not be unambiguous unless the analysis is carried out at the firm level, with supplemental information about the residuals control measures not included in the environmental protection expenditure.

11.70. As mentioned earlier, this approach does not take into account the increasing potential for pollution prevention through process redesign, which may even reduce both production costs and emissions simultaneously. In another example, Swedish researchers were able to show policy-makers that policies to reduce carbon emissions may generate additional unintended (or ancillary) benefits that should be taken into account when considering the advantages and disadvantages of different environmental policy reforms (Nilsson and Huhtala, 2000). The study analysed the advantages of utilising a system of carbon trading permits as an alternative to implementing measures to reduce domestic levels of carbon emissions in order to meet Sweden's carbon target under the Kyoto Protocol. When only the benefits of reduced carbon emissions were considered, the purchase of low-cost carbon emission permits was the more cost-effective means of meeting Sweden's targets. However, measures to reduce domestic emissions of carbon also resulted in lower emissions of sulphur and nitrogen at no extra cost. When this ancillary benefit was taken into account, the purchase of carbon emission permits was not as advantageous as measures to reduce domestic carbon emissions.

11.71. In many industrialised countries, solid waste has become a serious environmental problem, in large part because of the shortage of landfill areas in which to store waste that is increasingly harmful. Analysis of the impact of various production and consumption patterns on the generation of solid waste was discussed in chapters 3 and 4 and also in Section B of this chapter. However, increasingly, in response to external pressures, recycling and reuse within the economic process of production is an important way to reduce the use of primary materials and, consequently, to reduce the quantity of solid waste.

11.72. Capture of toxic chemicals for reuse can also reduce the levels of harmful emissions. Some industries are already major on-site recyclers of materials, especially the chemical and primary metal industries. If the environmental protection expenditure accounts provide information about such reuse and recycling and integrate this information with physical flow accounts, they could be used, for example, to model the level of material use and solid waste associated with future economic growth and the role recycling of specific materials could play in reducing solid waste.

D Sustaining wealth

11.73. One of the ways of measuring sustainability is to track whether the stock of assets is being maintained over time or whether production and consumption processes diminish the stock without replacement. The ways in which such changes can be measured were described in Chapter 7.

11.74. A commonly used measure of sustainability requires that total national wealth is non-decreasing over time. However, there has been a great deal of controversy over whether produced and natural capital are real substitutes for one another and thus whether they should be aggregated. Advocates of "strong sustainability" suggest that substitution and aggregation is either not possible or not appropriate; the stock of natural capital should be maintained without substituting produced capital for those elements of natural capital which are exhausted. Other commentators, however, advocate "weak sustainability" in which substitutability and aggregation of different sorts of assets is allowed (see Chapter 1 for a broader discussion of these two concepts). As an alternative to the strong versus weak sustainability dichotomy, it has been proposed that some environmental assets which cannot be replaced in any meaningful way should be treated as "critical" capital. Such critical capital should be monitored separately in physical units. Substitution of other environmental assets would not pose the same order of risk.

11.75. Whether one chooses to aggregate the value of different forms of capital and whether one interprets the aggregate figure as an indicator of sustainability or not, it is certainly necessary for a country to monitor its wealth over time. While non-declining national wealth does not guarantee sustainable development, declining national wealth almost certainly indicates unsustainable development unless it is accompanied by technological interventions to enhance the growth rate of renewable resources or more efficient use of non-renewable resources. More comprehensive accounts for national wealth can only improve the ability of researchers and policy-makers to make informed decisions.

11.76. Like the other components of the SEEA, the asset accounts provide data that can be used for both monitoring and for analysis. This section begins with an explanation of the way the asset accounts contribute to more effective monitoring of national wealth and then discusses how the asset accounts can be used to improve management of natural capital.

1 Indicators and descriptive statistics

11.77. In order to monitor the level of national wealth, information is needed on the physical stocks of natural resources and the economic value of both produced and non-produced assets, as well as measures of the change in wealth over time and the cost of depletion.

11.78. From an ecological perspective, there are certain natural limits on the use of environmental assets. Non-renewable resources, by definition, cannot be increased and all use results in depletion. The use of renewable resources cannot exceed the rate of natural growth without incurring depletion. The physical asset accounts provide indicators of ecological sustainability which are the basis for measuring strong sustainability and detailed information for the management of resources. The volume of mineral reserves, for example, is needed to plan extraction paths and to indicate how long a country might rely on its minerals. The volume of fish or forestry biomass, especially when disaggregated by age-class, helps to determine sustainable yields and the harvesting policies appropriate to that yield.

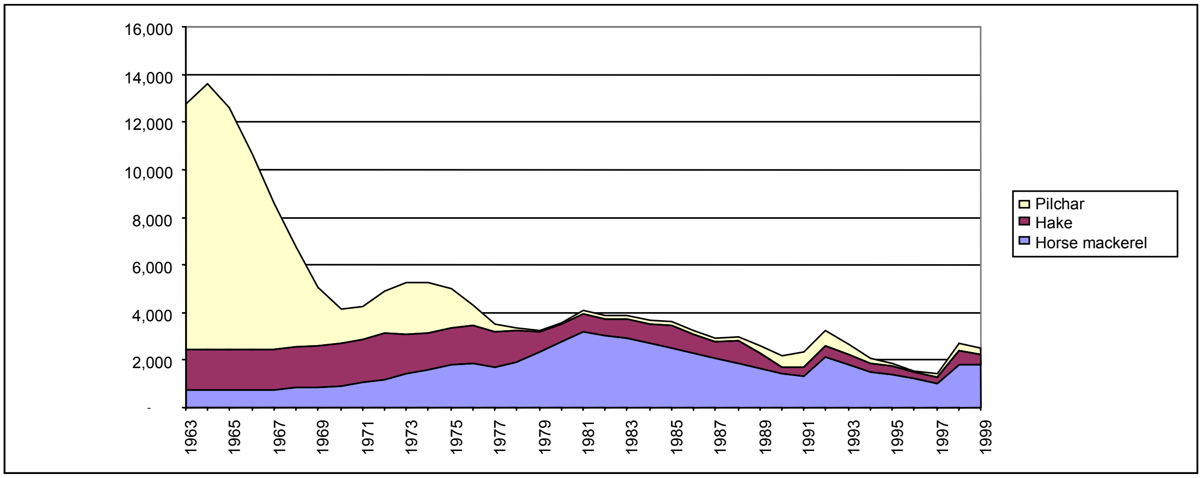
Stocks of assets in physical terms

11.79. The physical accounts provide a measure of depletion that can be useful for motivating changes in policy. For example, the biological depletion of Namibia's fish stocks since the 1960's has provided a very clear picture to policy-makers of the devastation resulting from uncontrolled, open-access fishing. Figure 11.6 shows how the stock of pilchard fell dramatically in the 1960s and then recovered slightly in the 1970s only to decline again. Stocks of hake have declined slowly but steadily over time and only horse mackerel has shown any continuous increase over the 1960s and 1970s.

11.80. Similar accounts of physical depletion have been constructed for tropical forests in Brazil, Malaysia, Indonesia and elsewhere. The physical accounts for water have provided important information to policy-makers in France, Spain, Moldova and Chile about availability (e.g., annual available supply relative to long-term average supply) and depletion (e.g., groundwater depletion, evaporation from dams) that is necessary for management.

Figure 11.6 Biomass of selected fish stocks in Namibia, 1963-1999

Thousand tonnes



Source: Lange, 2002.

11.81. Monitoring the potential contribution of the economy to climate change requires a physical assessment of stocks and flows of greenhouse gases (GHG). An important element in such an account is the carbon storage capacity of forests. Carbon binding is calculated as a given percentage of the estimated biomass of forests and changes in carbon stocks are estimated on the basis of changes in forest biomass. An example of this was provided for the forestry example in Chapter 8. Such accounts have been constructed for Australia and were constructed for South Africa's forests in a recent academic study (Hassan, 2000). Although carbon storage clearly has an economic value, that value is very uncertain at this time and the benefits of carbon sequestration may be best represented in physical units. Table 11.6 shows a table of this sort for Australia for the 1990s.

Table 11.6 Forest area, carbon uptake and carbon release in Australia, 1990-1998

Thousand tonnes of carbon

	Area of Forests, 000 (thousand hectares)	Total carbon uptake through annual biomass increment	Annual carbon release due to commercial harvest, other uses and clearing losses	Net annual Carbon uptake (+) or release (-)
1990	15 929	19 457	12 793	6 663
1995	15 962	19 599	13 480	6 119
1996	15 996	19 742	13 746	5 995
1997	16 029	19 884	13 963	5 921
1998	16 062	20 206	14 122	5 904

Source: Government of Australia, 2000.

11.82. Many countries are concerned with land use changes, such as the loss of agricultural land to urban growth, or the conversion of forest land to agricultural land. Physical accounts for land are useful for tracking changes in land use that have important environmental and economic consequences. Chapter 8 provides a discussion of land use and the development indicators.

11.83. Table 11.7 gives an example from Canada's land accounts, which monitor the conversion of dependable agricultural land to urban areas, roads and other non-agricultural uses. Although Canada is a very large country, 90 per cent of its population and much of its dependable agricultural land are concentrated along a relatively narrow band along its southern border. As in many countries, urban growth has often involved the conversion of agricultural land to other uses and has diminished the supply of dependable land for agricultural purposes. Between 1971 and 1996, urban land area grew by 76 per cent while dependable agricultural land declined by 8 per cent.

Table 11.7 Land use change in Canada, 1971-1996

Million hectares

	Urban land use	Dependable agricultural land
1971	1.6	41
1981	1.8	41
1991	2.3	39
1996	2.8	38
% change	**76%**	**-8%**

Source: Statistics Canada, 2001.

Stocks of assets in monetary terms

11.84. The physical accounts for individual assets can be used to monitor strong sustainability and to help design resource policies. However, an assessment of natural assets that is comparable with estimates of produced assets requires that, wherever possible, the economic value of a resource also be known.

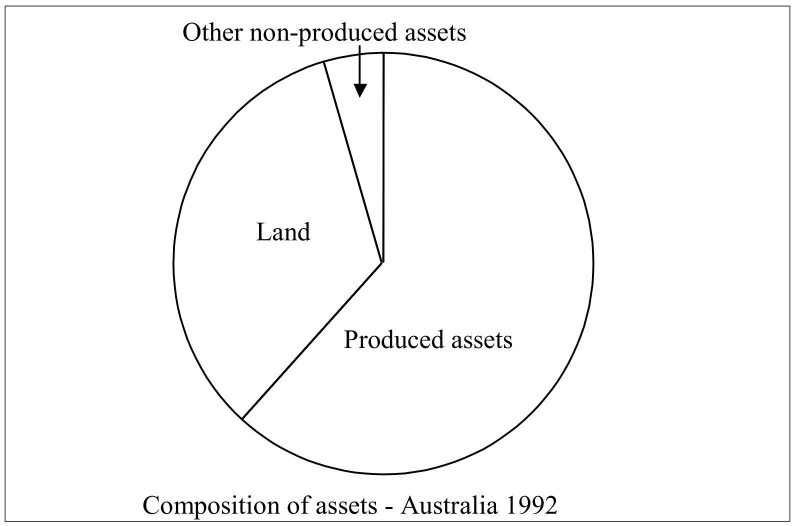
11.85. The monetary value of both produced and natural assets can be analysed to assess the diversity of wealth, its ownership distribution and its volatility due to price fluctuations (an important feature for economies dependent on primary commodities). Diversity is important because, in general, the more diverse an economy the more resilient it will be to economic change. Understanding volatility is also important in planning for the future; lower volatility contributes to more stable economic development. The distribution of the ownership of assets between the public and private sectors and the concentration between different groups in society and between domestic and foreign enterprises can have significant economic implications and can influence the sustainable management of resources.

11.86. Even the proponents of weak sustainability, who accept substituting other forms of capital for natural capital, caution against the use of total national wealth as an indicator of sustainability unless all assets are included. In practice, this is quite difficult because there are many environmental assets which are extremely difficult to value and there is no accepted measure for human or social capital. Where there is substitution of one type of capital for another (say, running down natural capital in order to enhance human capital by expanding education) the omission of any one type of capital from total national wealth may give policy-makers a false indicator of declining sustainability. However, even if the aggregate figure for total wealth as measured may not be wholly appropriate to monitor sustainability, it is useful to compare the economic value of different assets and how it changes over time.

Composition of assets

11.87. A few countries now report figures for natural assets along with produced assets. Australia currently includes land, subsoil assets and native forests in its non-produced (natural) asset accounts. Only one of these assets, subsoil assets, is an exhaustible resource, although forests can certainly be (mis-)managed in such a way as to result in depletion. Although Australia is considered to be a resource rich country, the value of subsoil deposits and natural forests accounted for less than four per cent of total non-financial assets in 2000. Produced assets made up about two thirds of the total with land accounting for the just under one third (Figure 11.7).

Figure 11.7 Composition of the stock of non-financial assets in Australia, 1992



Source: Australian Bureau of Statistics, 2001.

Changes over time

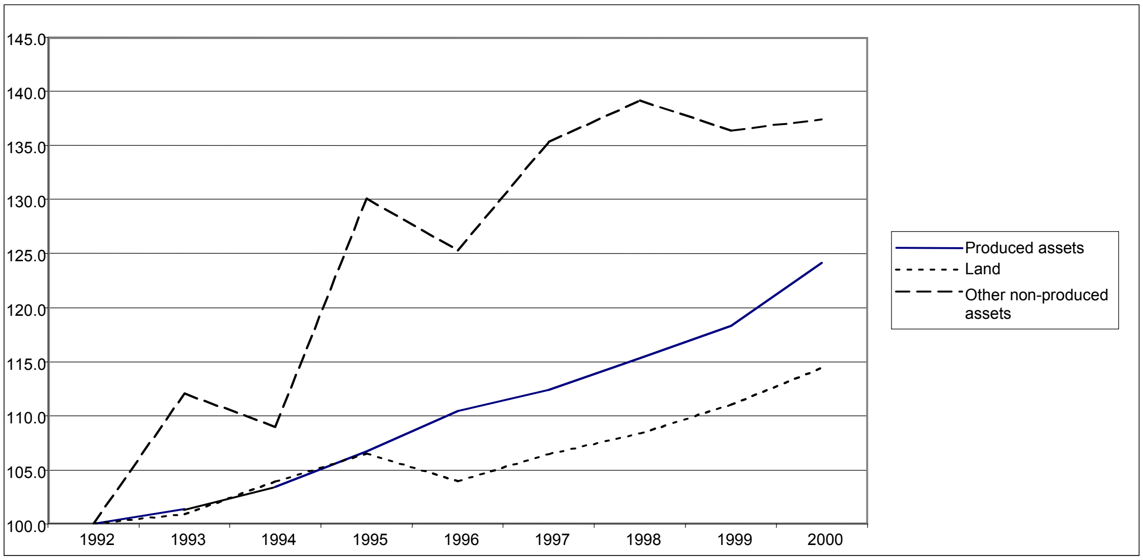
11.88. Figure 11.8 shows the change in the value of these assets over the period 1992 to 2000 expressed as index numbers based on 1992 as 100. The underlying data are expressed in constant prices.

11.89. Over the period, non-produced assets other than land increased by one third, driven by the increases in subsoil resources. Stocks of native timber declined slightly in real terms. Land increased by 16 per cent due to the reclassification (rezoning) of some land from rural to urban status with a consequent increase in value.

11.90. Over the same period, produced assets increased also, by about one quarter. However, while the growth in produced assets was steady over the whole time period, both land and subsoil deposits showed decreases in some years. In the case of subsoil deposits, this was due to the combined effect of depletion, discoveries and reappraisals. In the case of land, the fall in 1996 was due to a reclassification of some land between urban and rural categories.

11.91. The composition of total assets is important because, generally, a more diverse economy is more resilient. A comparison of the shares of produced and natural assets over time is one approach to monitoring progress toward diversification. The composition of total assets indicates whether depletion of natural capital is compensated for by increases in other forms of capital. While the asset structure of Australia has shown relatively little change over time, the structure of national wealth in developing countries may change very rapidly. In Botswana, for example the share of produced capital increased from 35 per cent to 50 per cent during the 1990s, while subsoil assets declined from 65 per cent to 50 per cent (Lange, 2000).

Figure 11.8 Index of real growth of different classes of assets in Australia, 1992-2000



Source: Australian Bureau of Statistics, 2001.

Financial assets and liabilities

11.92. The discussion so far relates to the distribution and growth of non-financial assets. In order to monitor sustainability, attention should also be paid to financial assets and liabilities. Wealth, termed "net worth" in the SNA, is defined as total assets less total liabilities. In the case of Australia, total assets increased from 1992 to 2000 by one third in real terms whereas wealth increased by only one fifth because part of the accumulation of assets was financed by external borrowing rather than by domestic saving.

11.93. Some resource-rich developing countries (like oil-producing countries and Botswana) are able to invest much of the income from resource exploitation in foreign assets. For such countries, net financial assets form a significant share of national wealth. It is more common, though, for developing countries to have large foreign liabilities which may more than offset the value of any exploitable natural resources. Managing a country's portfolio of assets means taking account of each of produced assets, natural resources and financial assets and liabilities to have a complete picture of economic resources.

Per capita measures

11.94. So far, the discussion has considered only trends in total assets and wealth. However, in most countries population is still increasing, so a constant level of wealth and income would result in a declining per capita level of wealth and income for future generations. Inter-generational equity requires that not just total wealth, but per capita national wealth in constant prices be non-declining over time. Continuing with the Australian example, although wealth in real terms increased by 18 per cent over the period, at the same time the population increased by 9.7 per cent. Thus the increase in per capita wealth over this period was closer to 8 per cent.

Ownership

11.95. The public and private sectors may have different resource management objectives which affect the way resources are exploited. Consequently, monitoring the distribution of asset ownership between the public and private sectors may be useful, not as a direct indicator of sustainability, but as an aid to resource management. The private sector is motivated largely by commercial concerns, which can favour economic efficiency but also depletion of renewable resources under certain conditions. Government may or may not utilise resources in a sustainable way and it may use resources to achieve other socio-economic objectives, even if this lowers the economic return from a resource.

11.96. The response to the depletion of natural assets may also differ between the private and public sector. Where depletion occurs, sustainability requires reinvestment in other forms of capital. Private ownership may result in reinvestment in private sector activities, but foreign ownership may result in reinvestment elsewhere which does not benefit the country providing the wealth. In countries where the government owns the resource and recovers most of the resource rent, the government bears responsibility for reinvestment, often investing in public sector capital. There is disagreement over the extent to which growth in government assets is an effective substitute for other forms of capital. There is a tendency to assume that government is economically inefficient compared to the private sector, but it is also well documented that the private sector will under-invest in assets where social benefits exceed private benefits, like public infrastructure and human capital.

11.97. Table 11.8 shows the composition of non-financial assets for Australia for 2000. The first data column may be compared with the information in Figure 11.7 which related to 1992 and the growth rates of the various types of assets shown in Figure 11.8. However, a finer breakdown of assets is given in Table 11.8 as well as the percentage share owned by general government. (This is not quite the same as the whole of the public sector, but data on that basis are not available). Among produced assets, most dwellings, machinery and equipment, and livestock are in private hands. Government owns a significant share of plantation standing timber and other building and structures. Most of the value of non-produced assets is represented by land, none of which is owned by general government. However all subsoil assets and most native standing timber are owned by the state.

Table 11.8 Ownership of different asset classes in Australia, 2000

Type of asset	Per cent of total non-financial assets	Per cent of asset class owned by general government
Produced assets	**62.6**	**14.8**
Dwellings	20.9	0.5
Other buildings and structures	25.8	31.6
Machinery and equipment	11.0	5.9
Livestock	0.6	0.0
Plantation standing timber	0.3	63.8
Other produced assets	4.0	5.0
Non-produced assets	**37.4**	**14.0**
Land	32.1	0.0
Subsoil assets	5.1	100.0
Native standing timber	0.1	80.0
Other non-produced assets	0.1	54.8

Source: Australian Bureau of Statistics, 2001.

2 Policy analysis and strategic planning

11.98. In terms of managing natural resources, there are three main areas of interest for policy analysis: economic efficiency, the question of sustainability and other socio-economic objectives.

11.99. As described in Chapter 7, the value of natural resources stems from the resource rent that they generate in the course of production. In many countries, resources such as minerals, natural forests and capture fisheries belong, by law, to the state. As the owner of the resources, the government has a right to charge for their use by private companies. Private companies utilising these national assets are often regulated by government to ensure that they are managed for the best interest of the citizens. From an economic perspective, resource management that is efficient, sustainable and equitable suggests that part of the resource rent be recovered by the government and used for the benefit of all citizens, including future generations.

11.100. As discussed earlier, non-renewable resources are not physically sustainable in a strict sense but they can be judged to be economically sustainable if the resource rent received from them is reinvested in alternative forms of capital. Renewable resources, like forests or fisheries, are capable of providing an income for all future generations if managed sustainably. But in the absence of regulation or sustainable management practices, they are often subject to over-exploitation and eventual exhaustion. Policy instruments to promote sustainable management include restricting harvest rates and levying fees to discourage over-exploitation.

11.101. In addition to concerns about efficiency and sustainability, recovery of resource rent from commercial operations may be deployed to ensure a more equitable distribution of benefits from the use of resources between current and future generations. This is especially true for economies that rely heavily on extractive industries. Within the current generation, the resource rent can be used to support economic development that betters the lives of all citizens, not only the minority who may own companies. However, to ensure inter-generational equity, countries need to resist the pressure to consume all the income in the current period. At least some portion of the rent must be re-invested to contribute to increased well-being for future generations. Part of the discussion concerning human capital centres round whether and how far education of the present generation benefits future generations and whether this benefit is as great as the investment in other forms of capital.

Economic efficiency

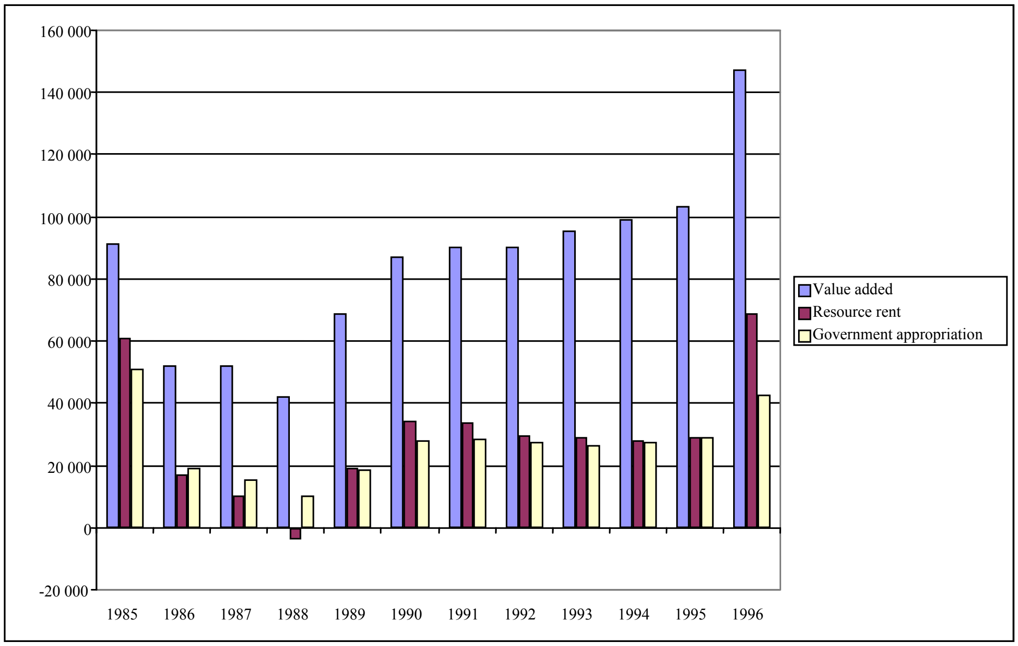
11.102. There is discussion in Chapter 6 about the sort of transactions which are recorded as payments by the user of an asset to its owner. When the owner is government, these payments may sometimes be referred to as taxes. In strict accounting parlance, though, these are often payments of property income; taxes being payable only when nothing is received in return. The property income payable to government for the use of natural resources can be compared with the total resource rent earned in the production process. One question of interest is whether government is recovering the whole of the resource rent. A second is whether the appropriation by government at least covers the costs of managing the industry. A third question is whether current management policies maximise the amount of rent that can be generated from the resource or whether rent could be higher under an alternative management regime.

11.103. The management of three major resources in Norway, petroleum, forests and fisheries, provides an example of three very different approaches to management that affect the value of the natural assets. Figure 11.9 to Figure 11.11 show the rent generated by each of these resources and the share appropriated by government.

11.104. Figure 11.9 shows information for the oil and gas industry in Norway. Resource rent and government appropriation of this rent can be compared with the value added in the industry. The share of rent in value added has fallen over time and in 1988 rent was negative. The proportion of rent appropriated by the government remains high and in 1988 a payment was due to government even though rent was negative. Further analysis is possible looking at the rent per unit of oil or gas extracted, as explained in Chapter 7, in order to separate the effect of changing levels of unit rent from changing levels of extraction and other factors affecting the calculation of resource rent.

Figure 11.9 Resource rent and taxes from oil and gas mining in Norway, 1985-1996

Million Norwegian kroner

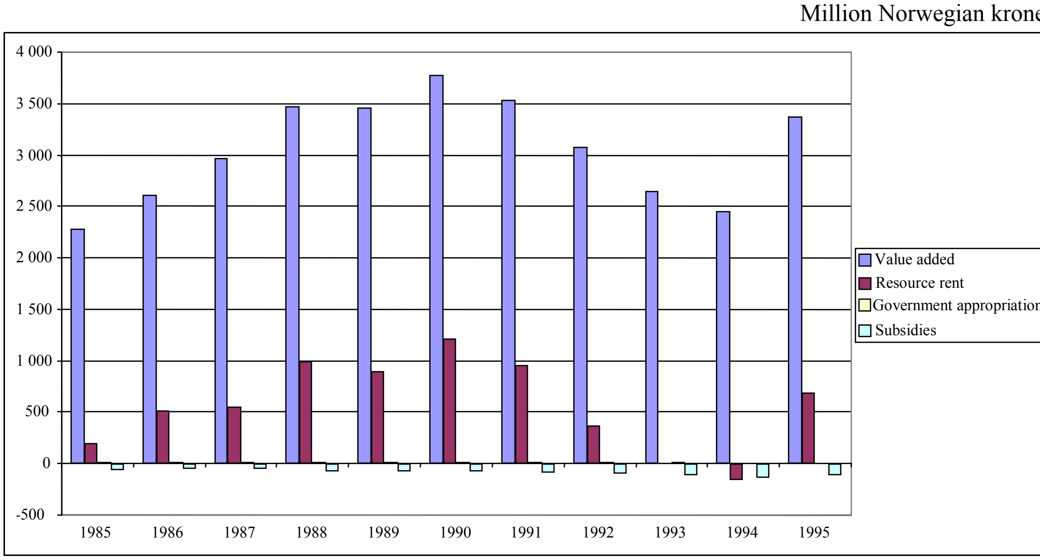


Source: Lindholt, 2000.

11.105. Uncultivated forests in Norway generate substantial value added and resource rent, but since they are privately owned, the rent accrues to the private sector. Government not only does not appropriate part of this rent, it pays some subsidies to the industry. These data series are shown in Figure 11.10.

Figure 11.10 Resource rent and taxes from forestry in Norway, 1985-1995

Million Norwegian kroner

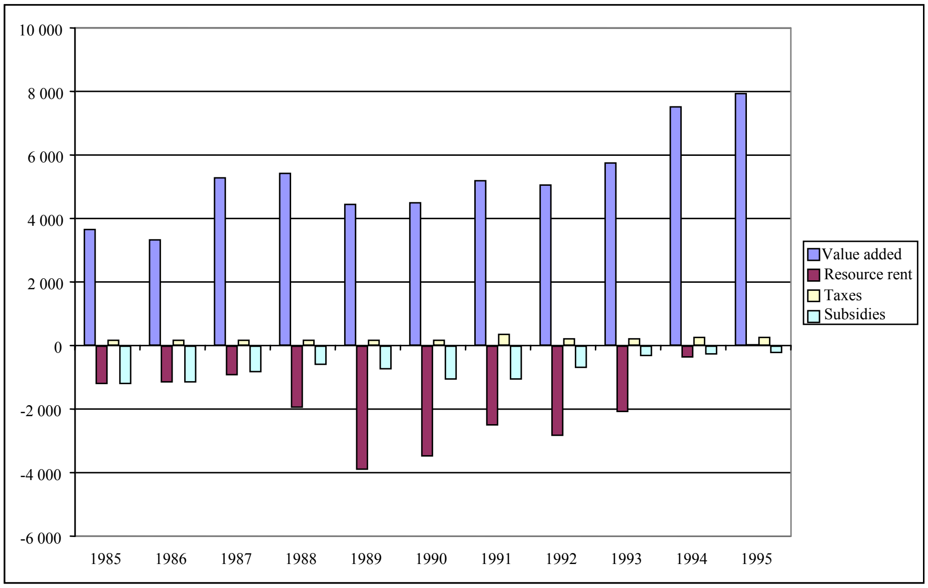


Source: Lindholt, 2000.

11.106. Figure 11.11 shows that fisheries (capture fisheries plus aquaculture) in Norway are managed in a way that generates significant value added but no positive rent. The economic value of fish under this management regime is zero. Although small amounts of taxes are levied on the fishing industry, these payments are more than offset by subsidies. The management regime promotes exploitation of fish stocks by relatively small inefficient vessels in order to support Norway's regional economies, an issue taken up in more detail below.

Figure 11.11 Resource rent and subsidies to fisheries in Norway, 1985-1995

Million Norwegian kroner



Source: Lindholt, 2000.

11.107. These figures are illustrative of different management regimes. They show that different regimes may be adopted even within the same country for different resources and, of course, they differ across countries. A pilot study for oil and natural gas in the Netherlands found that the Dutch government appropriated between 82 per cent and 97 per cent of the rent between 1990 and 1998. The corresponding figures were generally lower in the UK; after the industry began to earn a positive rent in 1993, government's share ranged from 45 per cent to 99 per cent (Eurostat, 2000a).

11.108. In Norway, the petroleum industry is the only resource-based industry which makes a net contribution to government revenue and this contribution is still a relatively small share of total revenues. Between 1986 and 1996 it varied only between five and eight per cent of the total. By contrast, in some small, resource-dependent economies, government's reliance on revenues from the nation's natural resources may be quite significant. For example, the government of Botswana receives about 50 per cent of its revenue from mining.

11.109. In assessing the contribution of natural resources to the economy, it is also useful to compare the share of resource rent in total government revenues and the share of resource management costs incurred by government. This type of analysis makes use of some of the information compiled under the environmental protection and resource management accounts discussed in Chapter 5. The share of the resource rent paid by the petroleum industry to government is sufficient to cover the costs of government resource management for mining in Norway in most years. Both forestry and fisheries receive net subsidies from government, so none of the costs of resource management (discussed later in this chapter) are recovered by government.

Efficiency with multiple uses of a resource

11.110. The values for assets discussed so far have been based on a single use, such as the timber value of forests. The full economic value of an asset and the efficient management of the asset must be based on an accounting of the full range of environmental services which a resource can provide. Forests may provide multiple benefits, such as timber, recreational benefits, carbon sequestration and the provision of traditional medicines and foods, which can be critical for rural populations in developing countries. In practice, comprehensive valuation may be difficult to achieve. In the example of Norwegian forest assets, only the timber value of the asset was considered. In Chapter 8, a fuller picture of the value of forests in Finland is given.

11.111. Forests in Alaska have provided substantial economic benefits to the logging, recreation and fishing industries. Economic efficiency requires assessing the optimal mix of these competing uses. Forest valuation based on timber value alone would underestimate the total economic value of the forests. Although the non-market benefits are more difficult to value, it is increasingly important to do so. It is likely, for example, that the carbon sequestration value of forests will be increasingly important as progress is made on an international agreement to address climate change.

Sustainability

11.112. The issue of whether extractive industries are managed in a way that promotes sustainable development is an important one for all economies. A first question is whether the rent received from a non-renewable resource is being reinvested to maintain the level of capital stock in accordance with the principle of weak sustainability.

11.113. Aggregate figures for national wealth may indicate whether new capital formation is replacing assets that are being depleted, but do not indicate whether there is a direct link between the revenue from the extractive industry itself and asset acquisition. When resource rent is recovered by government, it is useful to know whether the rent goes into a dedicated revenue fund used for investment. If so, it is useful to know what share of the rent goes into the revenue fund and what the revenue fund is used for. Some countries have such dedicated revenue funds, but they are not common.

11.114. Countries may institute their own measures to monitor the use of resource rent based on they type of information which can be provided by the SEEA. For example, Botswana, whose economy is highly dependent on mineral revenues, has developed the Sustainable Budget Index (SBI) to indicate how much of the mineral revenues are used for capital expenditures (including spending for human capital on education and health). Although there are no strict rules for policy based on the SBI, the government has adopted an informal fiscal guideline that no revenues from mining should be used for recurrent expenditures; in effect, all revenues from mining are reinvested. While spending under government's capital budget does not ensure that all investment is productive, the SBI is one type of indicator based on information that can be provided by the SEEA that can help to monitor sustainability.

Potential vs. actual value of assets

11.115. The value of an asset depends, in part, on how efficiently it is exploited. For renewable resources, the sustainable solution is a pattern of exploitation which maximises economic efficiency over the long run. This maximises the return to the resource and minimises (or avoids) depletion of the resource. Determining the maximum return depends on examining the factors which influence the partition of resource rent into an income and a depletion element as described in Chapter 7. The question arises, therefore, of whether the property rights, pricing and other policies imposed by the owner (often government) promote sustainable management.

11.116. Resource management can be evaluated from the point of view of economic efficiency to determine if alternative policies might increase the income generated and, hence, the economic value of a resource. Another option is to maximise not income but the sustainable yield. Usually this solution will lead to a larger stock than the income maximising solution.

11.117. Analysis of micro-survey data of Norway's herring fishery found significant differences in rent-earning capacity between large and small fishing vessels. Generally, the large-scale operations were more efficient and generated substantial rent. Assuming that most of the fishery could potentially be managed in such an efficient manner, one study of Norway's herring fishery estimated the potential resource rent of 1 billion Norwegian kroner (Flåm, 1993). However, as noted below, Norway chooses to support small-scale fishing for social reasons.

Other socio-economic objectives

11.118. Two socio-economic objectives whose pursuit may modify an approach of simple maximisation of economic efficiency are the goals of distributional equality between the present groups in society and between present and future generations.

11.119. Countries may choose to sacrifice economic efficiency in order to achieve other important socio-economic objectives. An obvious case is where the exploitation of a given resource is the foundation of the economy in a given region. For example, Norway has chosen to support small-scale fisheries as a component of its strategy to promote regional development. Fisheries are a mechanism to create employment and generate income in parts of the country that have few options for employment. Norway is willing to sacrifice economic efficiency and the greater income this would generate in order to achieve this goal (Sørenson and Hass, 1998).

11.120. The terms of access by foreign operators to a country's resources may have important implications for domestic employment and income. Examples are found in developing countries where foreign companies are invited to join the national government in exploiting a natural resource because there are insufficient financial resources and expertise available locally to do this without assistance from outside. Monitoring this situation requires estimating the share of rent that accrues to domestic operators, to government and to foreign operators. Where there are joint ventures between domestic and foreign companies, it may be difficult to determine these shares.

11.121. The pursuit of socio-economic goals that conflict with economic efficiency may have a cost and policy is more effective when this cost is known. The costs of a policy which distributes access to resources more widely in society, for example, but results in less efficient exploitation, can be measured as the resource rent that has been sacrificed and the corresponding, lower value of national wealth that results from the difference between the potential rent and rent actually generated. An initial, static analysis of the trade-off might measure this loss of rent based simply on information from micro data sets of individual companies under an existing resource management regime, such as the study of Norway's herring fishery. More sophisticated modelling of an industry would be required to determine the long-term economic effects of alternative management strategies on the value of a resource. Economy-wide modelling would be necessary to take into account all the changes that would result from alternative resource management policies.

11.122. As the case of Norway shows, resource management may be motivated by different objectives and result in very different outcomes in terms of efficiency, sustainability and equity. Countries may well use different resources to achieve a range of socio-economic objectives, some resources managed purely commercially and others not. However, in some instances, policies for managing resources may have been determined independently for each resource without the benefit of an economy-wide review which would establish a comprehensive policy for all resources. This may have occurred in the past because there was no comparable framework for measuring and analysing all resources. It is particularly important for certain resources, such as forests, which have multiple uses cutting across different economic activities. Thus, comparing the management of all resources in the common framework of the SEEA provides a valuable tool for more rational resource management.

E How much does degradation matter?

11.123. Effective environmental management is based not only on an understanding of the physical accounts, but also an understanding of the economic implications of residuals generation and energy and material use. Policy-makers need to know where limited financial resources will be most effective; that is, what are the relative costs of reducing different forms of environmental degradation from different sources and what are the relative economic benefits.

11.124. The issue of economic valuation of the flow accounts and the valuation methodologies are discussed extensively in chapters 7 and 9. Two different conceptual approaches to valuing environmental degradation are identified: the cost approach and the damage approach. The former shows policy-makers the cost of certain actions to prevent or remedy degradation and the latter shows the benefit of policy actions (that is, the value of the damages that will be prevented). In the absence of efficient markets these measures are likely to be quite different but both measures can be useful for environmental management depending on the policy question that is addressed.

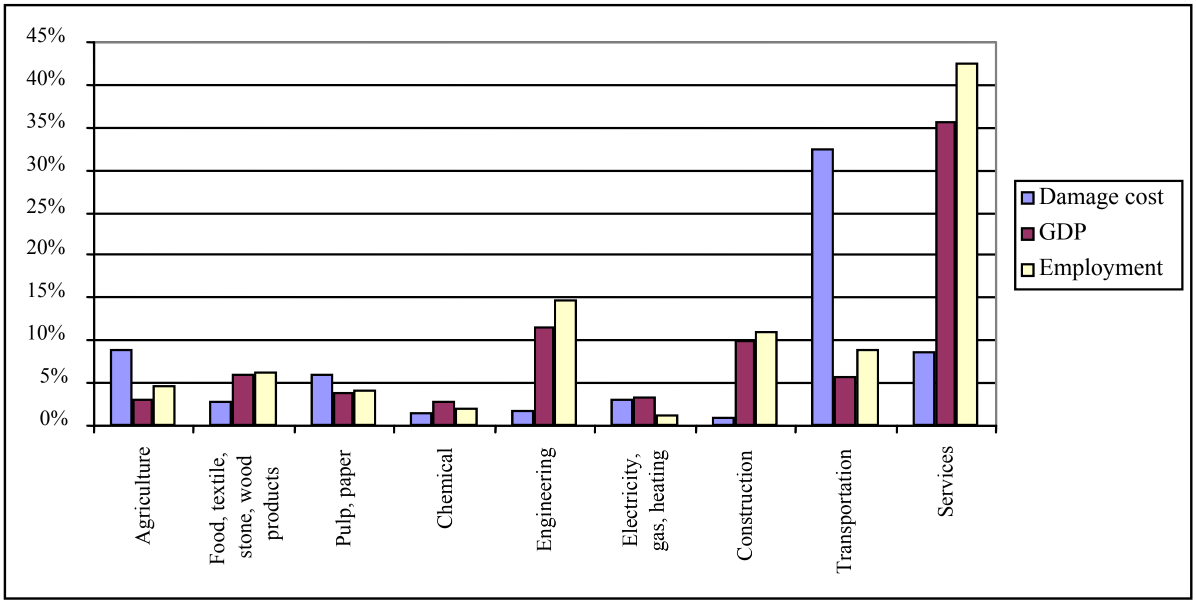
1 Indicators and descriptive statistics

11.125. The indicators described earlier coming from hybrid accounts show how an individual industry contributes to the economy, to employment and to the generation of residuals. It is beneficial to be able to place a value on the damage done by residuals so that the costs and benefits of economic activity and employment can be viewed in a context which includes environmental concerns as well as economic ones.

11.126. Figure 11.12 provides a snapshot for Sweden of the overall economic contribution and environmental burden posed by each industry in 1991. The environmental burden is represented by the damages caused by domestic emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_X), volatile organic compounds (VOC), nitrogen to water and ammonia (NH_3). The economic contribution is represented by shares of GDP (value added) and employment.

11.127. Far and away the highest burden is imposed by transportation. It accounts for 33 per cent of the damage costs, but only six per cent of national income and nine per cent of employment. Services and agriculture come next in order but the relative level of value added and employment offered by services is much the highest of any industry grouping shown (36 per cent of GDP and 43 per cent of employment) whereas its environmental burden is only nine per cent of the total damage costs. The economic contribution of the other industries, except for pulp and paper, is relatively small compared to the environmental burden they impose. Information about relative economic contributions and environmental burdens is essential for policy-makers when identifying industries that will play a key role in economic development. In the absence of such information, incentives to promote growth of a specific industry, such as subsidies to pulp and paper or agriculture, may result in levels of environmental damage that far outweigh apparent economic gains.

Figure 11.12 Economic contribution and environmental burden from domestic pollution by selected industries in Sweden, 1991



Source: Ahlroth, 2000.

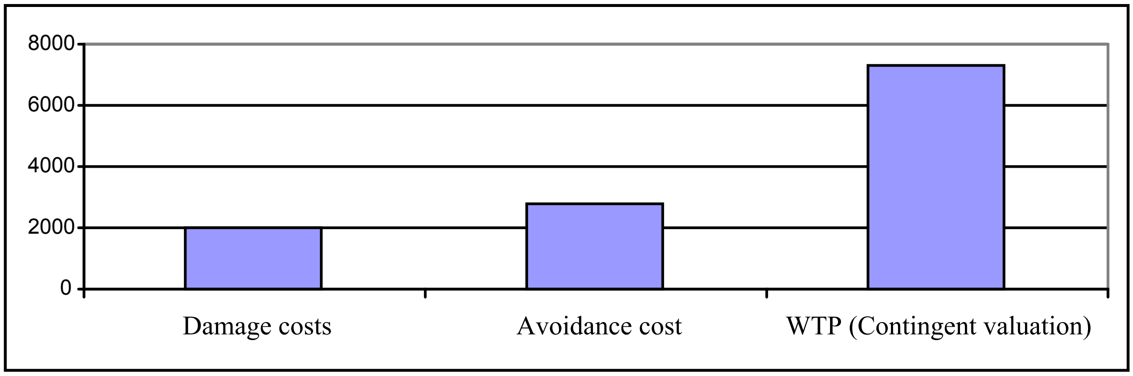
11.128. In cases where environmental policy takes the form of setting emission standards without regard for balancing economic costs and benefits, the policy challenge is to find the most cost-effective measure to meet these standards; in other words, to start with the cheapest opportunities for pollution reduction. In this case, the maintenance cost approach is useful because it provides an indication (subject to the caveats discussed in Chapter 10) of what it would cost to prevent or mitigate environmental degradation.

11.129. Where economic factors play a greater role in setting environmental policy, a cost-benefit approach might be used as an input to setting environmental priorities. In such cases, both forms of valuation are required to calculate the ratio of benefits (damages that can be prevented) to costs (costs of measures to reduce residuals). Even where cost-benefit analysis is not used in decision-making, it is still useful to know the relative costs and benefits from different actions.

11.130. Three methods of valuation have been applied to the physical accounts for NO_X in Sweden: the damage cost approach (termed repercussions on the economy in the Swedish accounts), the avoidance cost approach (one measure of maintenance cost) and willingness to pay (WTP). Figure 11.13 indicates that the damage cost approach yields the lowest value, at just over 2 000 million Swedish kroner; the avoidance cost approach is higher, but not that dissimilar, at around 2 800 million Swedish kroner. At 7 300 million Swedish kroner, WTP yields a much higher value than either of the other two, more than three times the value obtained using the damage approach.

Figure 11.13 Damage costs, avoidance costs and willingness to pay for NO_X emissions in Sweden, 1991

Million Swedish kroner



Source: Ahlroth, 2000.

11.131. The Philippines has constructed environmental degradation accounts for a range of pollutants to air and water from selected industries, as well as nutrient loss in agriculture and soil loss in forestry using the maintenance cost approach. Some results from the accounts for biological oxygen demand (BOD) are shown in Table 11.9. As discussed in Chapter 10, the maintenance approach indicates the economic cost of reducing residuals, but not the benefits from doing so. Nonetheless, the results are instructive. Although aquaculture is responsible for 64 per cent of total BOD emissions, the cost of pollution abatement in that industry is extremely small, less than one per cent of total costs. By contrast, the hog industry produces 34 per cent of BOD but accounts for nearly 80 per cent of the maintenance costs. The sugar industry contributes a tiny share of total BOD emissions, only 0.4 per cent, but it would be quite costly to reduce these emissions since its share of environmental damage costs is 13 per cent.

Table 11.9 Emissions of BOD and environmental damage by selected industries in the Philippines, 1993

	Percent of emissions	Percent of environmental damage	Ratio of cost shares to emission shares
Aquaculture	63.7	0.7	0.01
Hog Industry	34.2	79.7	2.33
Tuna Canning	0.1	0.3	2.86
Textile Industry	1.4	5.8	4.02
Leather Tanning	0.1	0.3	5.03
Sugar Industry	0.4	13.2	31.09
Total	100.0	100.0	na
Level of emissions (MT) and total costs (thousands of pesos)	1 303 452	2 053 000	

Note: Environmental damage estimated using the maintenance cost approach.
Emissions of BOD were not calculated for all industries.

Source: Philippine National Statistical Coordination Board, 2000.

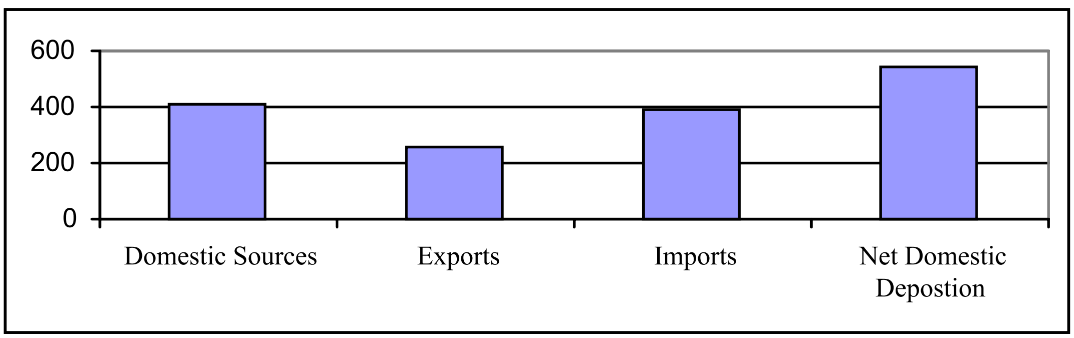
Transboundary residuals

11.132. Ideally, damage and avoidance costs would provide an indication of the relative benefits and costs of reducing emissions. However, there is not a simple correspondence between domestic environmental damage and domestic maintenance costs because of the role played by trans-boundary residuals. Like many countries, Sweden imports and exports a great deal of residuals. As shown in Figure 11.14 more than 60 per cent of its domestic production of NO_X is exported, but even more is imported (72 per cent) so that domestic deposition is 112 per cent of domestic generation.

11.133. The very high share of imported emissions indicates that Sweden will need to cooperate with neighbouring countries, which are sources of its imported NO_X, in order to improve Sweden's domestic environment. The suggestion is that it may be more cost effective for Sweden to work with neighbouring countries to reduce their emissions and thus the imports to Sweden, than to concentrate on reducing emissions in Sweden. The crude evidence from these accounts of the relative costs and benefits of reducing domestic emissions in Sweden lends further support to that approach. However, given Sweden's considerable exports of NO_X, an efficient strategy for reducing emissions must take into account all countries involved, in order to identify in a regional context where the greatest benefits at lowest cost are to be found.

Figure 11.14 Domestic emissions, exports and imports of NO_X in Sweden, 1991

Thousand tonnes



Source: Hellsten *et al*., 1999.

2 Policy analysis

11.134. Valuation issues discussed in Chapter 9 largely focus on environmental degradation, but policy-makers can use this approach to address another challenge, pricing non-market goods and environmental services. Two examples of particular importance for developing countries have been water and recreational services from nature-based protected areas. Where the costs are not recovered from users, as is the case for water in many countries, there is little incentive for resource conservation. Tourists visiting national parks and protected areas usually pay an entrance or user fee but this may not even cover the costs incurred in managing the park. Even if the costs are covered, a valuation of the recreational services and the unique ecosystems on which they depend based on entrance fees will undervalue the environmental services of the parks. Given the apparently low economic value for this form of land use, countries often face pressure to convert protected areas to other uses. This problem can be especially severe for developing countries (for example, the clearing of protected forests for agriculture in many tropical countries) but is by no means limited to developing countries, as shown in the controversy over the permitting of oil extraction in Alaska's arctic wilderness.

11.135. There is an extensive literature on the economic value of protected areas, though relatively little has found its way into environmental accounts yet. More work has been done within the accounts on the value of water. Where water rights are traded in reasonably competitive markets, as in parts of Australia, the value of water is reflected in the price of these rights. However, water is often not traded in competitive markets and its value can be difficult to measure, requiring a great deal of information that is not always readily available. Case studies in Namibia (Lange *et al*., 2000) for agriculture, the main user of water, found a very low value for water, though one that varied enormously by crop.

11.136. These calculations are not only important for domestic environmental policy, but also for issues that are regional or global. For example, Namibia's' policy of making water available at reduced cost to commercial agriculture has changed since the early 1990s when a policy of gradually introducing full-cost recovery was adopted. A comparison of the extent to which water was provided at less than full cost in Namibia and South Africa in 1996 (Lange and Hassan, 1999) showed that commercial agriculture in Namibia continued to benefit significantly from cheap water, though much less than commercial agriculture in South Africa. Quantifying the value of the effective subsidy has been particularly useful both in domestic discussions about water and agricultural policy and also in the negotiations over future allocation of shared river water between Namibia and South Africa.

11.137. Even without estimating the economic value of water, there is monetary information about costs and tariffs that is very useful to policy-makers. Flow accounts can be compiled for the cost of providing water to each sector, the tariffs charged and, from this information, the benefit of cheap water to each sector can be calculated. Monitoring effective subsidies is clearly important both for sustainable management of resources as well as for equity by identifying which groups in society receive the greatest assistance from them.

F Adjusting the macro-economic aggregates

11.138. Chapter 10 explains at some length the difficulties inherent in trying to devise an accounting measure of sustainable income and explained why many commentators prefer a modelling approach which addresses the question of how to develop a sustainable economy rather than devising an aggregate referring to the economy in its present unsustainable state with adjustments for the degree of non-sustainability.

11.139. This section describes some of the work which has been undertaken in this area. The first sub-section deals with adjustments to national income for depletion of natural resources. The second sub-section addresses cost-based adjustments to GDP and includes reference to work conducted in trying to implement the 1993 SEEA. The third sub-section looks at experience using damage based estimates. The fourth sub-section looks at modelling approaches to estimating alternative paths for the economy. All sub-sections draw on the techniques described in Chapter 10.

1 Depletion adjusted macro-aggregates

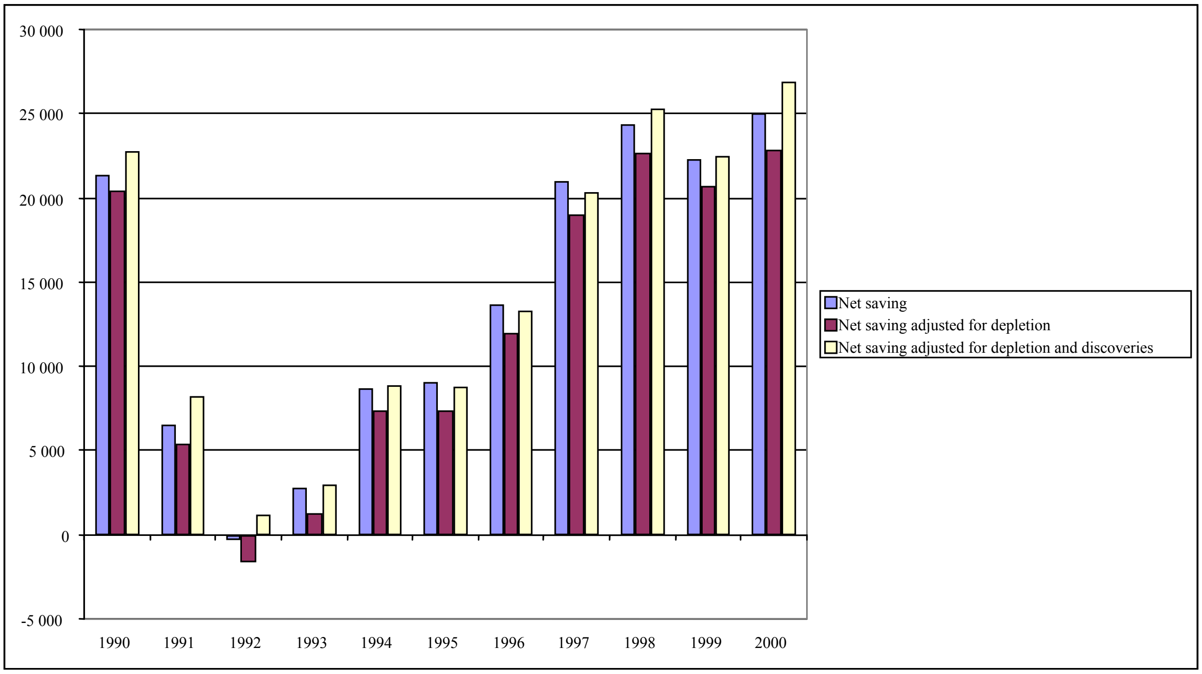
11.140. During 2001, a research paper from the Australian Bureau of Statistics appeared containing adjustments which could be made to the estimates of savings and net domestic product for the depletion of subsoil resources. The techniques used for the adjusted estimates follow closely those described in chapters 7 and 10 for the calculation of resource rent and its separation into a depletion element and an income element. Further, separate estimates are given for the case when depletion of the resource only is allowed for as well as the case when an addition for new discoveries is also made.

11.141. Australia has considerable mineral resources, the most valuable of which are oil and gas. However, as noted when looking at the components of wealth for the country in Section D above, these reserves form quite a small proportion of national wealth. It is therefore not surprising that the impact of a depletion adjustment on NDP is small at one half of one per cent for each of the years from 1990 to 2000. In all these years (except the period 1995-1997) the level of discoveries was such that NDP adjusted for both depletion and discoveries was up to one half of one per cent higher than NDP. For the three years from 1995 to 1997, the adjusted NDP figure was only just lower than NDP at 99.9 per cent in each year.

11.142. Figure 11.15 shows these changes relative to saving for each of the ten years in question. In only one year is net saving negative. Although the adjustment for depletion exacerbates this negative amount, the compensation of including discoveries brings the adjusted saving figure back above zero.

Figure 11.15 Savings data adjusted for depletion and discoveries of natural resources in Australia, 1990-2000

Million Australian dollars



Source: Ryan *et al*., 2001.

2 *Cost-based estimates*

11.143. An environmentally adjusted measure of domestic product was calculated in early work on environmental accounting by Repetto and his colleagues in the 1980s as a way of focusing the attention of policy-makers on the importance of environmental degradation and depletion of natural capital (Repetto *et al*., 1989). Repetto's work in Indonesia on petroleum, forests, and land degradation and in Costa Rica on forests, fisheries, and land degradation was followed by similar pilot studies in the early 1990s in Papua-New Guinea and Mexico sponsored by the UN and the World Bank.

11.144. More recently, eaNDP has been calculated for a number of countries, including Japan (Oda *et al*., 1998), Korea (Korea Environment Institute *et al*., 1998), the Philippines (Philippine National Statistical Coordination Board, 1998), Sweden (Skånberg, 2001) and Germany (Bartelmus and Vesper, 2000). There are a number of limitations to these studies. Not all forms of environmental degradation are included and the valuation estimates have, in some cases, been rather crude in assuming, for example, the same cost of abatement in all industries. Some exercises are described below. The important differences between countries in terms of the types of environmental damage included and valuation methods used make it impossible to compare results across countries directly.

Korea

11.145. Environmental accounts were constructed for Korea over the period 1985-1992. eaNDP was calculated by subtracting from conventional NDP depletion of natural assets (minerals, forests, fish) and degradation of land, air and water. Korea used the maintenance cost approach to environmental degradation and assumed the same abatement costs in all industries. Table 11.10 shows that the resulting eaNDP is between 96-97 per cent of NDP over the seven-year period.

Table 11.10 eaNDP as percentage of NDP in Korea, 1985-1992

Percentage

1985	1986	1987	1988	1989	1990	1991	1992
95.9	96.6	96.9	97.1	97.3	97.1	97.3	97.4

Source: Korea Environment Institute *et al*., 1998.

Environmental degradation due to selected economic activities in the Philippines

11.146. The Philippines also used the maintenance cost approach, but with a more realistic costing of environmental degradation. Abatement costs were estimated separately for each industry based on the technology appropriate to a given industry rather than assuming the same cost in all industries. As in Korea, the difference between NDP and eaNDP was very small.

11.147. As part of the implementing the Philippine SEEA since 1995, the degradation due to selected economic activities was also estimated. The economic activities covered agriculture, manufacturing, gold mining, electricity generation and land (road) transportation. Fishing and forestry, upland rice growing, shrimp aquaculture, pig farming and logging were covered within agriculture. In manufacturing, the industries covered were tuna canning, sugar milling, cotton textiles, leather tanning, paint manufacturing, petroleum refining and cement.

11.148. Except for electricity generation, which is only measured in physical terms, all of the economic activities were measured in both physical and monetary terms. The prioritisation of these selected economic activities was based on data availability and on experts' opinions that they are the most polluting.

Methodology

11.149. In the estimation of the environmental degradation of economic activities, the maintenance cost approach was utilised. This means that the cost of degradation of environmental media such as land, air and water was generated by using the market prices of the pollution control equipment that would have to have been installed to maintain the quality of the environment. A major assumption of the maintenance cost approach is that only the emissions which are not absorbed by the environment should be valued. However, in implementing the maintenance cost approach for the Philippines, degradation from almost all emissions and effluents was valued given that no data were available to identify which are controlled and uncontrolled. Hence, there was an implicit assumption that the environment can no longer absorb any of the wastes generated by these activities, with the exception of the hog and the land transport industries for which the controlled pollutants were identified.

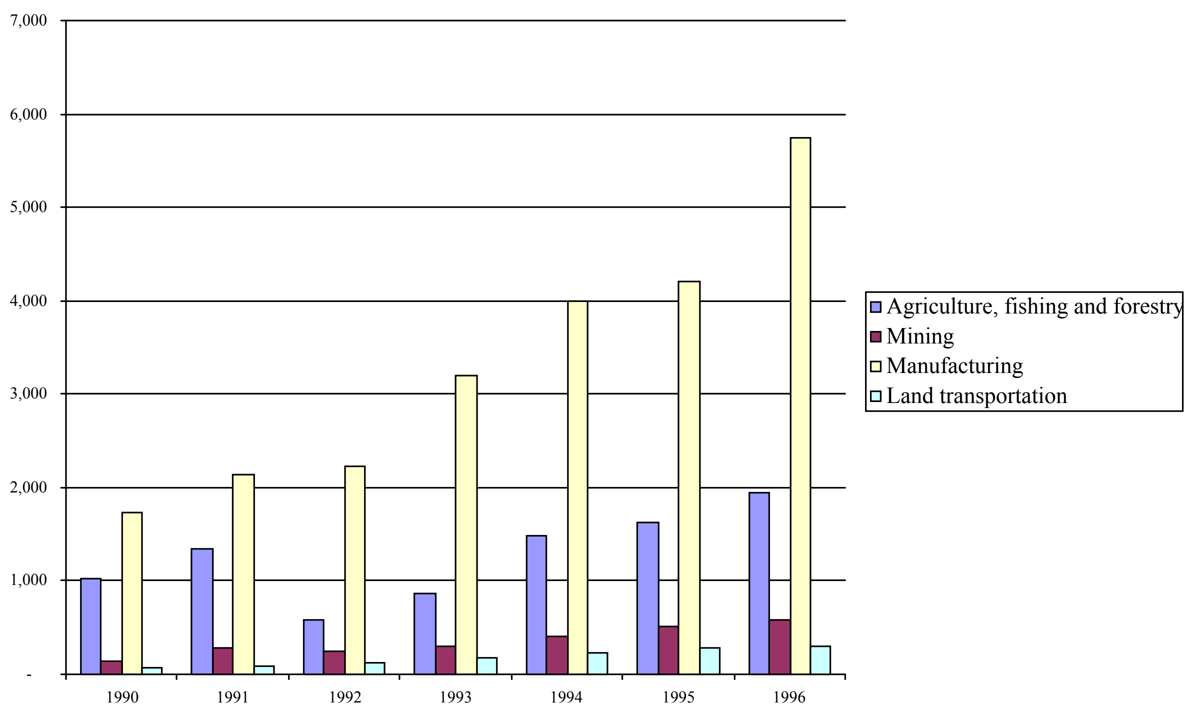
11.150. The cost of a relevant pollution control device was taken to be the sum of the annualised capital cost and operating cost. The average cost per unit of pollutant was then calculated and applied to the level of pollutant to reach the estimated cost of environmental degradation. In some economic activities the maintenance approach took the form of expenditures for avoiding the degradation such as the average cost required to avoid soil erosion and to contain mine tailings.

Key Results

11.151. The degradation associated with selected economic activities is shown in Figure 11.16. The manufacturing sector is the most polluting mainly due to the cement industry, which was the top polluter among the economic activities measured.

Figure 11.16 Cost of environmental degradation due to selected economic activities

Million pesos



Source: Philippine National Statistical Coordination Board, 2000.

11.152. One particular use of the degradation estimates is to compare the economic contribution and environmental burden by industry as a criterion in selecting what industries should be supported by the government in mapping out its economic development policies with environmental policies, such as the identification of growth industries and provision of incentives/disincentives. Table 11.11 shows that cement alone contributes almost 60 per cent of the degradation but only just over one per cent of GDP. Another three industries contribute over 30 per cent of degradation but less than one quarter of GDP.

Table 11.11 Share of GDP and share of total degradation costs in the Philippines, 1996

Industry	Percentage share of degradation costs	Percentage share of GDP
Land transport	3.6	5.6
Upland rice farming	22.5	16.4
Small-scale gold mining	6.8	0.8
Cement manufacturing	59.3	1.3
Total for these four industries	92.2	24.1

Source: Philippine National Statistical Coordination Board, 2000.

Limitations

11.153. In most estimation procedures adopted, parameters are assumed to be the same for all the years under study since the parameters are mostly based on one-time or *ad hoc* surveys. Hence trends exhibited by both the physical and monetary estimates were mostly based on the trends of the pollution base (output, input, total area and amount of wastewater generated) and the changes in the assumed trends of average cost of pollution control devices.

11.154. The use of the implicit GDP deflator for other miscellaneous durable equipment from the Philippine national accounts to extrapolate the average cost of pollution control in manufacturing sector may not reflect the true situation since this category may or may not include pollution control devices. The same holds true in estimating the cost of maintaining such devices.

3 Damage-based estimates

Swedish experience with damage-adjusted income

11.155. The green accounting work in Sweden is the result of co-operation between three government agencies: Statistics Sweden; the Environmental Protection Agency, which provides physical environmental data and input-output tables; and the National Institute for Economic Research (NIER), which carries out monetary valuation. NIER has made estimates for a partially adjusted "green" NDP for Sweden for 1993 and 1997 (Table 11.12). The aim has been to evaluate the total value of the production of goods and services during an accounting year, including estimates of present and future negative environmental effects generated by the same production. The SNA is extended in three directions and some rearrangements are made within it.

- The resource rent from mining is subtracted applying Hartwick's rule which assumes that all resource rents from exploiting non-renewable resources are reinvested and all but the interest from the new investment is considered as depreciation.

- All activities incorporated in the GDP that aim at maintaining or improving natural capital or the expenditures that are undertaken to protect against environmental deterioration are deducted. That is, defensive expenditures are considered as intermediate consumption and not as final use.

- The future income losses (after the defensive expenditures undertaken) stemming from the degradation of renewable resources (forestry soils and agricultural soils) have been calculated by applying market prices to modelling results presented by scientists from the fields of chemistry and agricultural sciences.

- Damages to buildings from environmentally related corrosion have been valued using dose-response functions and reinvestment costs. Real estate depreciation has been estimated from official taxation values.

Table 11.12 A partially environmentally adjusted NDP for Sweden, 1993 and 1997

Millions of Millions of $US at 2000 prices

	1993	1997
NDP	180 550	202 470
Total adjustments	-1 960	-1 900
Depletion of metallic ores	*-135*	*-160*
Degradation of ecosystems	*-200*	*-190*
Exploitation of biological resources	*-15*	*-15*
Increased depreciation of produced capital	*-270*	*-205*
Expenditures aimed at maintaining natural capital	*-1 340*	*-1 330*
Environmentally adjusted domestic produce (EDP)	*178 587*	*200 568*

Source: Skånberg, 2001.

11.156. Note that not all environmental damages generating income losses during the accounting year are specified. According to the polluter pays principle (PPP) these income losses should be paid by the sector emitting the substances causing the damage, which could as well be a firm in a foreign country. In the case of problems caused by the accumulation of residuals in the environment, the emissions affecting the Swedish environment this year might also be from past years. For example, it has been estimated that Swedish farmers lose 1 billion Swedish kroner annually due to ozone damages on crops. According to the PPP, the polluting sectors, among which the transport sector is very important, should compensate the agricultural sector for its losses. Assuming that all emissions leading to increased ozone concentrations are of Swedish origin and from this year, these compensation payments would affect both sectors' value added but not GDP, NDP or damage-adjusted income, as the sums cancel out.

11.157. The Swedish damage-adjusted income measure is partial in that only environmental damages caused by emissions of sulphur and nitrogen are evaluated. Some of the damages caused by these pollutants are omitted because neither the natural scientists nor the economists/statisticians have the necessary data/methods to carry out a valuation. Note especially that major environmental problems such as climate change, ozone depletion and loss of biodiversity are not incorporated.

Genuine saving

11.158. Chapter 9 also discusses depletion-adjusted measures of national income and mentions briefly the World Bank's work on genuine savings. This is reported in the World Bank's *World Development Indicators* (Kunte *et al*., 1998; Hamilton, 2000; World Bank, 1999). This indicator is derived from modifications to the measure of savings in the existing accounts. In addition to making allowance for the depletion of energy, minerals and forests and for environmental damage caused by carbon dioxide emissions, an adjustment is also made for education expenditure, which is taken to be an important contributor to increases in human capital.

11.159. A comparison between gross domestic saving and genuine saving for different regions of the world in 1997 is given in Table 11.13. Crude assumptions were made in order to calculate this indicator for all countries. In all instances, genuine saving is less than gross domestic saving, but there is great variation among regions. In the Middle-East and North Africa, genuine saving is actually negative. If genuine saving is negative at any point, it implies that social welfare will be lower at some point in future than currently, which is to say that negative genuine saving is an indicator of unsustainability. In practice, a persistent negative saving indicates that the economy is on an unsustainable path.

Table 11.13 Genuine savings in various regions of the world, 1997

	Gross domestic savings	Consumption of fixed capital	Net domestic savings	Education expenditure	Energy depletion	Mineral depletion	Net Forest depletion	Carbon Dioxide damage	Genuine Domestic savings
World	22.2	11.7	10.5	5.0	1.2	0.1	0.1	0.4	13.6
Low income	17.0	8.0	9.1	3.4	4.2	0.6	1.8	1.2	4.8
Middle income	26.2	9.2	17.0	3.5	3.8	0.5	0.2	1.1	15.0
High income	21.4	12.4	9.0	5.3	0.5	0.0	0.0	0.3	13.5
East Asia and Pacific	38.3	6.9	31.4	2.1	0.9	0.5	0.7	1.7	29.7
Europe and Central Asia	21.4	13.7	7.9	4.2	4.9	0.1	0.0	1.6	5.6
Latin America and Caribbean.	20.5	8.3	12.2	3.6	2.7	0.7	0.0	0.3	12.1
Middle East and North. Africa	24.1	8.8	15.3	5.2	19.7	0.1	0.0	0.9	-0.3
South Asia	18.2	9.1	9.1	3.8	2.1	0.4	2.0	1.3	7.1
Sub-Saharan Africa	16.8	9.1	7.8	4.5	5.9	1.4	0.5	0.9	3.4

Source: World Bank, 1999.

4 Modelling approaches to macroeconomic indicators

11.160. As explained in Chapter 10, environmentally adjusted NDP is criticised for combining actual transactions (conventional GDP and NDP) with hypothetical values (monetary value of environmental degradation). If the costs of environmental mitigation had actually been paid, relative prices throughout the economy would have changed, thereby affecting economic behaviour and, ultimately, the level and structure of GDP and NDP. The response to this criticism has led to the construction of a new indicator, greened economy NDP or geNDP (or geGDP). This indicator is estimated by an economic model which internalises the costs of environmental degradation measured in the SEEA. In fact, geGDP actually seeks to provide policy-makers with guidance on how economic behaviour can be changed to reach a level of income which is more sustainable (more environmentally benign) than the present one.

11.161. Identifying a greened economy national income (geNI) is a complex economic modelling exercise. It requires assumptions and projections about preferences or priorities accorded to environmental functions and the corresponding environmental standards to achieve them, the technological means to achieve them, the response to policy instruments as well as the usual range of assumptions for an economic model including responses to changing prices by households and producers, impact on trade, and so on. Different assumptions will result in quite different levels of greened economy national income. Much depends on assumptions about the way in which resource use and emissions approach environmental standards and thus the period of time over which geNI would be achieved.

11.162. A distinction can be made between geNI achievable under current conditions but with stronger preferences for environmental functions and geNI that could be achieved in a future economy with a broader range of options. The first approach has been referred to as *ex post* or counterfactual (O'Connor, 2001) because it attempts to estimate what the existing economy might have been if (counterfactually) it had been required to meet environmental standards. The second approach has been referred to as *ex ante* because it seeks to explore future economic development paths that are subject to environmental constraints. The *ex post* approach yields historical time series; the *ex ante* approach yields forecasts. Examples of each are described below.

Hueting's sustainable national income

11.163. Hueting's sustainable national income (SNI), described in Chapter 10, is an example of the *ex post* method. The intention of the method is to get an impression of the difference between the income levels on the current path and on a sustainable path. This may be interpreted as a measure of the distance between the paths in the year under review. An equally important intention is to get a measure of the course of welfare on the sustainable path. At the same time, the method provides information on which steps should be taken to shift to more environmentally benign activities in order that indispensable environmental functions will be available to future generations. In making these changes, only technologies known to exist (whether currently implemented or in the pipeline) are used in the model. This is in concurrence with the precautionary principle. In order to value the functions and their losses, which is a prerequisite for calculating SNI, data or assumptions are needed both on the costs of the steps to restore and maintain environmental functions (the supply side) as well as on the preferences for those functions (the demand side).

11.164. The SNI is the maximum income that can be sustained without taking technological development into account (except for the use of non-renewable resources). In theory, the calculation should involve finding a sustainable path with maximum income within a comprehensive model of production, consumption and the environment. As yet, this is an impossible task. The calculation procedure is therefore simplified by making two assumptions.

1. The economic damage due to loss of vital environmental functions under sustainability is negligible.

2. The maximum demands on the environment which can be supported indefinitely without loss of functions will be reached when the following conditions are met:

    - biological species may not become extinct faster than natural evolution would lead to;

    - hazards to human health are accepted only to an extent comparable to those caused by other non-violent human activities; and

    - environmental functions should be well distributed throughout the country and not lead to unreasonable pockets of abundance and deprivation.

The resulting procedure consists of several steps as illustrated in Figure 11.17.

11.165. Hueting's method involves setting standards for residual emissions and resource use based on scientific assessments of physical sustainability reflecting assumed preferences for sustainability. The conditions mentioned under point (2) in the preceding paragraph are converted into standards for the state variables of the environment. For instance, to prevent loss of species by excessive use of space and climate change, the minimum areas of land and water needed for resilient natural ecosystems and the maximum limits for the temperature of the atmosphere and its rate of change are formulated. For use of space, the geographical limits to the available space are used directly as sustainability standards for this environmental problem (or theme). With the aid of models of the other relevant environmental problems, like climate change, the limits to the state variables are converted into the sustainability limits or standards for the environmental burdens (or pressures, or types of use), such as the emissions of greenhouse gases (de Boer, 2000; Hueting and de Boer, 2001).

11.166. The method further requires estimates of abatement cost curves to achieve the desired standards using currently available or foreseen technology. Where available technology is inadequate to reach the desired standards, less harmful products are substituted; if they are not available, output is reduced to the point where the standard is achieved. Sustainability standards are enforced by requiring polluters to purchase pollution rights in a market where price is determined to reflect the scarcity of these rights. SNI was calculated for the Netherlands for 1990 using a static, applied general equilibrium model.

11.167. A small number of basic assumptions have been made for the calculation, both in theory and in the practical procedure, some of which are relevant for the determination of the standards. First, it is assumed that the transition to sustainable activities is made in every country in the world simultaneously and in the same way. This prevents the transfer of burdening activities from one country to another. Secondly, sustainability standards for environmental pressures are set for the region in which they affect functions (that is, national, regional or global). As a consequence of both assumptions, a country's contribution to meeting a regional or global standard is set equal to its contribution to regional or global pressure in the first year of the calculation.

11.168. The sustainability standards hold in the long run. They are time-dependent for non-renewable resources, with future trends in efficiency improvement, recycling possibilities and substitutes for the resource being based on observed historical development. For land use and for environmental phenomena with the characteristics of renewable resources, the pressure limits are constants.

11.169. Sustainability standards and elimination cost curves are input to a general equilibrium model of the economy. In Figure 11.17 blocks represent models of (sets of) processes and lines represent variables. The order of the steps is from left to right of the figure. No cross-over effects between environmental problem areas are shown. The static equilibrium model maximises the feasible SNI and optimises the mix of technical and structural measures required. This part of the project was carried out by the Institute of Environmental Studies in Amsterdam (Verbruggen, 2000 and 2001).

11.170. Four variants of Hueting's SNI were constructed based on different assumptions about trade impacts (constant shares of output or shares that adjust as prices change) and the set of prices used to report the results. Regardless of the variant, large changes would have to occur in order to fulfil the sustainability standards in a hypothetically instantaneous moment without adaptation costs (that is, in a comparative analysis). Results are shown in Table 11.14 for major macro-economic indicators. SNI is 56 per cent lower than national income in the base year. Household consumption declines by 49 per cent, government consumption by 69 per cent and net investment by 79 per cent. Both exports and imports fall by nearly two-thirds. Production in all industries falls. Revenues from pollution rights are so high that they replace all taxes. These revenues exceed government consumption and are redistributed as lump sum payments to households to pay for consumption.

11.171. The purpose of the SNI is not to provide policy-makers with a goal for national income as such, but to indicate the distance between current income and sustainable income. If this exercise were updated, with new technologies introduced into the model as they become available, Hueting's SNI would indicate whether the economy is becoming more or less sustainable over time.

Figure 11.17 Main steps in the calculation of the SNI (simplified)

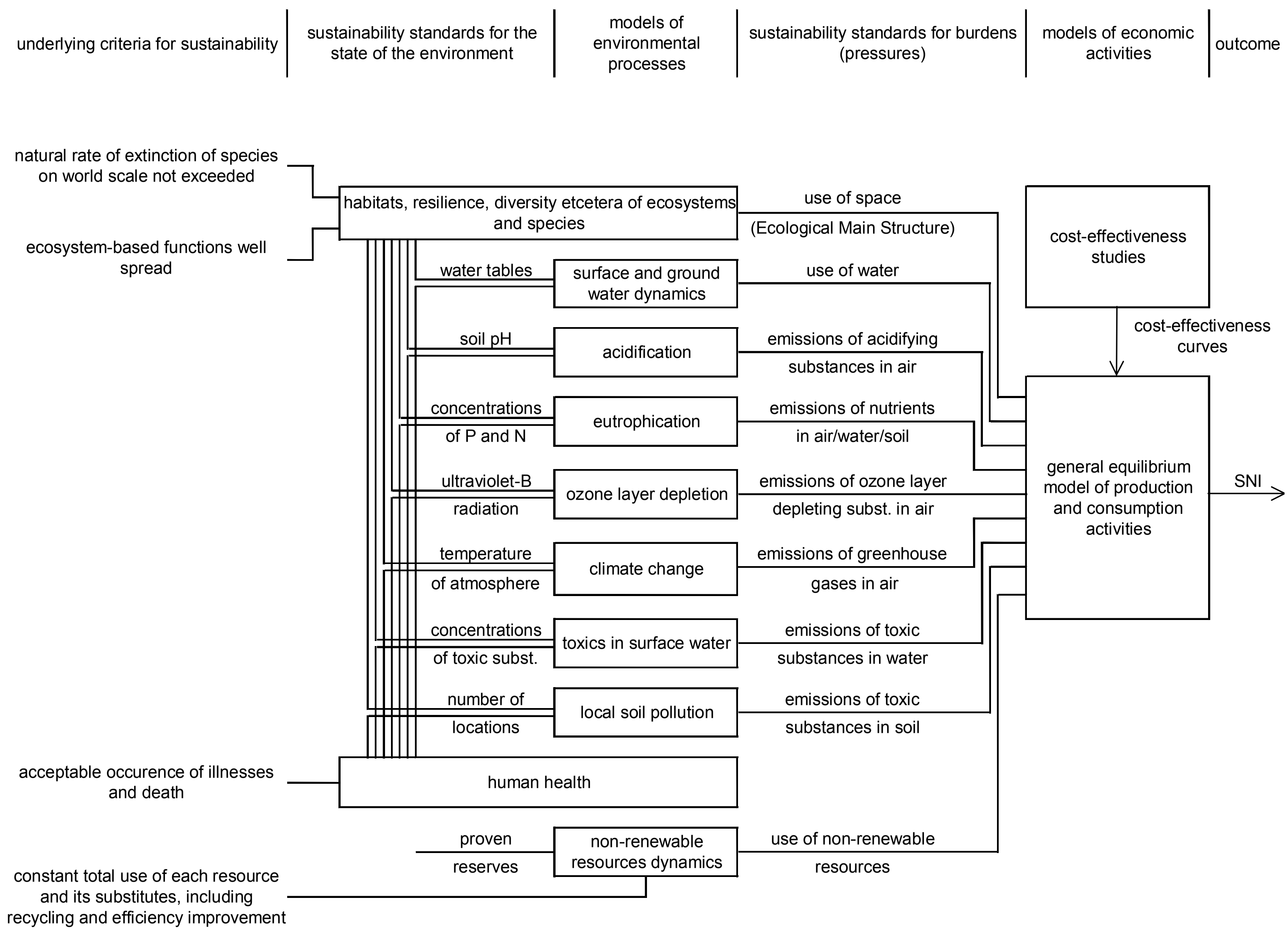


Table 11.14 Hueting's Sustainable National Income

Billions of guilders

	Base 1990	SNI	Change (%)
National Income	**457**	**201**	**-56**
Private households consumption	314	159	-49
Government consumption	75	23	-69
Net investments	51	11	-79
Trade Balance	16	8	-53
Exports	229	80	-65
Imports	-213	-72	-66
National Product	**457**	**201**	**-56**
Agricultural production	15	4	-76
Industrial production	113	19	-83
Services production	242	37	-85
Taxes on production	88	0	-100
Pollution rights	0	165	
Double counting	0	-24	

Note: SNI Variant 2b: constant trade shares; new equilibrium prices

Source: Verbruggen *et al*., 2000; Table 7.5.

Forward-looking estimates of geNDP

11.172. An alternative approach, the *ex ante* approach, estimates greened national income (geNI) looking into a hypothetical future in which economic development must meet certain environmental standards that internalise the costs of pollution prevention or abatement. The purpose of this approach is to provide policy-makers with guidance about the likely impacts of alternative development paths and the instruments for achieving them. An example of geNDP is a study carried out by the Swedish National Institute of Economic Research about the macroeconomic impacts of achieving different levels of reduction of CO_2 emissions. The governmental Climate Committee of Sweden is responsible for recommending target levels for greenhouse gases and also for providing a good basis for the political decisions on this matter, including estimates of the macroeconomic costs for achieving different targets.

11.173. In order to assist the Climate Committee, the Swedish National Institute of Economic Research carried out simulations for the three scenarios to reduce greenhouse gas emissions: the implementation of the Kyoto protocol for CO_2 reduction and two alternative scenarios with even greater reductions. Under the Kyoto Protocol, Sweden has agreed to stabilise CO_2 emissions at a level four per cent higher than its emissions in 1990. However, there is a widespread view in Sweden that CO_2 emissions should be reduced, so the alternative scenarios included two more restrictive target levels: two and eight per cent lower than the emissions in 1990. The latter is the same as the commitment for EU as a whole.

11.174. For these simulations, a static general equilibrium model was used with 18 production sectors including the public sector, one household sector and six types of energy inputs (from the energy accounts).

The model had four mechanisms to reduce CO_2 emissions: enhancements to energy efficiency; reductions in the use of coal fuels; reduced production in coal-intensive industries (and expansion of industries which are less coal intensive); and reduced production (and consumption) overall.

11.175. The baseline scenario outlines a "business-as-usual" probable growth path for the economy up to 2010 with no restrictions on CO_2 emissions. In this case, the emissions would rise to approximately 65 million tonnes, which is about 17 per cent higher than the level in 1990 (56 million tonnes). To keep emissions within four per cent of emissions in 1990 thus would require a large increase of the CO_2 emission tax. In 1997 the tax rate (with exceptions for energy-intensive export sectors[1]) was 370 Swedish kroner per tonne of CO_2. In the scenario representing the Kyoto Protocol, the tax would have to be increased to 820 Swedish kroner per tonne of CO_2. The changes in the economy would reduce GDP by 0.3 per cent under the +4 per cent scenario and by 0.4 per cent and 0.6 per cent under the -2 per cent and -8 per cent scenarios respectively. Table 11.15 shows that investment, trade and real income are significantly affected under all scenarios; consumption much less so.

Table 11.15 Macroeconomic effects of measures to reduce carbon emissions in Sweden

	Percent change compared to baseline scenario, 2010		
	+4% Scenario	-2% Scenario	-8% Scenario
GNP	-0.3	-0.4	-0.6
Private consumption	0.0	-0.1	-0.2
Public consumption	0.0	0.0	0.0
Investment	-0.4	-0.7	-1.1
Exports	-0.6	-1.0	-1.3
Imports	-0.5	-0.7	-0.9
Real income	-0.2	-0.4	-0.5

Source: Nilsson, 2002.

11.176. The Climate Committee recommended that the mean value of greenhouse gas emissions (in terms of carbon dioxide equivalents) for the period 2008 to 2012 should be 2 per cent lower than emissions in 1990. The committee also suggested a long-term objective of reducing greenhouse gas emissions to 50 per cent of 1990 levels by 2050.

11.177. Estimation of geNDP varies not only in terms of the environmental issues addressed and the assumptions made, but also in terms of the type of model used. Many of the geNDP exercises have used comparative static general equilibrium models. As static models, they do not describe the dynamic path an economy would follow to achieve the transition from the present economy to a sustainable one.

11.178. Meyer and Ewerhart (1998) have addressed the greenhouse gas issue for the German economy using a different approach based on a dynamic econometric input-output model. The model is more disaggregated by industry and uses the sale of carbon emission permits as a means to achieve the target levels of emission reduction by 2005 (from 5 per cent to 30 per cent lower than Germany's emissions in 1990). A 5 per cent reduction of CO_2 emissions resulted in virtually no change in GDP, relative to the baseline scenario, but a 30 per cent reduction would reduce GDP by 3 per cent, which is still rather small. The dynamic adjustment of the economy over time (1996 to 2005) is not smooth, suggesting that such a model provides important information to policy-makers.

[1] Manufacturing industries (pulp and paper, chemicals, refineries, iron and steel, engineering and other manufacturing industries) pay half the normal rate for the carbon dioxide tax, or 185 Swedish kroner/tonne CO_2.

11.179. No studies have yet produced geNDP indicators that are comparable across nations. This is so for several reasons. For one, there are many assumptions that practitioners must make in constructing the indicators. Practitioners may also choose to include or ignore a wide range of environmental factors. Finally, different methodologies have been used.

G Indicators for sustainable development

11.180. Quite separately from the development of the SEEA, the last few years have seen an upsurge of interest in a set of indicators to measure sustainable development. There have been some initiatives to develop a single indicator to capture the essence of "sustainability". The various environmentally adjusted macro-economic aggregates discussed in Chapter 9 and the last section could be seen as candidates for such single indicators. In addition there are composite physical indicators which also claim to provide a synthetic measure of sustainability; the case of total material requirements discussed in Chapter 3 and earlier in this chapter is one.

11.181. In general, though, attention has focussed on assembling a set of indicators which include economic and environmental issues and also social issues to round out the picture on what sustainable development really means. Lists of indicators have been put forward by a number of national governments and by international organisations. One such list is that of the UN Commission on Sustainable Development. Those indicators from the UNCSD list which can be found within the SEEA are shown listed in Table 11.16.

Table 11.16 SEEA and the United Nations Sustainable Development Indicators

Sustainable Development Indicator			Source of data in SEEA
Atmosphere			
	Climate Change	Emissions of Greenhouse Gases	SEEA flow accounts for emissions of greenhouse gases
	Ozone Layer Depletion	Consumption of Ozone Depleting Substances	SEEA flow accounts for use of ozone depleting substances
Land			
	Agriculture	Arable and Permanent Crop Land Area	Reported in land asset accounts
		Use of fertilizers	Could be reported in the physical flow accounts
		Use of Agricultural pesticides	Could be reported in the physical flow accounts
	Forests	Forest Area as per cent of Land Area	Reported in land and forest asset accounts
		Wood Harvesting Intensity	Reported as harvesting in the forest asset accounts
	Desertification	Land Affected by Desertification	Could be reported in land asset accounts
	Urbanization	Area of Urban Formal and Informal Settlements	Could be reported in land asset accounts

Oceans, seas and coasts			
	Fisheries	Annual Catch by Major Species	Reported in fisheries asset accounts
Fresh water			
	Water Quantity	Annual Withdrawal of Ground and Surface Water as per cent of Total Available Water	Calculated from SEEA water flow accounts.
	Water Quantity	BOD in Water Bodies	Could be calculated from SEEA water quality accounts
		Concentration of Faecal Coliform in Freshwater	Could be calculated from SEEA water quality accounts
Biodiversity			
	Ecosystem	Area of Selected Key Ecosystems	Reported in ecosystem asset accounts
		Protected Area as per cent of Total Area	Reported in land asset accounts and in ecosystem asset accounts
	Species	Abundance of Selected Key Species	Reported in wildlife asset accounts
Consumption and production patterns			
	Material Consumption	Intensity of Material Use	SEEA flow accounts report total material inputs; indicator can be derived by dividing GDP by total material inputs
	Energy Use	Annual Energy Consumption Per Capita	SEEA flow accounts report total energy use; indicator derived by dividing total energy use by population
		Share of Consumption of Renewable Energy Resources	Calculated from composition of energy flow accounts
		Intensity of Energy Use	SEEA flow accounts report total energy inputs; indicator can be derived by dividing GDP by total energy inputs
	Waste Generation and Management	Generation of Industrial and Municipal Solid Waste	SEEA flow accounts for solid waste.
		Generation of Hazardous Waste	SEEA flow accounts for specific types of waste
		Generation of Radioactive Waste	SEEA flow accounts for specific types of waste
		Waste Recycling and Reuse	SEEA flow accounts for waste, recycling and reuse

Annex 1 SEEA asset classification

Asset Category	Within SNA Boundary	Outside SNA Boundary
EA.1 Natural Resources		
EA.11 Mineral and energy resources	(AN.212) [1]	[2]
EA.111 Fossil fuels (cubic metres, tonnes, tonnes of oil equivalent, joules)	(AN.2121)	
EA.112 Metallic minerals (tonnes)	(AN.2122)	
EA.113 Non-metallic minerals (tonnes)	(AN.2123)	
EA.12 Soil resources (cubic metres, tonnes)	not applicable [3]	
EA.121 Agricultural		
EA.122 Non-agricultural		
EA.13 Water resources (cubic metres)		
EA.131 Surface water	not applicable [4]	[16]
EA.1311 Artificial reservoirs		
EA.1312 Lakes		
EA. 1313 Rivers and streams		
EA.132 Groundwater	(AN.214)	
EA.14 Biological resources		
EA.141 Timber resources (cubic metres)		
EA.1411 Cultivated	(Part of AN.1221)	Not applicable
EA.1412 Non-cultivated	(Part of AN.213) [5]	[6]
EA.142 Crop and plant resources, other than timber (cubic metres, tonnes, number)		
EA.1421 Cultivated		Not applicable
EA.14211 Yielding repeat products (vineyards, orchards, etc.)	(AN.11142)	
EA.14212 Yielding one-time harvests (crops, etc.)	(Part of AN.1221)	
EA.1422 Non-cultivated	(Part of AN.213) [7]	[8]
EA.143 Aquatic resources (tonnes, number)		
EA.1431 Cultivated		Not applicable
EA.1432 Non-cultivated	(Part of AN.213) [9]	[10], [17]

EA.144 Animal resources, other than aquatic (number)		
EA.1441 Cultivated		Not applicable
EA.14411 Livestock for breeding purposes	(Part of AN.11141)	
EA.14412 Livestock for slaughter	(Part of AN.1221)	
EA.1442 Non-cultivated	(Part of AN.213) [11]	[12]
EA.2 Land and surface water (hectares)	**(AN.211)**	**Not applicable [13]**
Of which, recreational land	(AN.2113)	
EA.21 Land underlying buildings and structures	***(AN.2111)***	
EA.211 In urban areas		
EA.2111 For dwellings		
EA.2112 For non-residential buildings		
EA.2113 For transportation and utilities		
EA.212 Outside urban areas		
EA.2121 For dwellings		
EA.21211 Farm		
EA.21212 Non-farm		
EA.2122 For non-residential buildings		
EA.21221 Farm		
EA.21222 Non-farm		
EA.2123 For transportation and utilities		
EA.21231 Roads		
EA.21232 Railways		
EA.21233 Electric power grids		
EA.21234 Pipelines		
EA.22 Agricultural land and associated surface water	***(AN.2112)***	
EA.221 Cultivated land		
EA.2211 For temporary crops		
Of which, drained		
Of which, irrigated		
EA.2212 For permanent plantations		
Of which, drained		
Of which, irrigated		
EA.2213 For kitchen gardens		
EA.2214 Temporarily fallow land		
EA.222 Pasture land		

EA.2221 Improved		
EA.2222 Natural		
EA.223 Other agricultural land		
EA.23 Wooded land and associated surface water	***(Part of AN.2112, AN.2113 and AN.2119)***	
EA.231 Forested land		
EA.2311 Available for wood supply		
EA.2312 Not available for wood supply		
EA.232 Other wooded land		
EA.24 Major water bodies	***(Part of AN.2119)***	
EA.241 Lakes		
EA.242 Rivers		
EA.243 Wetlands		
EA.244 Artificial reservoirs		
EA.25 Other land	***(Part of AN.2119)***	
EA.251 Prairie and grassland		
EA.252 Tundra		
EA.253 Sparsely vegetated/Barren land		
EA.254 Permanent snow and ice		
EA.3 Ecosystems [14, 15]	**not applicable**	
EA.31 Terrestrial ecosystems		
EA.311 Urban ecosystems		
EA.312 Agricultural ecosystems		
EA.313 Forest ecosystems		
EA.314 Prairie and grassland ecosystems		
EA.315 Tundra ecosystems		
EA.316 Dryland ecosystems		
EA.317 Other terrestrial ecosystems		
EA.32 Aquatic ecosystems		
EA.321 Marine ecosystems		
EA.322 Coastal ecosystems		
EA.323 Riverine ecosystems		
EA.324 Lacustrine ecosystems		
EA.325 Other aquatic ecosystems		

EA.33 Atmospheric systems		
EA.M Memorandum item – Intangible environmental assets		
EA.M1 Mineral exploration	(AN.1121)	not applicable
EA.M2 Transferable licences and concessions for the exploitation of natural resources	(Part of AN.222)	
EA.M3 Tradable permits allowing the emission of residuals	(Part of AN.222)	
EA.M4 Other intangible non-produced environmental assets	(Part of AN.222)	

Light shading indicates that monetary valuation is normally possible; dark shading that while physical valuation is possible, it may be doubtful that monetary valuation is possible.

Notes:

1. The mineral and energy resource assets that fall within the SNA boundary are those that are defined as proven reserves. In practice, though, some countries may include a wider class of resources even within the SNA accounts.

2. The mineral and energy resource assets that fall outside the SNA boundary are those that are defined as probable, possible and speculative reserves.

3. The value of soil resources cannot be separated from the value of the land of which they form an integral part. Therefore, only the physical extent of soil resources is measured in the SEEA.

4. The value of surface water as a natural resource cannot be separated from its value as an integral component of the national territory. Therefore, only the physical extent of surface water resources (measured in volumetric terms) is included in the natural resource category of the asset classification.

5. The non-cultivated timber resources that fall within the SNA boundary are those that are capable of producing a merchantable stand within a reasonable period of time, are accessible for logging purposes and are not protected from logging.

6. The non-cultivated timber resources that fall outside the SNA boundary are those that are not suitable for timber harvesting, either because of low productivity, inaccessibility and/or protection from logging.

7. The non-cultivated crop and plant resources that fall within the SNA boundary are those that provide harvestable materials that may be traded in the market or used for subsistence purposes, that are accessible and that are not protected from harvesting.

8. The non-cultivated crop and plant resources that fall outside the SNA boundary are those that potentially provide harvestable materials, but that are not suitable for harvesting because of inaccessibility or protection from harvesting.

9. The non-cultivated aquatic resources that fall within the SNA boundary are those that are the target of commercial or subsistence fishers, are found within the exclusive economic zone of the nation, are close enough to existing markets to be profitably exploitable and are not protected from harvesting.

10. The non-cultivated aquatic resources that fall outside the SNA boundary are those that are potentially harvestable, but that are not currently the target of fishers because they are not of commercial or subsistence interest, are located in remote fishing zones or are protected from harvesting.

11. The non-cultivated animal resources that fall within the SNA boundary are those that are the target of commercial, subsistence or sport hunters, are accessible for hunting and are not protected from harvest.

12. The non-cultivated animal resources that fall outside the SNA boundary are those that are potentially harvestable, but that are not currently the target of hunters because they are not of commercial, subsistence or sport interest, are located in remote areas or are protected from harvesting.

13. In principle, the entire national territory is included within the SNA asset boundary. For small densely populated countries, this should almost certainly be so. For large, sparsely populated countries, especially those with large areas which are remote and climatically hostile to mankind, there may be areas of land which are not thought to have any economic value. These would be included in this SEEA heading together with any recreational land not covered elsewhere.

14. In principle, ecosystems can be measured in both monetary and physical terms. In practice, valuing these systems may be extremely difficult and physical measures may be all that is possible.

15. Depending on the aspect of the ecosystem being measured, many different units of measure may be appropriate for describing environmental systems in physical terms. For example, biodiversity might be measure in terms of number of species or in terms of the area of suitable habitat. Waste assimilation capacity might be described in terms of the concentration of some key pollutant in the system. Other aspects will call for other units of measure.

16. With the increasing establishment of property rights over water, valuation may in some cases be possible.

17. Fish which are located outside a country's EEZ but over which internationally agreed quotas exist, may also be included.

Annex 2 Classification of flows of natural resources and ecosystem inputs

Introduction

Physical flow accounting looks at natural resource and ecosystem inputs as a sub-set of the assets occurring in the SEEA asset classification shown in Annex I. Only those natural resources and ecosystem inputs which are physically drawn into the economy are included. For coal, for example, the asset consists of all the known coal deposits, but only the coal extracted is relevant for physical flow accounting. Some of the SEEA assets, such as land and surface water, are used *in situ* and are not absorbed by the economy.

Cultivated biological resources such as timber or livestock for breeding are considered to be both natural resources and products. This double role can lead to material imbalances in physical flow accounts if care is not taken. Thus, in principle, physical flows from cultivated biological assets which fall under the products classification (as in Annex III) are regarded not as natural resources or ecosystem inputs but as product flows. The growth of some cultivated assets such as timber or agricultural plants is largely the result of ecosystem inputs from the environment. These ecosystem inputs (in a gross concept) or the resulting biomass growth (in a net concept) have to be recorded as inputs from the environment. The net concept is often more convenient as it only requires estimation of the natural growth and deduction of the re-absorption of products used to enhance natural growth (for example, nitrogen from fertiliser absorbed by plants).

In practice, it can sometimes be appropriate to treat certain cultivated products as natural resource inputs; for example, when input flows such as biomass harvest cannot be separated into those originating from cultivated and those originating from non-cultivated biological assets or when it would be difficult to estimate or impractical to record the ecosystem inputs for the growth of cultivated assets. For economy-wide material flow accounting, by convention the harvest of timber and crops from agriculture are regarded as flows from nature to the economy. A classification of minerals and biomass regarded as flows from the environment to the economy has been produced by Eurostat (2001a).

For practical flow accounting, the SEEA asset classification can be used as starting point for the accounting for flows of natural resource and ecosystem inputs. The table below illustrates the parts of the asset classification that are relevant as a starting point in relation to physical flow accounting.

SEEA Asset classification	Flows of natural resources
EA.1 Natural resources	
EA.11 Mineral and energy resources	The parts which are extracted. For energy accounting it can be relevant to account for the calorific value (PJ) of *hydro, wind, solar and nuclear energy* and regard them as natural resources. These types of energy resources are not included in the asset classification. For energy accounts a cross-classification which includes biological resources included under EA.14 might be used. Furthermore, an explicit distinction between renewable and non-renewable resources might be included in a classification of energy resources.
EA.12 Soil Resources	The parts which are excavated.
EA.13 Water resources	The parts which are extracted. If it is subsequently sold, it becomes a product. Also flows of water for own account use can be regarded as products after extraction. Sea water is not included in the asset account but for physical flow accounting it might be appropriate to include seawater extracted (for example, for cooling purposes).
EA.14 Biological resources	
EA.141 Timber resources	
EA.1411 Cultivated	Both the natural growth and the harvest are flows of *products*. Instead, the part of biomass growth caused by ecosystem inputs (i.e., non-product inputs) is recorded. For some accounts, it is more practical to regard all the harvest of timber as a natural resource input.
EA.1412 Non-cultivated	The parts which are harvested.
EA.142 Crop and plant resources, other than timber	
EA.1421 Cultivated	Both the natural growth and the harvest are flows of *products*. Instead, the part of biomass growth caused by ecosystem inputs (i.e., non-product inputs) is recorded. For some accounts, it is more practical to regard all the harvest of crop and plant resources as a natural resource input.

EA. 1422 Non-cultivated	The parts which are harvested.
EA.143 Aquatic resources	
EA.1431 Cultivated	Both the natural growth and the extraction are flows of *products*. Instead, the part of biomass growth caused by ecosystem inputs (i.e., non-product inputs) is recorded. For some accounts, it is more practical to regard all the aquatic resources extracted as a natural resource input.
EA.1432 Non-cultivated	The parts which are harvested by fisheries.
EA.144 Animal resources	
EA.1441 Cultivated	Both the natural growth and the extraction are flows of *products*. Instead, the part of biomass growth caused by ecosystem inputs (i.e., non-product inputs) is recorded. For some accounts, it is more practical to estimate the inputs from the amount of plants taken in by grazing on land.
EA.1442 Non-cultivated	The parts which are harvested.
EA. 2 Land and surface water	Not relevant as no extractive use takes place.
EA.3 Ecosystems	
EA.31 Terrestrial ecosystems EA.32 Aquatic ecosystems EA.33 Atmospheric systems	Ecosystems can be regarded as the provider of chemical substances for production of cultivated biological assets and other purposes. Thus, the input from nature for the production of cultivated biological assets (nitrogen, oxygen, carbon dioxide, etc.) and other purposes (for example, nitrogen taken from air for the production of fertilisers, oxygen for combustion, seawater for desalination, etc.) can be included here. Care must be taken not to include inputs that are a result of production (such as, fertiliser, feeding stuff, etc.) These ecosystem inputs will often have to be estimated based on the harvest of products (see under cultivated biological assets above). Oxygen needed for combustion and other processes may be recorded as an ecosystem input to ensure that the physical accounts balance. This ecosystem input can be estimated based on the quantity of oxygen in products or in residuals (for example, the quantity of oxygen included in carbon dioxide emissions).

Source: Eurostat 2001a.

Annex 3 Classification of physical product flows (based on Central Product Classification (CPC))

0 Agriculture, forestry and fishery products

01 Products of agriculture, horticulture and market gardening

Cereals; Vegetables; Fruit and nuts; Oil seeds and oleaginous fruit; Living plants; cut flowers and flower buds; flower seeds and fruit seeds; vegetable seeds; Beverages and spice crops; Unmanufactured tobacco; Plants used for sugar manufacturing; Raw vegetable materials n.e.c.

02 Live animals and animal products

Bovine cattle, sheep and goats, horses, asses, mules and hinnies, live; Swine, poultry and other animals, live

03 Forestry and logging products

Wood in the rough; Natural gums; other forestry products

04 Fish and other fishing products

Fishes, live, fresh or chilled; Crustaceans, not frozen; oysters; other aquatic invertebrates, live, fresh or chilled; other aquatic animals

1 Ores and minerals; electricity, gas and water

11 Coal and lignite; peat

Coal, not agglomerated; Briquettes and similar solid fuels manufactured from coal; Lignite, whether or not agglomerated; Peat

12 Crude petroleum and natural gas

Petroleum oils and oils obtained from bituminous minerals, crude; Natural gas, liquefied or in the gaseous state; Bituminous or oil shale and tar sands

13 Uranium and thorium ores

Uranium and thorium ores and concentrates

14 Metal ores

Iron ores and concentrates, other than roasted iron pyrites; Non-ferrous metal ores and concentrates (other than uranium or thorium ores and concentrates)

15 Stone, sand and clay

Monumental or building stone; Gypsum; anhydrite; limestone flux; limestone and other calcareous stone, of a kind used for the manufacture of lime or cement; Sands, pebbles, gravel, broken or crushed stone, natural bitumen and asphalt; Clays

16 Other minerals

Chemical and fertiliser minerals; Salt and pure sodium chloride; sea water; Precious and semi-precious stones; pumice stone; emery; natural abrasives; other minerals

17 Electricity, town gas, steam and hot water

Electrical energy; Coal gas, water gas, producer gas and similar gases, other than petroleum gases and other gaseous hydrocarbons; Steam and hot water;

18 Water

Natural water

2 Food products, beverages and tobacco; textiles, apparel and leather products

21 Meat, fish, fruit, vegetables, oils and fats

Meat and meat products; Prepared and preserved fish; Prepared and preserved vegetables; Fruit juices and vegetable juices; Prepared and preserved fruit and nuts; Animal and vegetable oils and fats; Cotton linters; Oil-cake and other residues resulting from the extraction of vegetable fats or oils; flours and meals of oil seeds or oleaginous fruits, except those of mustard; vegetable waxes, except triglycerides; degras; residues resulting from the treatment of fatty...

22 Dairy products

Processed liquid milk and cream; other dairy products

23 Grain mill products, starches and starch products; other food product

Grain mill products; Starches and starch products; sugars and sugar syrups n.e.c.; Preparations used in animal feeding; Bakery products; Sugar; Cocoa, chocolate and sugar confectionery; Macaroni, noodles, couscous and similar farinaceous products; Food products n.e.c.

24 Beverages

Ethyl alcohol; spirits, liqueurs and other spirituous beverages; Wines; Malt liquors and malt; Soft drinks; bottled mineral waters;

25 Tobacco products

Cigars, cheroots, cigarillos and cigarettes of tobacco or tobacco substitutes; other manufactured tobacco and manufactured tobacco substitutes; "homogenised" or "reconstituted" tobacco; tobacco extracts and essences

26 Yarn and thread; woven and tufted textile fabrics

Natural textile fibres prepared for spinning; Man-made textile staple fibres processed for spinning; Textile yarn and thread of natural fibres; Textile yarn and thread of man-made filaments or staple fibres; Woven fabrics (except special fabrics) of natural fibres other than cotton; Woven fabrics (except special fabrics) of cotton; Woven fabrics (except special fabrics) of man-made filaments and staple fibres; Special fabrics;

27 Textile articles other than apparel

Made-up textile articles; Carpets and other textile floor coverings; Twine, cordage, ropes and cables and articles thereof (including netting); Textiles n.e.c.

28 Knitted or crocheted fabrics; wearing apparel

Knitted or crocheted fabrics; Wearing apparel, except fur apparel; Tanned or dressed furskins and artificial fur; articles thereof (except headgear)

29 Leather and leather products; footwear

Tanned or dressed leather; composition leather; Luggage, handbags and the like; saddlery and harness; other articles of leather; Footwear, with outer soles and uppers of rubber or plastics, or with uppers of leather or textile materials, other than sports footwear, footwear incorporating a protective metal toe- cap and miscellaneous special footwear; Sports footwear, except skating boots; Other footwear, except asbestos footwear, orthopaedic footwear and skating boots; Parts of footwear; removable in-soles, heel cushions and similar articles; gaiters, leggings and similar articles, and parts thereof

3 Other transportable goods, except metal products, machinery and equipment

31 Products of wood, cork, straw and plaiting materials

Wood, sawn or chipped lengthwise, sliced or peeled, of a thickness exceeding 6 mm; railway or tramway sleepers (cross-ties) of wood, not impregnated; Wood continuously shaped along any of its edges or faces; wood wool; wood flour; wood in chips or particles; Wood in the rough, treated with paint, stains, creosote or other preservatives; railway or tramway sleepers (cross-ties) of wood, impregnated; Boards and panels; Veneer sheets; sheets for plywood; densified wood; Builders' joinery and carpentry of wood (including cellular wood panels, assembled parquet panels, shingles and shakes); Packing cases, boxes, crates, drums and similar packings, of wood; cable-drums of wood; pallets, box pallets and other load boards, of wood; casks, barrels, vats, tubs and other coopers' products and parts thereof, of wood (including staves); Other products of wood; articles of cork, plaiting materials and straw

32 Pulp, paper and paper products; printed matter and related articles

Pulp, paper and paperboard; Books, brochures and leaflets (except advertising material) printed, printed maps; music, printed or in manuscript; Newspapers, journals and periodicals, appearing at least four times a week; Newspapers, journals and periodicals, appearing less than four times a week; Stamps, cheque forms, banknotes, stock certificates, postcards, greeting cards, advertising material, pictures and other printed matter; Registers, account books, note books, letter pads, diaries and similar articles, blotting-pads, blinders, file covers, forms and other articles of stationery, of paper or paperboard; Composed type, prepared printing plates or cylinders, impressed lithographic stones or other impressed media for use in printing

33 Coke oven products; refined petroleum products; nuclear fuel

Coke and semi-coke of coal, of lignite or of peat; retort carbon; Tar distilled from coal, from lignite or from peat, and other mineral tars; Petroleum oils and oils obtained from bituminous materials, other than crude; preparations n.e.c. containing by weight 70% or more of these oils, such oils being the basic constituents of the preparations; Petroleum gases and other gaseous hydrocarbons, except natural gas; Petroleum jelly; paraffin wax, micro- crystalline petroleum wax, slack wax, ozokerite, lignite wax, peat wax, other mineral waxes, and similar products; petroleum coke, petroleum bitumen and other residues of petroleum oils or of oils obtained from bitumen...; Radioactive elements and isotopes and compounds; alloys, dispersions, ceramic products and mixtures containing these elements, isotopes or compounds; radioactive residues; Fuel elements (cartridges), for or of nuclear reactors

34 Basic chemicals

Basic organic chemicals; Basic inorganic chemicals n.e.c.; Tanning or dyeing extracts; tannins and their derivatives; colouring matter n.e.c.; Activated natural mineral products; animal black; tall oil; terpenic oils produced by the treatment of coniferous woods; crude dipentene; crude para-cymene; pine oil; rosin and resin acids, and derivatives thereof; rosin spirit and rosin oils; rum gums; w...; Miscellaneous basic chemical products; Fertilizers and pesticides; Plastics in primary forms; Synthetic rubber and factice derived from oils, and mixtures thereof with natural rubber and similar natural gums, in primary forms or in plates, sheets or strip

35 Other chemical products; man-made fibres

Paints and varnishes and related products; artists' colours; ink; Pharmaceutical products; Soap, cleaning preparations, perfumes and toilet preparations; Chemical products n.e.c.; Man-made fibres

36 Rubber and plastics products

Rubber tyres and tubes; other rubber products; Semi-manufactures of plastics; Packaging products of plastics; other plastics products

37 Glass and glass products and other non-metallic products n.e.c.

Glass and glass products; Non-structural ceramic ware; Refractory products and structural non-refractory clay products; Cement, lime and plaster; Articles of concrete, cement and plaster; Monumental or building stone and articles thereof; other non-metallic mineral products n.e.c.

38 Furniture; other transportable goods n.e.c.

Furniture; Jewellery and related articles; Musical instruments; Sports goods; Games and toys; Roundabouts, swings, shooting galleries and other fairground amusements; Prefabricated buildings; other manufactured articles n.e.c.

39 Wastes or scraps

Wastes from food and tobacco industry; Non-metal wastes or scraps; Metal wastes or scraps

4 Metal products, machinery and equipment

41 Basic metals

Basic iron and steel; Rolled, drawn and folded products of iron and steel; Basic precious metals and metals clad with precious metals; Copper, nickel, aluminium, alumina, lead, zinc and tin, unwrought; Semi-finished products of copper, nickel, aluminium, lead, zinc and tin or their alloys; Other non-ferrous metals and articles thereof (including waste and scrap); cermets and articles thereof; ash and residue (except from the manufacture of iron or steel), containing metals or metallic compounds

42 Fabricated metal products, except machinery and equipment

Structural metal products and parts thereof; Tanks, reservoirs and containers of iron, steel or aluminium; Steam generators, (except central heating boilers) and parts thereof; other fabricated metal products

43 General purpose machinery

Engines and turbines and parts thereof; Pumps, compressors, hydraulic and pneumatic power engines, and valves, and parts thereof; Bearings, gears, gearing and driving elements, and parts thereof; Ovens and furnace burners and parts thereof; Lifting and handling equipment and parts thereof; other general purpose machinery and parts thereof

44 Special purpose machinery

Agricultural or forestry machinery and parts thereof; Machine-tools and parts and accessories thereof; Machinery for metallurgy and parts thereof; Machinery for mining, quarrying and construction, and parts thereof; Machinery for food, beverage and tobacco processing, and parts thereof; Machinery for textile, apparel and leather production, and parts thereof; Weapons and ammunition and parts thereof; Domestic appliances and parts thereof; Other special purpose machinery and parts thereof.

45 Office, accounting and computing machinery

Office and accounting machinery, and parts and accessories thereof; Computing machinery and parts and accessories thereof

46 Electrical machinery and apparatus

Electric motors, generators and transformers, and parts thereof; Electricity distribution and control apparatus, and parts thereof; Insulated wire and cable; optical fibre cables; Accumulators, primary cells and primary batteries, and parts thereof; Electric filament or discharge lamps; arc lamps; lighting equipment; parts thereof; Other electrical equipment and parts thereof

47 Radio, television and communication equipment and apparatus

Electronic valves and tubes; electronic components; parts thereof; Television and radio transmitters and apparatus for line telephony or telegraphy; parts and accessories thereof; Radio broadcast and television receivers; apparatus for sound and video recording and reproducing; microphones, loudspeakers, amplifiers, etc.; reception apparatus for radio-telephony or radio-telegraphy; Parts for the goods of classes 4721 to 4733 and 4822; Audio and video records and tapes; Cards with magnetic strips or chip

48 Medical appliances, precision and optical instruments, watches and clocks

Medical and surgical equipment and orthopaedic appliances; Instruments and appliances for measuring, checking, testing, navigating and other purposes, except optical instruments; industrial process control equipment; parts and accessories thereof; Optical instruments and photographic equipment, and parts and accessories thereof; Watches and clocks, and parts thereof

49 Transport equipment

Motor vehicles, trailers and semi-trailers; parts and accessories thereof; Bodies (coachwork) for motor vehicles; trailers and semi-trailers; parts and accessories thereof; Ships; Pleasure and sporting boats; Railway and tramway locomotives and rolling stock, and parts thereof; Aircraft and spacecraft, and parts thereof; other transport equipment and parts thereof

Annex 4 Classification of residuals

Introduction

This classification reflects the need for accounting flexibly for different kinds of residuals as outlined in chapters 3, 4, 6 and 7. The first three one-digit items are mainly tailored towards emission or substance accounts. The fourth and fifth one-digit items complete the classification of residuals and ensure consistency with the classification of natural resources and ecosystem inputs. These latter two items are mainly for the purpose of mass balancing and are useful for economy-wide material flow accounts, water accounts or consistency checks. In many cases, accounts will be made either for selected substances or for some aggregate categories but usually not for the complete set of detailed items of the classification of residuals.

1. Solid waste
- 1.1 Chemical waste
- 1.2 Radioactive waste
- 1.3 Infectious biological waste (human health care etc.)
- 1.4 Metal waste
- 1.5 Non-metallic waste
  - 1.5.1 paper waste
  - 1.5.2 glass waste
  - 1.5.3 rubber waste
  - 1.5.4 plastic waste
  - 1.5.5 other
- 1.6 Discarded equipment
- 1.7 Slurry and manure
- 1.8 Animal and vegetable waste
- 1.9 Mixed ordinary wastes
- 1.10 Common sludges
- 1.11 Mineral wastes
- 1.12 Stabilised waste
- 1.13 Other waste

2. Emissions to air
- 2.1 Carbon dioxide (CO_2)
- 2.2 Emissions of acidifying substances
  - 2.2.1 Ammonia (NH_3)
  - 2.2.2 Nitrogen oxides (as NO_2)
  - 2.2.3 Sulphur oxides (as SO_2)
- 2.3 Metal compounds
  - 2.3.1 Cadmium compounds (as Cd)
  - 2.3.2 Chromium compounds (as Cr)
  - 2.3.3 Other (as Cu, Hg, Ni, Zn etc.)
- 2.4 Organic compounds
  - 2.4.1 NMVOC

2.4.2 Methane (CH_4)
2.4.3 Aromatics (benzene, dioxins, phenols, methane etc.)
2.5 Other residuals
2.5.1 Asbestos
2.5.2 Carbon oxides (CO)
2.5.3 Chlorides
2.5.4 Nitrous oxides (N_2O)
2.5.5 Particles
2.5.6 Other

3. Emissions to water
3.1 Eutrophicating substances
3.1.1 Nitrogen compounds (as N)
3.1.2 Phosphor compounds (as P)
3.2 Metal compounds
3.2.1 Cadmium compounds (as Cd)
3.2.2 Chromium compounds (as Cr)
3.2.3 Other (as Cu, Hg, Ni, Zn etc.)
3.3 Organic compounds
3.3.1 NMVOC
3.3.2 VOC
3.3.3 Aromatics (benzene, dioxins, phenols, methane etc.)
3.4 Other residuals
3.4.1 Chlorides
3.4.2 Cyanides
3.4.3 Fluorides
3.4.4 Other compounds

4. Dissipative use of products and dissipative losses
4.1 Dissipative use of products
4.1.1 Dissipative use on agricultural land (fertiliser, etc.)
4.1.2 Dissipative use on roads (thawing and grit materials)
4.1.3 Dissipative use of other kind
4.2 Dissipative losses
4.2.1 Abrasion (tyres, etc.)
4.2.2 Accidents with chemicals
4.2.3 Erosion and corrosion of infrastructures (roads, etc.)

5. Returned water and memorandum items for mass balancing
5.1 Returned water
5.2 Water vapour from combustion (H_2O)
5.2.1 From water (H_2O) contents of fuels
5.2.2 From hydrogen (H) contents of fuels
5.3 Water evaporation from products
5.4 Respiration of humans and livestock (CO_2 and water vapour)

Annex 5 The Classification of Environmental Protection Activities and Expenditure (CEPA 2000)

with explanatory notes

A Introductory notes

CEPA 2000 is a generic, multi-purpose, functional classification for environmental protection. It is used for classifying activities but also products, actual outlays (expenditure) and other transactions. The classification unit is often determined by the units of the primary data sources that are being classified and by the presentation formats used for results. For example, the analysis of government budgets and accounts requires the coding of items of government environmental protection expenditure into CEPA. Some of these expenditure items will be transfers such as subsidies or investment grants whereas others will be inputs into an environmental protection activity (for example, wages and salaries). The compilation of environmental expenditure accounts requires determining environmental protection activities and their output of environmental protection services by categories of CEPA.

Environmental protection activities are production activities in the sense of national accounts (see, for example, 1993 SNA paragraph 6.15 or ESA para 2.103); that is, they combine resources such as equipment, labour, manufacturing techniques, information networks or products to create an output of goods or services. An activity may be a principal, secondary or ancillary activity.

CEPA is designed to classify transactions and activities whose primary purpose is environmental protection. The management of natural resources (for example, water supply) and the prevention of natural hazards (landslides, floods, etc.) are not included in CEPA. Resource management and prevention of natural hazards are covered in broader frameworks (for example, SERIEE (Eurostat, 1994) or the OECD/Eurostat (1999) environment industry manual). Separate classifications (for resource management for example) should be set up which, together with the CEPA, would be part of a family of environment-related classifications.

Environmental protection products are:

the environmental protection services produced by environmental protection activities; and

adapted (cleaner) and connected products.

The expenditures recorded are the purchasers' prices of environmental protection services and connected products and the extra costs over and above a viable but less-clean alternative for cleaner products.

Expenditure for environmental protection includes outlays and other transactions related to:

inputs for environmental protection activities (energy, raw materials and other intermediate inputs, wages and salaries, taxes linked to production, consumption of fixed capital);

capital formation and the purchase of land (investment) for environmental protection activities;

outlays of users for the purchase of environmental protection products;

transfers for environmental protection (subsidies, investment grants, international aid, donations, taxes earmarked for environmental protection, etc.).

For the presentation of aggregate results and indicators of expenditure, care is needed when adding up expenditure of different types. Available frameworks such as the SERIEE or the OECD/Eurostat PAC framework offer ways to avoid double counting of items of expenditure. In particular, they offer guidance on how to avoid mixing transfer payments with the expenditure that are financed by the transfers and purchases of environmental products with the expenditure for their production.

B Classification structure

The level 1 structure of CEPA (1-digit) shows the *CEPA classes*. CEPA classes 1 to 7 are also called *(environmental) domains*. The main function of most 2-digit and 3-digit headings in CEPA is to guide classification into the classes. Selected 2-digit and 3-digit headings may also be used for data collection and coding as well as for publication purposes. In statistical practice, countries will have to adapt the CEPA structure to some extent to reflect national policy priorities, data availability and other circumstances. Examples include separate 1-digit headings for traffic, international aid, energy-savings programmes, general administration of the environment or soil erosion. For international comparison purposes, the level 1 structure of CEPA should be fully adhered to.

1 General classification principles

Classification should be made according to the main purpose taking into account the technical nature as well as the policy purpose of an action or activity. Multi-purpose actions, activities and expenditure that address several CEPA classes should be divided by these classes. Classification under the heading "indivisible expenditure and activities" should only be made as a last resort.

Classification of individual items cannot be based solely on the technical nature of the items. For example, the purchase of double-glazed windows in warm countries will typically relate to issues of noise protection, whereas in colder countries they will be a standard energy saving device. Measures to reduce fertiliser use may primarily fall under CEPA 4 (protection of groundwater), CEPA 2 (prevention of runoff to protect surface waters) or CEPA 6 (prevention of nutrient enrichment to protect biotopes) depending on the main purpose of measures and policies. Measures against forest fires will be unimportant or purely serve economic purposes (and thus fall outside of CEPA) in some countries, whereas in others the main aspect of forest fires will be an environmental one related to landscape and habitat preservation rather than protection of a natural resource.

2 Classification of transversal and indivisible activities and expenditure

Transversal activities are R&D, administration and management as well as education, training and information. All R&D should be allocated to CEPA 8. Administration and management as well as education, training and information should, to the extent possible, be allocated to the "Other" positions in CEPA 1-7. Ideally, transversal activities would be identified separately, as well as by CEPA class but primary data sources related to CEPA 1-7 often do not allow this. R&D, education and training or administration and management are often either not separable from other actions relating to another class (administration or training as part of waste management, for example) or cannot be split by class (R&D data collected by industry expenditure surveys, for example). If such identification problems are considered substantial, data on R&D, administration and management and on education, training and information should not be published at the 2-digit level.

The classification of R&D in CEPA 8 follows the NABS 1993 (the Eurostat Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets). CEPA 8 should be used when primary data following the NABS are available from R&D statistics. When this is not the case, other data sources employed (for example, budget analysis) may not allow a systematic separation of R&D from other actions and activities. R&D may then be included under several CEPA classes.

The above considerations will apply differently across countries, depending on the availability and level of detail of primary data sources. Often, differences in the main data sources will result in different practices for coding transversal activities and expenditure, and international comparability for these may be limited.

C Classification of environmental protection activities and expenditure (CEPA 2000)

1. Protection of ambient air and climate

- 1.1 Prevention of pollution through in-process modifications
  - 1.1.1 for the protection of ambient air
  - 1.1.2 for the protection of climate and ozone layer
- 1.2 Treatment of exhaust gases and ventilation air
  - 1.2.1 for the protection of ambient air
  - 1.2.2 for the protection of climate and ozone layer
- 1.3 Measurement, control, laboratories and the like
- 1.4 Other activities

2. Wastewater management

- 2.1 Prevention of pollution through in-process modifications
- 2.2 Sewerage networks
- 2.3 Wastewater treatment
- 2.4 Treatment of cooling water
- 2.5 Measurement, control, laboratories and the like
- 2.6 Other activities

3. Waste management

- 3.1 Prevention of pollution through in-process modifications
- 3.2 Collection and transport
- 3.3 Treatment and disposal of hazardous waste
  - 3.3.1 Thermal treatment
  - 3.3.2 Landfill
  - 3.3.3 Other treatment and disposal
- 3.4 Treatment and disposal of non-hazardous waste
  - 3.4.1 Incineration
  - 3.4.2 Landfill
  - 3.4.3 Other treatment and disposal
- 3.5 Measurement, control, laboratories and the like
- 3.6 Other activities

4. Protection and remediation of soil, groundwater and surface water

- 4.1 Prevention of pollutant infiltration
- 4.2 Cleaning up of soil and water bodies
- 4.3 Protection of soil from erosion and other physical degradation
- 4.4 Prevention and remediation of soil salinity
- 4.5 Measurement, control, laboratories and the like
- 4.6 Other activities

5. Noise and vibration abatement (excluding workplace protection)

- 5.1 Preventive in-process modifications at the source
  - 5.1.1 Road and rail traffic
  - 5.1.2 Air traffic
  - 5.1.3 Industrial and other noise
- 5.2 Construction of anti noise/vibration facilities
  - 5.2.1 Road and rail traffic
  - 5.2.2 Air traffic
  - 5.2.3 Industrial and other noise
- 5.3 Measurement, control, laboratories and the like
- 5.4 Other activities

6. Protection of biodiversity and landscapes

- 6.1 Protection and rehabilitation of species and habitats
- 6.2 Protection of natural and semi-natural landscapes
- 6.3 Measurement, control, laboratories and the like
- 6.4 Other activities

7. Protection against radiation (excluding external safety)

- 7.1 Protection of ambient media
- 7.2 Transport and treatment of high level radioactive waste
- 7.3 Measurement, control, laboratories and the like
- 7.4 Other activities

8. Research and development

- 8.1 Protection of ambient air and climate
  - 8.1.1 Protection of ambient air
  - 8.1.2 Protection of atmosphere and climate
- 8.2 Protection of water
- 8.3 Waste
- 8.4 Protection of soil and groundwater
- 8.5 Abatement of noise and vibration
- 8.6 Protection of species and habitats
- 8.7 Protection against radiation
- 8.8 Other research on the environment

9. Other environmental protection activities

- 9.1 General environmental administration and management
  - 9.1.1 General administration, regulation and the like
  - 9.1.2 Environmental management
- 9.2 Education, training and information
- 9.3 Activities leading to indivisible expenditure
- 9.4 Activities not elsewhere classified

D Explanatory notes and definitions

1 Protection of ambient air and climate

Protection of ambient air and climate comprises measures and activities aimed at the reduction of emissions into the ambient air or ambient concentrations of air pollutants as well as to measures and activities aimed at the control of emissions of greenhouse gases and gases that adversely affect the stratospheric ozone layer.

Excluded are measures undertaken for cost saving reasons (e.g. energy saving).

1.1 Prevention of pollution through in-process modifications

Activities and measures aimed at the elimination or reduction of the generation of air pollutants through in-process modifications related to:

- cleaner and more efficient production processes and other technologies (cleaner technologies),
- the consumption or use of "cleaner" (adapted) products.

Cleaner technologies

Prevention activities consist of replacing an existing production process by a new process designed to reduce the generation of air pollutants during production, storage or transportation (e.g., fuel combustion improvement, recovery of solvents, prevention of spills and leaks through improving air-tightness of equipment, reservoirs and vehicles, etc.

Use of cleaner products

Prevention activities consist of modifying facilities so as to provide for the substitution of raw materials, energy, catalysts and other inputs by non- (or less) polluting products, or of treating raw materials prior to their use in order to make them less polluting (e.g., desulphuration of fuel. Expenditure under this position also includes the extra-cost of the use of cleaner products (low sulphur fuels, unleaded gasoline, clean vehicles, etc.).

1.2 Treatment of exhaust gases and ventilation air

Activities involving the installation, maintenance and operation of end-of-pipe equipment for the removal and reduction of emissions of particulate matter or other air-polluting substances either from the combustion of fuels or from processes: filters, dedusting equipment, catalytic converters, post-combustion and other techniques. Also included are activities aimed at increasing the dispersion of gases so as to reduce concentrations of air pollutants.

Exhaust gases are emissions into the air, usually through exhaust pipes, stacks or chimneys, due to the combustion of fossil fuels. Ventilation air is exhausts of air conditioning systems of industrial establishments.

1.3 Measurement, control, laboratories and the like

Activities aimed at monitoring the concentrations of pollutants in exhaust gases, the quality of air, etc. Included are measurement services of exhaust gases from vehicles and heating systems and the monitoring related to ozone layer, greenhouse gases and climate change. Weather stations are excluded.

1.4 Other activities

All other activities and measures aimed at the protection of ambient air and climate. Includes regulation, administration, management, training, information and education activities specific to CEPA 1, when they can be separated from other activities related to the same class and from similar activities related to other environmental protection classes.

2 Wastewater management

Wastewater management comprises activities and measures aimed at the prevention of pollution of surface water through the reduction of the release of wastewater into inland surface water and seawater. It includes the collection and treatment of wastewater including monitoring and regulation activities. Septic tanks are also included.

Excluded are actions and activities aimed at the protection of groundwater from pollutant infiltration and the cleaning up of water bodies after pollution (see CEPA 4).

Wastewater is defined as water that is of no further immediate value for the purpose for which it was used or in the pursuit of which it was produced because of quality, quantity, or time of its occurrence.

2.1 Prevention of pollution through in-process modifications

Activities and measures aimed at reducing the generation of surface water pollutants and wastewater through in-process modifications related to:

- cleaner and more efficient production processes and other technologies (cleaner technologies),
- the consumption or use of "cleaner" (adapted) products.

Cleaner technologies

Prevention activities consist of replacing an existing production process by a new process designed to bring about a reduction of water pollutants or wastewater generated during production. It includes separation of networks, treatment and re-use of water used in the production process, etc.

Use of cleaner products

Prevention activities consist of modifying an existing production process so as to provide for the substitution of raw materials, catalysts and other inputs by non- (or less) water polluting products.

2.2 Sewerage networks

Activities aimed at the operation of sewerage networks; that is, the collection and transport of wastewater from one or several users, as well as rainwater, by means of sewerage networks, collectors, tanks and other means of transport (sewage vehicles, etc.), including maintenance and repair.

Sewerage networks are the systems of collectors, pipelines, conduits and pumps to evacuate any wastewater (rainwater, domestic and other wastewater) from the points of generation to either a sewage treatment plant or to a point where wastewater is discharged into surface water.

2.3 Wastewater treatment

Wastewater treatment designates any process to render wastewater fit to meet applicable environmental standards or other quality norms. Three broad types of treatment (mechanical, biological, and advanced treatment) are specified below. Alternative definitions of types of treatment may be used; for example, based on removal rates for BOD.

Mechanical treatment of wastewater designates processes of a physical and mechanical nature which result in decanted effluent and separate sludge. Mechanical processes are also used in combination and/or in conjunction with biological and advanced unit operations. Mechanical treatment is understood to include at least such processes as sedimentation, flotation, etc. The activity is aimed at separating materials in suspension by the use of screens (large solids) or through sedimentation eventually assisted by chemicals or flotation (elimination of sand, oil, part of the sludge, etc.).

Equipment includes screens for large solids, biological plants, equipment for filtration, flocculation, sedimentation; separation of oils and hydrocarbons; separation using inertia or gravity, including hydraulic and centrifugal cyclones, diaphragm floats, etc.

Biological treatment of wastewater designates processes which employ aerobic or anaerobic micro-organisms and result in decanted effluent and separate sludge containing microbial mass together with pollutants. Biological treatment processes are also used in combination and/or in conjunction with mechanical and advanced unit operations. This activity is designed to eliminate pollution from oxidisable materials through the use of bacteria: activated sludge technique or anaerobic treatment for specific concentrated wastewater. Biodegradable materials are treated with the addition of bacteria-enriched sludge in open or closed tanks.

Treatment of wastewater by advanced technologies designates processes capable of reducing specific constituents in wastewater not normally achieved by other treatment options. Covers all unit operations which are not considered to be mechanical or biological. Includes, for example, chemical coagulation, flocculation and precipitation; break-point chlorinating; stripping; mixed media filtration; micro-screening; selective ion exchange; activated carbon absorption; reverse osmosis; ultra-filtration; elector flotation. Advanced treatment processes may be used in combination and/or in conjunction with mechanical and biological unit operations. This activity is aimed at eliminating oxidisable non-biodegradable matter at a higher level, as well as metals, nitrate, phosphorous, etc. by using powerful biological or physical and chemical action. Special equipment is required for each depollution.

Septic tanks are settling tanks through which wastewater is flowing and the suspended matter is decanted as sludge. Organic matters (in the water and in the sludge) are partly decomposed by anaerobic bacteria and other micro-organisms. Maintenance services of septic tanks (emptying etc.) And other products for septic tanks (biological activators, etc.) are included.

2.4 Treatment of cooling water

Treatment of cooling water designates "processes which are used to treat cooling water to meet applicable environmental standards before releasing it into the environment. Cooling water is used to remove heat." Means, methods, facilities used may be: air cooling (extra cost compared with water cooling), cooling towers (to the extent they are required to reduce pollution, as distinct from technical needs), cooling circuits for processing water from work sites and for condensing released vapour, equipment for enhancing the dispersion of cooling water on release, closed cooling circuits (extra cost), circuits for use of cooling water for heating purposes (extra cost).

2.5 Measurement, control, laboratories and the like

Activities aimed at monitoring and controlling the concentration of pollutants in wastewater and the quality of inland surface water and marine water at the place wastewater is discharged (analysis and measurement of pollutants, etc.).

2.6 Other activities

All other activities and measures aimed at wastewater management. Includes regulation, administration, management, training, information and education activities specific to CEPA 2, when they can be separated from other activities related to the same class and similar activities related to other environmental protection classes

3 Waste management

Waste management refers to activities and measures aimed at the prevention of the generation of waste and the reduction of its harmful effect on the environment. Includes the collection and treatment of waste, including monitoring and regulation activities. It also includes recycling and composting, the collection and treatment of low level radioactive waste, street cleaning and the collection of public litter.

Waste are materials that are not prime products (that is, products made for the market) for which the generator has no further use for own purposes of production, transformation, or consumption, and which he wants to dispose of. Wastes may be generated during the extraction of raw materials, during the processing of raw materials to intermediate and final products, during the consumption of final products, and during any other human activity. Residuals recycled or reused at the place of generation are excluded. Also excluded are waste materials that are directly discharged into ambient water or air.

Hazardous waste is waste that due to its toxic, infectious, radioactive, flammable or other character defined by the legislator poses a substantial actual or potential hazard to human health or living organisms. For the purposes of this definition, "hazardous waste" comprises for each country all those materials and products which are considered to be hazardous in accordance with that country's practices. Low level radioactive waste is included, whereas other radioactive waste is excluded (see CEPA 7).

Low level radioactive waste is waste that, because of its low radionuclide content, does not require shielding during normal handling and transportation.

Treatment and disposal of waste

Treatment of waste refers to any process designed to change the physical, chemical, or biological character or composition of any waste to neutralise it, render it non-hazardous, safer for transport, amenable for recovery or storage, or to reduce it in volume. A particular waste may undergo more than one treatment process.

Composting and recycling activities for the purpose of environmental protection are included. Often composting is a waste treatment method and the resulting compost provided free of charge or at a very low price. The manufacture of compost classified in division 24 of ISIC/NACE (Manufacture of fertilisers and nitrogen compounds) is excluded.

Division 37 of ISIC/NACE defines ***recycling*** as "the processing of waste, scraps whether or not used, into a form feasible to be transformed in new raw materials. Typical is that, in terms of commodities, both input and output consist of waste and scrap, the input being sorted or unsorted but always unfit for further direct use in an industrial process whereas the output is made fit for further processing and is to be considered then as an intermediate good. A process is required, either mechanical or chemical". The main purpose of activities classified in division 37 of ISIC/NACE is the manufacture of secondary raw materials but there may be important secondary waste management activities.

Compost and secondary raw materials (as well as products made of secondary raw materials) are not considered environmental protection products. Their use is excluded.

Disposal of waste is the final deposition of waste on or underground in controlled or uncontrolled fashion, in accordance with the sanitary, environmental or security requirements.

3.1 Prevention of pollution through in-process modifications

Activities and measures aimed at eliminating or reducing the generation of solid waste through in-process modifications related to:

Cleaner and more efficient production processes and other technologies (cleaner technologies),

The consumption or use of "cleaner" (adapted) products.

Cleaner technologies

Prevention activities consist of replacing an existing production process by a new process designed to reduce the toxicity or volume of waste produced during the production process, including by separation and re-processing.

Use of cleaner products

Protection activities consist of modifying or adapting the production process or facilities so as to provide for the substitution of raw materials, catalysts and other intermediate inputs by new, "adapted" inputs the use of which produces less waste or less hazardous waste.

3.2 Collection and transport

Collection and transport of waste is defined as the collection of waste, either by municipal services or similar institutions or by public or private corporations, and their transport to the place of treatment or disposal. It includes the separate collection and transport of waste fractions so as to facilitate recycling and the collection and transport of hazardous waste. Street cleaning is included for the part referring to public litter and collection of garbage from the streets. Excluded are winter services.

3.3 Treatment and disposal of hazardous waste

Treatment of hazardous waste comprises the processes of physical/chemical treatment, thermal treatment, biological treatment, conditioning of wastes, and any other relevant treatment method. Disposal of hazardous waste comprises landfill, containment, underground disposal, dumping at sea, and any other relevant disposal method.

Thermal treatment of hazardous waste refers to any process for the high-temperature oxidation of gaseous, liquid, or solid hazardous wastes, converting them into gases and incombustible solid residues. The flue gases are released into the atmosphere (with or without recovery of heat and with or without cleaning) and any slag or ash produced is deposited in the landfill. The main technologies used in the incineration of hazardous waste are the rotary kiln, liquid injection, incinerator grates, multiple chamber incinerators, and fluidised bed incinerators. Residues from hazardous waste incineration may themselves be regarded as hazardous waste. The resulting thermal energy may or may not be used for the production of steam, hot water, or electric energy.

Landfill is an activity concerning final disposal of hazardous waste in or on land in a controlled way, which meets specific geological and technical criteria.

Other treatment and disposal of hazardous waste may consist of chemical and physical treatment, containment and underground disposal.

Chemical treatment methods are used both to effect the complete breakdown of hazardous waste into non-toxic gases and, more usually, to modify the chemical properties of the waste; for example, to reduce water solubility or to neutralise acidity or alkalinity.

Physical treatment of hazardous waste: includes various methods of phase separation and solidification whereby the hazardous waste is fixed in an inert, impervious matrix. Phase separation encompasses the widely used techniques of lagooning, sludge drying in beds, and prolonged storage in tanks, air flotation and various filtration and centrifugation techniques, adsorption/desorption, vacuum, extractive and azeotropic distillation. Solidification or fixation processes, which convert the waste into an insoluble, rock-hard material, are generally used as pre-treatment prior to landfill disposal. These techniques employ blending the waste with various reactants or organic polymerisation reactions or the mixing of the waste with organic binders.

Containment is the retention of hazardous material in such a way that it is effectively prevented from dispersing into the environment, or is released only at an acceptable level. Containment may occur in specially built containment spaces.

Underground disposal includes temporary storage or final disposal of hazardous wastes underground that meet specific geological and technical criteria.

3.4 Treatment and disposal of non-hazardous waste

Treatment of non-hazardous waste comprises the processes of physical/chemical treatment, incineration of waste, biological treatment, and any other treatment method (composting, recycling, etc.).

Incineration is the thermal treatment of waste during which chemically fixed energy of combusted matters is transformed into thermal energy. Combustible compounds are transformed into combustion gases leaving the system as flue gases. Incombustible inorganic matters remain in the form of slag and fly ash.

Disposal of non-hazardous waste comprises landfill, dumping at sea, and any other disposal method.

3.5 Measurement, control, laboratories and the like

Activities and measures aimed at controlling and measuring the generation and storage of waste, their toxicity, etc.

3.6 Other activities

All other activities and measures aimed at waste management. It includes administration, management, training, information and education activities specific to the class, when they can be separated from other activities related to the same class and from similar activities related to other environmental protection classes.

4 Protection and Remediation of soil, groundwater and surface water

Protection and remediation of soil, groundwater and surface water refers to measures and activities aimed at the prevention of pollutant infiltration, cleaning up of soils and water bodies and the protection of soil from erosion and other physical degradation as well as from salinisation. Monitoring, control of soil and groundwater pollution is included.

Excluded are wastewater management activities (see CEPA 2), as well as activities aimed at the protection of biodiversity and landscape (see CEPA 6).

4.1 Prevention of pollutant infiltration

Activities and measures aimed at the reduction or elimination of polluting substances that may be applied to soil, percolate into groundwater or run-off to surface water. Included are activities related to sealing of soils of industrial plants, installation of catchment for pollutant run-offs and leaks, strengthening of storage facilities and transportation of pollutant products.

4.2 Cleaning up of soil and water bodies

Processes to reduce the quantity of polluting materials in soil and water bodies either *in situ* or in appropriate installations. It includes soil decontamination at former industrial sites, landfills and other black spots, dredging of pollutants from water bodies (rivers, lakes, estuaries, etc.), The decontamination and cleaning up of surface water following accidental pollution (e.g., through collection of pollutants or through application of chemicals, as well as the cleaning up of oil spills on land, inland surface waters and seas – including coastal areas. Excludes the liming of lakes and artificial oxygenation of water bodies (see CEPA 6). Excludes civil protection services.

Activities may consist of: measures for separating, containing and recovering deposits, extraction of buried casks and containers, decanting and re-storage, installation of off-gas and liquid effluent drainage networks, soil washing by means of degasification, pumping of pollutants, removal and treatment of polluted soil, biotechnological methods capable of intervening without affecting the site (use of enzymes, bacteria, etc.), Physical chemistry techniques such as pervaporation and extraction using supercritical fluids, injection of neutral gases or bases to stifle internal fermentation, etc.

4.3 Protection of soil from erosion and other physical degradation

Activities and measures aimed at the protection of soil from erosion and other physical degradation (compacting, encrusting, etc.). They may consist of programs intended to restore the protective vegetal cover of soils, construction of anti-erosion walls, etc. Measures may also consist in subsidising agricultural and grazing practices less harmful for soils and water bodies.

Excluded are activities carried out for economic reasons (e.g. agricultural production or protection of settlements against natural hazards such as landslides).

4.4 Prevention and remediation of soil salinity

Activities and measures aimed at the prevention and remediation of soil salinity. Concrete actions will depend on climatic, geological and other country-specific factors. Included are actions to increase groundwater tables; for example, through increased freshwater infiltration to avoid infiltration of seawater into groundwater bodies, lowering of groundwater tables (when groundwater contains high levels of salts) through long-term re-vegetation programmes, changes in irrigation practices, etc.

Excluded are measures that respond to economic purposes (agricultural production, reclamation of land from the sea, etc.).

4.5 Measurement, control, laboratories and the like

All activities and measures aimed at controlling and measuring the quality and pollution of soils, groundwater and surface water, measuring the extent of soil erosion and salinisation etc. Includes the operation of monitoring systems, inventories of "black spots", maps and databases of groundwater and surface water quality, of soil pollution, erosion and salinity, etc.

4.6 Other activities

All other activities and measures aimed at the protection and remediation of soil, groundwater and surface water. It includes administration, management, training, information and education activities specific to the class, when they can be separated from other activities related to the same class and from similar activities related to other environmental protection classes.

5 Noise and vibration abatement (excluding workplace protection)

Noise and vibration abatement refers to measures and activities aimed at the control, reduction and abatement of industrial and transport noise and vibration. Activities for the abatement of neighbourhood noise (soundproofing of dancing halls, etc.) as well as activities for the abatement of noise in places frequented by the public (swimming pools, etc.) are included.

Excluded is the abatement of noise and vibration for purposes of protection at the workplace.

5.1 Preventive in-process modifications at the source

Activities and measures aimed at the reduction of noise and vibration from industrial equipment, vehicle motors, aircraft and ships engines, exhaust systems and brakes, or noise level due to tyre/road or wheel/rail surface contact. Includes the adaptation of equipment, vehicles (buses, trucks, or train and power units in the case of rail transport, aircraft and ships) in order to make them less noisy: soundproofing of hoods, brakes, exhaust systems, etc. Includes also plant modifications, specially conceived foundations to absorb vibrations, extra cost for regrouping of buildings and/or of facilities in the interest of noise abatement, special facilities in building construction or reconstruction, equipment and machines conceived or constructed for low noise or vibrations, low noise level flares and burners, etc.

Other preventive activities consist of noise abatement through the modification of surfaces. As noise emissions from motors, engines, exhaust systems and brakes are lowered, those from other sources becomes more important and in particular noise that originates from the contact between tyres and road surfaces. Activities consist of substituting concrete by silent asphalt, multi-layered surfaces, etc.

5.2 Construction of anti noise/vibration facilities

Activities and measures aimed at the installation and management of anti-noise facilities. These may be screens, embankments or hedges. They may consist of covering sections of urban motor ways or railroads. As concerns industrial and vicinity noise they also consist of add-on facilities, covering and soundproofing of machines and piping, fuel regulation systems and sound absorption, noise screens, barriers, soundproofing of buildings, noise protective windows, etc. in order to limit noise perception.

5.3 Measurement, control, laboratories and the like

Activities and measures aimed at controlling the level of noise and vibration: installation and operation of stationary measurement and monitoring sites or mobile equipment in urban areas, observation networks, etc.

5.4 Other activities

All other activities and measures aimed at noise and vibration abatement. It includes administration, management, training, information and education activities specific to the class, when they can be separated from other activities related to the same class and from similar activities related to other classes. It also includes, when separable, traffic management with noise abatement purposes (for example, lowering of speed limits, improvement of traffic flows), introduction of time and geographical restrictions for noisy vehicles, traffic detours at a distance from residential areas, creation of pedestrian areas, creation of construction-free buffer zones, restructuring of modal split (improvement of public transportation, use of bicycles). This covers a potentially large set of administrative measures which raise serious identification problems given their incorporation in integrated programmes of traffic control and urban planning and the difficulty of separating that part of measures and expenditure that, in these programmes, concern noise and vibration abatement from expenditure related to air pollution control, improvement of the living environment or traffic security.

In addition to regulation, other measures may consist of: financial incentives for the production and use of low-noise vehicles, labelling or information programmes for consumers so as to encourage the use of low-noise vehicles and the adoption of quiet driving behaviour.

6 Protection of biodiversity and landscapes

Protection of biodiversity and landscape refers to measures and activities aimed at the protection and rehabilitation of fauna and flora species, ecosystems and habitats as well as the protection and rehabilitation of natural and semi-natural landscapes. The separation between "biodiversity" and "landscape" protection may not always be practical. For example, maintaining or establishing certain landscape types, biotopes, eco-zones and related issues (hedgerows, lines of trees to re-establish "natural corridors") have a clear link to biodiversity preservation.

Excluded is the protection and rehabilitation of historic monuments or predominantly built-up landscapes, the control of weed for agricultural purposes as well as the protection of forests against forests fire when this predominantly responds to economic reasons. The establishment and maintenance of green spaces along roads and recreational structures (e.g., golf courses, other sports facilities) are also excluded.

Actions and expenditure related to urban parks and gardens would not normally be included but may be related in some cases to biodiversity – in such cases the activities and expenditure should be included.

6.1 Protection and rehabilitation of species and habitats

Activities and measures aimed at the conservation, reintroduction or recovery of fauna and flora species, as well as the restoring, rehabilitation and reshaping of damaged habitats for the purpose of strengthening their natural functions. Includes conserving the genetic heritage, re-colonising destroyed ecosystems, placing bans on exploitation, trade, etc. of specific animal and plant species, for protection purposes. Also includes censuses, inventories, databases, creation of gene reserves or banks, improvement of linear infrastructures (e.g., underground passages or bridges for animals at highways or railways, etc.), Feeding of the young, management of special natural reserves (botany conservation areas, etc.). Activities may also include the control of fauna and flora to maintain natural balances, including re-introduction of predator species and control of exotic fauna and flora that pose a threat to native fauna, flora and habitats.

Main activities are the management and development of protected areas, whatever the denomination they receive; that is, areas protected from any economic exploitation or in which the latter is subject to restrictive regulations whose explicit goal is the conservation and protection of habitats. Also included are activities for the restoration of water bodies as aquatic habitats: artificial oxygenation and lime-neutralisation actions. When they have a clear protection of biodiversity purpose, measures and activities related to urban parks and gardens are to be included. Purchase of land for protection of species and habitats purpose is included.

6.2 Protection of natural and semi-natural landscapes

Activities and measures aimed at the protection of natural and semi-natural landscapes to maintain and increase their aesthetic value and their role in biodiversity preservation. Included is the preservation of legally protected natural objects, expenditures incurred for the rehabilitation of abandoned mining and quarrying sites, renaturalisation of river banks, burying of electric lines, maintenance of landscapes that are the result of traditional agricultural practices threatened by prevailing economic conditions, etc. For biodiversity and landscape protection related to agriculture, the identification of specific state aid programmes to farmers may be the only data source available. Protection of forests against forest fires for landscape protection purpose is included.

Excluded are measures taken in order to protect historic monuments, measures to increase aesthetic values for economic purposes (e.g., re-landscaping to increase the value of real estate) as well as protection of predominantly built-up landscapes.

6.3 Measurement, control, laboratories and the like

Measurement, monitoring, analysis activities which are not classified under the preceding items. In principle, inventories of fauna and flora are not covered since they are classified under protection of species.

6.4 Other activities

All other activities and measures aimed at the protection of biodiversity and landscape. It includes administration, training, information and education activities specific to the domain, when they can be separated from other activities related to the same domain and similar activities related to other classes.

7 Protection against radiation (excluding external safety)

Protection against radiation refers to activities and measures aimed at the reduction or elimination of the negative consequences of radiation emitted from any source. Included are the handling, transportation and treatment of high level radioactive waste; that is, waste that because of its high radionuclide content requires shielding during normal handling and transportation.

Excluded are activities and measures related to the prevention of technological hazards (e.g. external safety of nuclear power plants), as well as protection measures taken at workplaces. Also excluded are activities related to collection and treatment of low-level radioactive waste (see CEPA 3).

Definition of radioactive waste

Any material that contains or is contaminated with radionuclides at concentrations or radioactivity levels greater than the "exempt quantities" established by the competent authorities, and for which no use is foreseen. Radioactive wastes are produced at nuclear power plants and at associated nuclear fuel cycle facilities as well as through other uses of radioactive material; for example, the use of radionuclides in hospitals and research establishments. Other important wastes are those from mining and milling of uranium and from the reprocessing of spent fuel.

7.1 Protection of ambient media

Protection of ambient media groups together activities and measures undertaken in order to protect ambient media from radiation. It may consist of protecting measures such as screening, creation of buffer zones, etc.

7.2 Transport and treatment of high level radioactive waste

Any process designed for the transport, conditioning, containment or underground disposal of high level radioactive waste.

Collection and transport of high level radioactive waste consists of the collection of high level radioactive waste, generally by specialised firms and their transport to the place of treatment, conditioning storage and disposal.

Conditioning of high level radioactive waste consists of activities that transform high level radioactive waste into a proper and fit condition for transport and/or storage and/or disposal. Conditioning may occur as part of ISIC/NACE 23 (processing of nuclear fuels) activities.

Containment of high level radioactive waste designates the retention of radioactive waste in such a way that it is effectively prevented from dispersing into the environment, or is released only at an acceptable level. Containment may occur in specially built containment spaces.

Underground disposal of high level radioactive waste is the temporary storage or final disposal of high level radioactive waste in underground sites that meet specific geological and technical criteria.

7.3 Measurement, control, laboratories and the like

Activities aimed at measuring, controlling and monitoring ambient radioactivity and radioactivity due to high level radioactive waste by means of specific equipment, instruments and installations.

7.4 Other activities

All other activities and measures aimed at the protection of ambient media against radiation and transport and treatment of high level radioactive waste. It includes administration, training, information and education activities specific to the domain, when they can be separated from other activities related to the same class and similar activities related to other environmental protection classes.

8 Research and development

Research and development (R&D) comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge and the use of this knowledge to devise new applications (see OECD, 1994b) in the field of environmental protection.

The class regroups all R&D activities and expenditure oriented towards environmental protection: identification and analysis of sources of pollution, mechanisms of dispersion of pollutants in the environment as well as their effects on human beings, the species and the biosphere. This heading covers R&D for the prevention and elimination of all forms of pollution, as well as R&D oriented towards equipment and instruments of pollution measurement and analysis. When separable all R&D activities even when referring to a specific class have to be classified under this position.

Environmental R&D is further classified in accordance with the 1993 NABS.

Excluded are R&D activities related to the management of natural resources.

9 Other environmental protection activities

Other environmental protection activities refers to all environmental protection activities which take the form of general environmental administration and management activities or training or teaching activities specifically oriented towards environmental protection or which consist of public information, when they are not classified elsewhere in CEPA. It also includes activities leading to indivisible expenditure, as well as activities not elsewhere classified.

9.1 General environmental administration and management

General administration of the environment designates any identifiable activity that is directed at the general support of decisions taken in the context of environmental protection activities, whether by governmental or by non-governmental units.

General administration of the environment, regulation and the like

Any identifiable activity within general government and NPISH units that is directed towards the regulation, administration of the environment and the support of decisions taken in the context of environmental protection activities. When possible such activities should be allocated to other classes. If this is impossible, they should be included under this position of the classification.

Environmental management

Any identifiable activity of corporations that is directed at the general support of decisions taken in the context of environmental protection activities. It includes the preparation of declarations or requests for permission, internal environmental management, environmental certification processes (ISO 14000, EMAS), as well as the recourse to environmental consultancy services. Activities of units specialised in environmental consultancy, supervision and analysis are included. When possible such activities should be allocated to other CEPA classes.

9.2 Education, training and information

Activities that aim at providing general environmental education or training and disseminating environmental information. Included are high school programs, university degrees or special courses specifically aimed at training for environmental protection. Activities such as the production of environmental reports, environmental communication, etc. are also included.

9.3 Activities leading to indivisible expenditure

Environmental protection activities that lead to indivisible expenditure; that is, those which cannot be allocated to any other CEPA class. International financial aid may be a case in point as it may be difficult for the donor countries to attribute international aid to individual classes. If international aid is important in volume and/or of specific political interest, a separate 2-digit heading under CEPA 9 could be adequate for national purposes.

9.4 Activities not elsewhere classified

This position groups together all these environmental protection activities that cannot be classified under other positions of the classification.

Annex 6 SNA functional classifications

COICOP (Classification of individual consumption by purpose)

Relevant categories

Division 4 – housing, water, electricity, gas and other fuels

04.4 Water supply and miscellaneous services related to dwellings

04.4.1 Water supply

Includes: associated expenditure such as hire of meters, reading of meters, standing charges, etc.

Excludes: drinking water sold in bottles or containers (01.2.2); hot water or steam purchased from district heating plants (04.5.5).

04.4.2 Refuse collection

Refuse collection and disposal.

04.4.3 Sewerage collection

Sewerage collection and disposal.

04.4.4 Other

Division 13 - individual consumption expenditure by NPISH

13.6.3 Environmental protection

Corresponds to COPNI headings 08.1 and 08.2. See below

COPNI (Classification of non-profit institutions serving households)

Relevant categories

Division 08. Environmental protection

08.1.0 Environmental protection services

This class covers the following NPISHs:

organisations set up to prevent or remedy damage to the environment;

associations that seek to protect wild animals or preserve particular species of animals, birds, fish, insects etc.;

organisations that seek to preserve forests, wet-lands and areas of natural beauty.

Excludes: political parties mainly concerned with environment issues (07.1.0); associations that seek to prevent cruelty to domesticated animals (09.1.0).

08.2.0 R&D Environmental protection

This class covers the following NPISHs:

organisations that undertake applied research and experimental development on subjects related to environment protection and trust funds and charitable organisations set up to finance such activities.

COFOG (Classifications of functions of government)

Relevant categories

04. Economic affairs

04.2 Agriculture, forestry, fishing and hunting

04.2.1 Agriculture

Administration of agricultural affairs and services; conservation, reclamation or expansion of arable land; agrarian reform and land settlement; supervision and regulation of the agricultural industry;

construction or operation of flood control, irrigation and drainage systems, including grants, loans or subsidies for such works;

operation or support of programmes or schemes to stabilise or improve farm prices and farm incomes; operation or support of extension services or veterinary services to farmers, pest control services, crop inspection services and crop grading services;

production and dissemination of general information, technical documentation and statistics on agricultural affairs and services;

compensation, grants, loans or subsidies to farmers in connection with agricultural activities, including payments for restricting or encouraging output of a particular crop or for allowing land to remain uncultivated.

Excludes: multi-purpose development projects (04.7.4).

04.2.2 Forestry

Administration of forestry affairs and services; conservation, extension and rationalised exploitation of forest reserves; supervision and regulation of forest operations and issuance of tree-felling licences;

operation or support of reforestation work, pest and disease control, forest fire-fighting and fire prevention services and extension services to forest operators;

production and dissemination of general information, technical documentation and statistics on forestry affairs and services;

grants, loans or subsidies to support commercial forest activities.

Includes: forest crops in addition to timber.

04.2.3 Fishing and hunting

This class covers both commercial fishing and hunting and fishing and hunting for sport. The fishing and hunting affairs and services listed below refer to activities that take place outside natural parks and reserves.

Administration of fishing and hunting affairs and services; protection, propagation and rationalised exploitation of fish and wildlife stocks; supervision and regulation of fresh-water fishing, coastal fishing, ocean fishing, fish farming, wildlife hunting and issuance of fishing and hunting licences;

operation or support of fish hatcheries, extension services, stocking or culling activities, etc.;

production and dissemination of general information, technical documentation and statistics on fishing and hunting affairs and services;

grants, loans or subsidies to support commercial fishing and hunting activities, including the construction or operation of fish hatcheries.

Excludes: control of off-shore and ocean fishing (03.1.0); administration, operation or support of natural parks and reserves (05.4.0).

04.3 Fuel and energy

04.3.1 Coal and other solid mineral fuels

This class covers coal of all grades, lignite and peat irrespective of the method used in their extraction or beneficiation and the conversion of these fuels to other forms such as coke or gas.

Administration of solid mineral fuel affairs and services; conservation, discovery, development and rationalised exploitation of solid mineral fuel resources; supervision and regulation of the extraction, processing, distribution and use of solid mineral fuels;

production and dissemination of general information, technical documentation and statistics on solid mineral fuel affairs and services;

grants, loans or subsidies to support the solid mineral fuel industry and the coke, briquette or manufactured gas industries.

Excludes: solid mineral fuel transportation affairs (classified to the appropriate class of group 04.5).

04.3.2 Petroleum and natural gas

This class covers natural gas, liquefied petroleum gases and refinery gases, oil from wells or other sources such as shale or tar-sands and the distribution of town gas regardless of its composition.

Administration of petroleum and natural gas affairs and services; conservation, discovery, development and rationalised exploitation of petroleum and natural gas resources; supervision and regulation of the extraction, processing, distribution and use of petroleum and natural gas;

production and dissemination of general information, technical documentation and statistics on petroleum and natural gas affairs and services;

grants, loans or subsidies to support the petroleum extraction industry and the industry refining crude petroleum and related liquid and gaseous products.

Excludes: petroleum or gas transportation affairs (classified to the appropriate class of group 04.5).

04.3.3 Nuclear fuel

Administration of nuclear fuel affairs and services; conservation, discovery, development and rationalised exploitation of nuclear material resources; supervision and regulation of the extraction and processing of nuclear fuel materials and of the manufacture, distribution and use of nuclear fuel elements;

production and dissemination of general information, technical documentation and statistics on nuclear fuel affairs and services;

grants, loans or subsidies to support the nuclear materials mining industry and the industries processing such materials.

Excludes: nuclear fuel transportation affairs (classified to the appropriate class of group 04.5); disposal of radio-active wastes (05.1.0)

04.3.4 Other fuels

Administration of affairs and services involving fuels such as alcohol, wood and wood wastes, bagasse and other non-commercial fuels;

production and dissemination of general information, technical documentation and statistics on availability, production and utilisation of such fuels;

grants, loans or subsidies to promote the use of such fuels for the production of energy.

Excludes: forest management (04.2.2); wind and solar heat (04.3.5) or (04.3.6); geothermal resources (04.3.6).

04.3.5 Electricity

This class covers both traditional sources of electricity such as thermal or hydro supplies and newer sources such as wind or solar heat.

Administration of electricity affairs and services; conservation, development and rationalised exploitation of electricity supplies; supervision and regulation of the generation, transmission and distribution of electricity;

construction or operation of non-enterprise-type electricity supply systems;

production and dissemination of general information, technical documentation and statistics on electricity affairs and services;

grants, loans or subsidies to support the electricity supply industry, including such outlays for the construction of dams and other works designed chiefly to provide electricity.

Excludes: non-electric energy produced by wind or solar heat (04.3.6).

04.3.6 Non-electric energy (CS)

Administration of non-electric energy affairs and services which chiefly concern the production, distribution and utilisation of heat in the form of steam, hot water or hot air;

construction or operation of non-enterprise-type systems supplying non-electric energy;

production and dissemination of general information, technical documentation and statistics on availability, production and utilisation of non-electric energy;

grants, loans or subsidies to promote the use of non-electric energy.

Includes: geothermal resources; non-electric energy produced by wind or solar heat.

04.4 Mining, manufacturing and construction

04.4.1 Mining of mineral resources other than mineral fuels

This class covers metal-bearing minerals, sand, clay, stone, chemical and fertiliser minerals, salt, gem stones, asbestos, gypsum, etc.

Administration of mining and mineral resource affairs and services; conservation, discovery, development and rationalised exploitation of mineral resources; supervision and regulation of prospecting, mining, marketing and other aspects of mineral production;

production and dissemination of general information, technical documentation and statistics on mining and mineral resource affairs and services;

grants, loans or subsidies to support commercial mining activities.

Includes: issuance of licences and leases, regulation of production rates, inspection of mines for conformity to safety regulations, etc.

Excludes: coal and other solid fuels (04.3.1), petroleum and natural gas (04.3.2) and nuclear fuel materials (04.3.3).

04.4.2 Manufacturing

Administration of manufacturing affairs and services; development, expansion or improvement of manufacturing; supervision and regulation of the establishment and operation of manufacturing plants; liaison with manufacturers' associations and other organisations interested in manufacturing affairs and services;

production and dissemination of general information, technical documentation and statistics on manufacturing activities and manufactured products;

grants, loans or subsidies to support manufacturing enterprises.

Includes: inspection of manufacturing premises for conformity with safety regulations, protection of consumers against dangerous products, etc.;

Excludes: affairs and services concerning the coal processing industry (04.3.1), the petroleum refinery industry (04.3.2) or the nuclear fuel industry (04.3.3).

04.4.3 Construction

Administration of construction affairs and services; supervision of the construction industry; development and regulation of construction standards;

production and dissemination of general information, technical documentation and statistics on construction affairs and services.

Includes: issuance of certificates permitting occupancy, inspection of construction sites for conformity with safety regulations, etc.

Excludes: grants, loans and subsidies for the construction of housing, industrial buildings, streets, public utilities, cultural facilities, etc. (classified according to function); development and regulation of housing standards (06.1.0).

05. Environmental protection

The breakdown of environment protection is based upon the Classification of Environmental Protection Activities (CEPA) as shown in Annex 5

05.1 Waste management

Corresponds to CEPA heading 3

05.2 Waste water management

Corresponds to CEPA heading 2

05.3 Pollution abatement

Corresponds to CEPA headings 1, 4, 5 and 7

05.4 Protection of biodiversity and landscape

Corresponds to CEPA heading 6

05.5 R&D Environmental protection

Corresponds to CEPA heading 8

05.6 Other

Corresponds to CEPA heading 9

06. Housing and community amenities

06.3 Water supply

Administration of water supply affairs; assessment of future needs and determination of availability in terms of such assessment; supervision and regulation of all facets of potable water supply including water purity, price and quantity controls;

construction or operation of non-enterprise-type of water supply systems;

production and dissemination of general information, technical documentation and statistics on water supply affairs and services;

grants, loans or subsidies to support the operation, construction, maintenance or upgrading of water supply systems.

Excludes: irrigation systems (04.2.1); multipurpose projects (04.7.4); collection and treatment of waste water (05.2.0).

COPP (Classification of the outlays of producers according to purpose)

Relevant categories

03 Outlays on environmental protection

The breakdown of environment protection is based upon the Classification of Environmental Protection Activities (CEPA) as shown in Annex 5
Excludes: outlays for measures intended to improve the health, comfort or safety of employees (05); R&D (02)

03.1 Outlays on protection of ambient air and climate

Corresponds to CEPA heading 1

03.2 Outlays on waste water management

Corresponds to CEPA heading 2

03.3 Outlays on waste management

Corresponds to CEPA heading 3

03.4 Outlays on protection of soil and groundwater

Corresponds to CEPA heading 4

03.5 Outlays on noise and vibration abatement

Corresponds to CEPA heading 5

03.6 Outlays on protection of biodiversity and landscape

Corresponds to CEPA heading 6

03.7.0 Outlays on environmental protection n.e.c.

Corresponds to CEPA headings 7 and 9

Annex 7 Useful categories in activity classifications

1 Introduction

The purpose of this annex is to give an indication of which activity classifications are likely to be most often used in environmental accounting. This first list given corresponds to the standard international industrial classification (ISIC) since that is the international standard. However the corresponding headings for both NACE, the official classification of economic activities in the European Union, and NAICS, the classification used by the North America Free Trade Area are given also.

ISIC categories which identify environmental protection activities

ISIC Rev. 3 Code	Category
37	*Recycling*
41*	*Collection, purification and distribution of water*
51	*Wholesale trade and commission trade, except of motor vehicles and motorcycles*
5149 (part of)	Wholesale of other intermediate products, waste and scrap
73 (part of)	*Research and development*
74	*Other business activities*
7421 (part of)	Architectural and engineering activities and related technical consultancy
75	*Public administration and defence; compulsory social security*
7512 (part of)	Regulation of the activities of agencies that provide health care, education, cultural services and other social services, excluding social security
90	*Sewage and refuse disposal, sanitation and similar activities*

Notes:

This list is not exhaustive. Environmental protection activities may also be part of other ISIC Divisions and Classes. Please also note that not all output of these activities is environmental protection output.

* Part of Resource Management.

NACE Rev. 1.1 categories which identify environmental protection activities

The NACE Rev. 1.1 replaces the NACE Rev. 1 from statistical year 2003 onwards.

NACE Rev. 1.1	Category	ISIC
23	Manufacture of coke, refined petroleum products and nuclear fuel	
23.30 (part of)	Processing of nuclear fuel	2330
37	Recycling	
37.10	Recycling of metal waste and scrap	3710
37.20	Recycling of non-metal waste and scrap	3720
41	Collection, purification and distribution of water	
41.00	Collection, purification and distribution of water	4100
51	Wholesale trade and commission trade, except of motor vehicles and motorcycles	
51.57	Wholesale of waste and scrap	5149 (part of)
74	Other business activities	
74.20 (part of)	Architectural and engineering activities and related technical consultancy	7421
74.30 (part of)	Technical testing and analysis	7422
75	Public administration and defence; compulsory social security	
75.12 (part of)	Regulation of the activities of agencies that provide health care, education, cultural services and other social services, excluding social security	7512
90	Sewage and refuse disposal, sanitation and similar activities	
90.01	Collection and treatment of sewage	9000 (part of)
90.02	Collection and treatment of other waste	9000 (part of)
90.03	Sanitation, remediation and similar activities	9000 (part of)

Notes:

This table is not exhaustive. Environmental protection activities may also be found in other NACE Classes.

Not all output of the activities listed is environmental protection output.

Environmental activities in the North American Industry Classification System (NAICS)

The North American Industry Classification System (NAICS) provides common industry definitions for Canada, Mexico and the United States.

22 Utilities

- 22.13 Water, sewage and other systems
  - 22.13.1 Water supply and irrigation systems*
  - 22.13.2 Sewage treatment facilities
  - 22.13.3 Steam and air-conditioning supply*

23 Construction

- 23.49 Other heavy construction
  - 23.49.1 Water, sewer, and pipeline construction**

54 Professional, scientific, and technical services

- 54.16 Management, scientific, and technical consulting services
  - 54.16.2 Environmental consulting services

56 Administrative and support and waste management and remediation services

- 56.2 Waste management and remediation services
  - 56.21 Waste collection
  - 56.22 Waste treatment and disposal
  - 56.29 Remediation and other waste management services

71 Arts, entertainment, and recreation

- 71.2 Museums, historical sites, and similar institutions
  - 71.21.9 Nature parks and other similar institutions

81 Other services (except public administration)

- 81.33 Social advocacy organisations
  - 81.33.12 Environment, conservation and wildlife organisations

92 Public administration

- 92.4 Administration of environmental quality programs

Notes:

* Part of Resource Management.

** Some part of this activity relates to Resource Management.

Annex 8 Classification of the environment industry

A POLLUTION MANAGEMENT group

Production of equipment and specific materials for:

1. Air pollution control.
2. Wastewater management.
3. Solid waste management:
   - 10.1 Hazardous waste collection, treatment and disposal;
   - 10.2 Waste collection, treatment and disposal;
   - 10.3 Waste recovery and recycling (excludes manufacture of new materials or products from waste and scrap).
4. Remediation and clean-up of soil, surface water and groundwater.
5. Noise and vibration abatement.
6. Environmental monitoring, analysis and assessment.
7. Other.

Provision of services for:

8. Air pollution control.
9. Wastewater management.
10. Solid waste management:
    - 10.1 Hazardous waste collection, treatment and disposal;
    - 10.2 Waste collection, treatment and disposal;
    - 10.3 Waste recovery and recycling (excludes manufacture of new materials or products from waste and scrap).
11. Remediation and clean-up of soil, surface water and groundwater.
12. Noise and vibration abatement.
13. Environmental R&D.
14. Environmental contracting and engineering.
15. Analytical services, data collection, analysis and assessment.
16. Education, training, information.
17. Other.

Construction and installation for:

18. Air pollution control.
19. Wastewater management.
20. Solid waste management:
    - 20.1 Hazardous waste collection, treatment and disposal;

20.2 Waste collection, treatment and disposal;
20.3 Waste recovery and recycling (excludes manufacture of new materials or products from waste and scrap).

21. Remediation and clean-up of soil, surface water and groundwater.
22. Noise and vibration abatement.
23. Environmental monitoring, analysis and assessment.
24. Other.

B CLEANER TECHNOLOGIES AND PRODUCTS group

Production of equipment, technology, specific materials or services for:

1. Cleaner/resource-efficient technologies and processes.
2. Cleaner/resource-efficient products.

C RESOURCE MANAGEMENT group

Note: For this group, activities aimed at the production of environmental goods and services and related construction are grouped together for convenience. However, it is suggested that, wherever possible, information on these items be separately collected and presented.

Production of equipment, technology and specific materials, provision of services, and construction and installation for:

1. Indoor air pollution control.
2. Water supply.
3. Recycled materials (manufacture of new materials or products from waste or scrap, separately identified as recycled).
4. Renewable energy plant.
5. Heat/energy saving and management.
6. Sustainable agriculture and fisheries.
7. Sustainable forestry.
8. Natural risk management.
9. Eco-tourism.
10. Other (e.g. nature conservation, habitats and biodiversity).

Annex 9 Relationship between the SEEA and the 1993 SNA

Introduction

The SEEA is envisaged as a satellite account of the 1993 SNA which means that while some flexibility in the SNA may be introduced, it is important that it is clear when such flexibility has been deliberately introduced and why this is so. The purpose of this annex is thus to explain how the accounting system of the SEEA is related to that of the SNA. It explains the relationships between concepts and definitions, accounting rules and methods of valuation in the two systems. It is written assuming the reader has detailed knowledge of the SNA.

For each of the chapters 3 to 10, the material is reviewed under up to four headings. The first, ***Adding supplementary information***, describes the extensions to the SNA which the SEEA introduces. The second heading, ***Clarifying SNA definitions***, highlights a number of cases where it was necessary to seek more precise definitions of SNA concepts for these to be operational in the context of environmental accounting. It is suggested that these clarifications be considered for incorporation into the SNA itself since there is no intention to change the system, simply to increase the precision which it is believed is intended. The third section, ***Expanding the SNA exposition***, refers to sections where the text in this handbook goes into rather greater detail than the text of the SNA to explain how particular accounts are to be elaborated. In this case also no change to the underlying system in intended. The last section, ***Changing the accounting entries***, refers to the cases where deliberate changes to the SNA accounts are suggested, as options, within the context of a satellite account. Not all sections appear under each chapter heading. When a heading is absent, this means that there is nothing relevant in the chapter. In particular, the fourth heading appears seldom.

Chapter 3 Physical flow accounts

Adding supplementary information

Chapter 3 shows how a supply and use framework, similar to that in the SNA, can be established measured in physical terms. Fundamental to this are four basic ***concepts***, those of products, natural resources, ecosystem inputs and residuals. Product is used in precisely the same way as in the SNA. None of the other three concepts have explicit prices. The means of determining implicit prices for natural resources are described in Chapter 7 and possible valuations which could be attributed to residuals are discussed in Chapter 9. There is no discussion of valuing ecosystem inputs (typically the air and water necessary to all life forms).

A number of ***classifications*** have to be used with the four basic concepts. Products are classified according to ISIC and CPC as in the SNA. Particularly relevant headings of the CPC are given in Annex 3. Relevant headings of industrial classifications (ISIC, NACE and NAICS) are given in Annex 7. Annex 2 gives a classification for use with natural resources and ecosystem inputs. A classification of residuals is given in Annex 4.

The ***accounts*** described in Chapter 3 are based on the normal supply and use identity and a composite supply and use table is developed. Columns for industries and final demand include products, natural resources and ecosystem inputs; rows for products include products and residuals.

Chapter 4 Hybrid flow accounts

Adding supplementary information

This chapter takes the supply and use ***account*** from Chapter 3 and superimposes the SNA supply and use table in monetary terms on that part of the physical table relating to products (hence the importance of using precisely the same definition and classifications for products).

Arising from this, it is possible to derive a set of prices for products but the difference in ***concept*** between physical volumes and national accounts volumes where quality changes are taken into account is emphasised here and later in the handbook.

Expanding the SNA exposition

The chapter explains how a supply and use table can be transformed to input-output format and discusses how the input output format can be used to track direct and indirect effects of particular final uses through the system.

Chapter 5 Accounting for economic activities and products related to the environment

Adding supplementary information

This chapter identifies four relevant activities associated with environmental protection and resource management. These are environmental protection activities, natural resource management and exploitation activities, environmentally beneficial activities and minimisation of natural hazards. So far most work has been done in respect of the first category and a new ***classification*** of environmental protection activities (CEPA) is introduced and reproduced in Annex 5. This classification has been adopted as an international standard. The functional classifications for final and intermediate consumption used by the SNA (COFOG, COICOP and COPP) have been updated since the SNA was published in 1993 and, in the updating, the proposals for CEPA were taken into account to ensure consistency among these classifications. The relevant headings from COFOG, COICOP and COPP are given in Annex 6.

Expanding the SNA exposition

Once the CEPA is established, the chapter goes on to describe how accounts to measure the level of environmental protection activity can be established. This represents an elaboration of proposals made in Chapter XXI of the SNA. One aspect is the identification of those activities producing goods and services characteristic of environmental protection. This group of activities is referred to as the "environment industry" and is listed in Annex 8.

Changing the accounting entries

In connection with elaborating the environmental protection accounts, it is desirable to record some ancillary activity separately. This alters the level of output in an industry but not the level of value added since intermediate consumption increases correspondingly. This process is described in SNA Chapter XXI also.

Chapter 6 Accounting for other environmentally related transactions

Clarifying SNA definitions

This chapter discusses how environmentally related taxes, property income and property rights can be identified within the SNA. The distinction between payment of a tax, the payment of rent for the use of a non-produced asset and payment for a service is reviewed. A set of taxes with an environmental base is established.

Although the SNA mentions only rent on land and rent on subsoil deposits, this handbook states that conceptually rent may be payable on other environmental resources and when this occurs the category of rent should be further disaggregated to show this. One example is the payment of licences for commercial fishing activities. The SNA guidance that licences for hunting, shooting and fishing be treated as taxes on income applies only to the case of licences paid by individuals in respect of recreational activities. (It is arguable that from an environmental point of view these too could be regarded as rent but there would be no impact of overall economic aggregates and the amounts involved are extremely small relative to total economic activity.)

The acquisition of property rights through the purchase (or acquisition by other means) of licences bestowing the right to use an asset for an extended period of time should be regarded as the acquisition of an intangible non-produced asset. Fishing licences and emissions permits are particularly relevant for environmental accounting.

The chapter discusses costs incurred when fixed assets are decommissioned and suggests that these costs be taken into account via the consumption of fixed capital during the life of the asset so that the cumulative value of consumption of fixed capital over the life of the asset (excluding the effects of inflation) covers both the initial cost and any disposal costs. This is particularly relevant for the disposal of oil rigs and landfill sites.

Expenditure to prevent leaching from landfill sites after their closure and soil decontamination should be recorded as part of land improvements and recorded as fixed capital formation in the SNA and not just in the SEEA.

Expanding the SNA exposition

The chapter explains how SNA Chapter XVIII extends an input-output table to the format of a matrix including all the current and capital flow transactions. It goes on to discuss how extra cross-classifications can be introduced (for example, household consumption by product and by function). The hybrid version of such a table contains the physical data for natural resource and ecosystem inputs and residual outputs and shows how more non-monetary data can be incorporated (for example, labour market information).

Chapter 7 Asset accounts and the valuation of natural resource stocks

Adding supplementary information

The chapter introduces a ***classification*** of environmental assets which is broader than that of the SNA by introducing assets that are not recognised as "economic assets" in the SNA. The details of this classification are given in Annex 1. An example may be land which is so remote and so inhospitable that it has no commercial value but still provides environmental services.

Clarifying SNA definitions

Even within the SNA context, there have been problems to determine when a biological resource such as a forest should be treated as cultivated and when as non-cultivated. As a result of discussions, the SEEA recommends that the SNA definition for cultivated assets be supplemented by the phrase given in bold italics in the extract below to replace the phrase "that are". This brings the definition for cultivated assets into line with that for non-cultivated asset where such a phrase exists.

> Cultivated assets cover livestock for breeding, dairy, draught, etc. and vineyards, orchards and other trees yielding repeat products ***whose natural growth and regeneration is*** under the direct control, responsibility and management of institutional units.

Further, it should be understood that the processes involved should constitute production in the SNA sense and not represent a purely legislative process. The activities concerned are likely to fall within ISIC tabulation categories A or B.

Expanding the SNA exposition

The SEEA makes extensive use of the asset account which shows how for a given asset the opening and closing balance sheets can be reconciled by accounting for all the changes which take place in the year. While the philosophy is well understood to national accountants, the asset account itself is little known or implemented (although it is described in the annex to Chapter II of the 1993 SNA). Chapter 7 of this handbook shows how the asset accounts for different classes of assets can be integrated with the flows matrix described in Chapter 6 by including a cross-classification of assets by type of asset and owner.

There is extensive discussion in Chapter 7 on the capital service approach to the valuation of assets, as described in two manuals published by the OECD on measuring capital and productivity (OECD 2001a and 2001b). This approach helps establish parallels between the valuation of fixed capital and natural assets and between the decline in value of fixed assets (consumption of fixed capital) and a value which can be ascribed to the decline in value (depletion) of natural resources.

Changing the accounting entries

Land appears as a non-produced asset in the SNA subdivided into land under buildings, land under cultivation, recreational land and other land. It is recognised that recreational land has characteristics which could lead to a potential classification into other categories. Where this is so, the SNA recommends choosing the category which represents the greater part of the value. This solution is not satisfactory from the SEEA perspective. It is recommended that recreational land be treated as a secondary characteristic shown as an "of which" category to permit reconciliation with the SNA.

The SNA recommends that the value of subsoil deposits recorded in the balance sheet should refer only to proven reserves. In some countries figures for proven reserves are not available separately from probable reserves. In others, even where a separation is possible, it is felt it would be more realistic to include probable reserves also, even in the SNA balance sheet. This handbook therefore recommends that reserves of all categories should be included in the SEEA balance sheet and that probable reserves should be included in the SNA balance sheet at least as a memorandum item.

Growing concern about dwindling fish stocks has led to the creation of country quotas in respect of fish in the ocean beyond national economic zones. This handbook recommends that the value of the fish represented by these allocated quotas should be included in the SEEA balance sheet and at least as a memorandum item in the SNA balance sheet. (The quotas in question are allocated by international agreement to a country rather than to individual fishing concerns. They are thus rather different from the fishing licences described above, though clearly such fishing licences issued by a national government could relate to fish to be caught under an international quota.)

Chapter 8 Specific resource accounts

The points raised under this heading actually include points relevant to specific resources in chapters 7 and 10 as well as those made in Chapter 8.

Mineral and energy resources

As noted above, the SEEA recommends that a more inclusive measure of subsoil deposits be recorded than simply proven reserves.

There is quite extensive discussion in both Chapter 7 and Chapter 8 on the interpretation of the treatment of mineral exploration. Although the SNA recommends valuation "at cost" this should not be taken to necessarily exclude an element of net operating surplus.

When the value of subsoil deposits is calculated using net present value techniques applied to resource rent, the implications are that the higher the value of mineral exploration the lower the value of the subsoil deposit. This means that two deposits of identical characteristics could have different values if one is found with relatively little effort and one only after extensive and expensive exploration.

The SNA recommends that the value of the resource should appear in the balance sheet of the owner. Alternative possible forms of recording are explored in the SEEA.

Water resources

At present, most water circulating within an economy does so without a direct cost. This is set to change in future as water becomes increasingly scarce and more explicit charging for its use is made. This may necessitate changes in the SEEA guidelines given in this handbook as less water is treated as an ecosystem input and more as an economic product. In addition, changes may be necessary for the coverage of water as an asset in the SNA. A further consequence is that water which has already been used may acquire a value and become a product like some other items which are candidates for recycling.

Forests

Chapter 8 examines how separate elements of forests may be valued individually; the standing timber, the land under the trees, forest products such as berries and game and the amenity value of the forest. By implication, the SNA recommends that the value to be placed on a forest in the SNA accounts should include all these elements though it is not certain this is always followed in practice.

Aquatic resources

From the point of view of management of fish stocks within a country's EEZ, it is desirable to have data available on total catches from the EEZ as well as total catches by residents in the EEZ and by residents world-wide. This information should be collected if at all possible in terms of both physical quantities and monetary values.

Chapter 9 Valuation techniques for measuring degradation

Expanding the SNA exposition

This chapter is concerned only with the description of pricing techniques. It describes prices consistent with the SNA, including some of the newer techniques being adopted such as hedonic pricing. It also discusses some pricing techniques which are not consistent with SNA valuation because of the inclusion of an element of consumer surplus.

Chapter 10 Making environmental adjustments to the flow accounts

Changing the accounting entries

This chapter discusses three areas in which changes to the SNA flow accounts might be introduced to derive macro-economic aggregates which differ from the conventional ones. It is made clear these are adjustments suggested only within the context of a satellite account. In each case a number of alternatives are presented, including the option not to make an adjustment. The three areas are those of depletion, defensive expenditure and degradation. To a considerable extent, the options applicable in each of these areas can be chosen independently of those in the other areas.

In the section on ***depletion***, various possibilities for incorporating an element into the flow accounts matching the decline in the value of a natural resource are discussed. Such an item could be introduced in either the generation of income account, or possibly the distribution of primary income account. The effect is to reduce subsequent balancing items, including the main macro-economic aggregates, to a "depletion-adjusted" basis where both the consumption of fixed capital and the consumption of natural capital have been deducted from the gross balancing items.

In the section on ***defensive expenditure***, an option is presented whereby environmental protection expenditure can be shown both as a form of capital formation and at the same time as consumption of fixed capital. This increases the value of GDP by the amount of environmental protection expenditure presently included in intermediate consumption (including as an ancillary activity) and decreases NDP by the amount of expenditure that takes the form of final consumption. This provides consistent treatment regardless of whether environmental protection is undertaken by a producing unit or for final consumption. The gap between GDP and NDP is widened by the whole of current environmental protection expenditure.

The section on ***degradation*** includes three main options. The first is to place a valuation on the damage done by the emission of residuals and to deduct this from income to reach a total called "damage adjusted" national income. It is noted that this is a partial implementation of a welfare approach to measurement of income and is strictly inconsistent with SNA aggregates because a deduction is made for reductions in welfare but no addition is made for the fact that welfare is generally supposed to exceed income.

The second approach is that appearing in the 1993 SEEA. It is called the maintenance cost approach and leads to "environmentally adjusted" aggregates. It presupposes that extra environmental protection expenditure will be undertaken either to eliminate residual generation or to reduce this to a pre-specified level. It is inconsistent with the SNA accounts in that no adjustments are made to explain the source of the imputed extra expenditure. It is also inconsistent with observed (and desired) economic behaviour which postulates that if faced with explicit costs to protect the environment, producers and consumers would adjust their behaviour as well as their spending patterns to achieve this.

The third approach is a modelling and not an accounting approach and leads to "greened economy" aggregates. It supposes that residual emission is avoided or reduced by a combination of changes in production and consumption patterns. The underlying accounting is perfectly consistent with the SNA but the resulting levels of activity and of macro-economic aggregates are hypothetical and not observed.

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