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REVISION OF THE SYSTEM OF ENVIRONMENTAL-ECONOMIC ACCOUNTS (SEEA)

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CHAPTERS 1 – 6

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United Nations Committee of Experts on Environmental Economic Accounting (UNCEEA)
Statistics Division / Department of Economic and Social Affairs, United Nations

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Chapter 1: Introduction

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1.1 What is the System of Environmental - Economic Accounts?

1.1 The System of Environmental - Economic Accounts (SEEA) is a multi-purpose, conceptual framework that describes the interactions between the economy and the environment and the changes in the state of the environment over time.

1.2 The concepts and definitions that comprise the SEEA are designed to be applicable across all countries, regardless of their level of economic development, their economic structure, or the composition and state of their environment.

1.3 At the heart of the SEEA is an accounting approach that describes, as completely as possible, the stocks and flows that are relevant to the analysis of environmental and economic issues. The analysis may pertain to the assessment of the state of the environment in terms of trends in environmental assets, the environmental impacts of economic activity, the application of environmental policy instruments, the impact of the environment on human health, and the trends concerning the environment in an international context.

1.4 The accounting approach of the SEEA is based on the System of National Accounts (SNA), a conceptual framework that has developed over the second half of the 20th century to be the pre-eminent approach to the measurement of economic activity, economic wealth and the general state of the economy.

1.5 An accounting approach distinguishes the SEEA from general sets of statistics on environmental and economic issues because it demands coherence and consistency with a core set of concepts and definitions. Thus, using a wide range of source data, the SEEA provides a systematic approach to compare and contrast source data and presents aggregates, indicators and trends across a broad spectrum of environmental and economic issues.

1.6 A particular strength of the SEEA emerges from its basis in the SNA. Using common concepts and definitions, the SEEA extends the monetary focused recording in the SNA to incorporate many environmental statistics that are usually available in physical or quantitative terms. The power of the SEEA comes from its capacity to present information in both physical and monetary terms in a coherent manner.

1.7 The integration of information concerning the economy and the environment requires a multi-disciplinary approach. The SEEA brings together, in a single framework, information on water, minerals, energy, timber, fish, soil, land and ecosystems, pollution and waste, production, consumption and accumulation. Each of these areas has specific and detailed measurement approaches that are integrated in the SEEA to provide a comprehensive view.

1.8 At a practical level, each area is governed by disciplines that have their own language and terminology. Where possible the SEEA incorporates this language, but the SEEA retains at its core the language and terminology of the SNA. The explanation of the relevant accounting concepts within a variety of environmental contexts is a key role of the SEEA.

1.9 The SEEA is not designed to provide or replace the richness and depth that each of these disciplines bring to their own areas. Rather it is the linkages and connections developed in the

SEEA that provide an additional and broader perspective and hence add value to the detailed information already available.

1.2 Policy relevance and uses of the SEEA

1.10 The effect of human activity on the environment has emerged as one of the most significant policy issues. 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 benefits obtained from the environment. These benefits include the provision of raw materials, energy and other resources used to produce goods and services; the absorption of waste and pollution from human activities by the environment; the regulatory functions such as pollination and flood protection; and the provision of amenity services such as places for recreation.

1.11 The policy issues translate into questions regarding whether environmental endowments are being used responsibly. For example, is there a threat to economic development now, either by using up resources too quickly with no prospect of replacement, or by generating a level of pollution that exceeds the absorptive capacity of the environment and that affects human health and well-being? And, even if current activities do not pose a problem at present, could they do so if continued without change into the future?

1.12 Ultimately, the benefits from the SEEA are embodied in the ability of the information within the SEEA to positively benefit the creation and setting of policy and the process of decision making. As a multi-purpose system, the SEEA can provide these benefits in a number of ways. First, the summary information in the SEEA (provided in the form of indicators of progress towards policy objectives) can be used to give broad guidance on issues and areas of the state of the environment that should be the focus of decision makers. Second, the detailed information in the SEEA on the key drivers of change in the state of the environment can be used to provide a richer understanding of the policy issues. Third, the framework of the SEEA permits the development of models and scenarios that can be used to assess the national and international impact of different policy scenarios both within a country, between countries and at a global level.

1.13 The benefits of the SEEA to policy and decision making processes can be seen in specific areas such as energy and water resource management; patterns of consumption and production and their impact on the environment; the green economy and economic activity related to adoption of environmental policies; and the changing condition and health of ecosystems and their capacity to continue to deliver benefits to humanity. The benefits are most broadly captured in policies concerning sustainable development – one of the most pressing policy issues for current and future generations. The capacity to consider all of these different topics within a single, coherent framework is core to the value that the SEEA provides.

1.14 The relevance of the SEEA framework emerges in a number of ways.

- First, the basic intent of the SEEA is to provide the measurement framework for sustainable development by informing the policy framework on the state of the environment and by integrating information on the state of the economy.
- Second, the SEEA framework is broad thus supporting the ambitions of sustainable development to offer a holistic view of development alternatives. In particular, the SEEA extends the coverage of assets to encompass all types of environmental assets in physical terms.
- Third, sustainability cannot be dissociated from assets and their measurement in the economic, social and environmental domains. The SEEA is designed to systematically record the stock of assets and the flows that link them over time and so lends itself to constructing relevant indicators.
- Fourth, the SEEA contains physical and monetary flow accounts that can structure information relevant to resource management, sectoral and general economic policies. For example, in many countries water scarcity is a problem and water pricing is used as a partial solution to this scarcity. Environmental–economic accounts record who is using the water and who pays; the impact (burden) of water charges on profitability of various sectors of the economy; changes to the return on produced assets used for water supply and water treatment; and over time the resultant changes in water use by enterprises and households. Similar analyses can be undertaken for issues such as energy supply and demand; forestry and fisheries management; land use; and pollution abatement, including the management of greenhouse gas emissions.
- Fifth, the SEEA provides a framework within which the stocks and economic value of certain natural resources can be measured (for example, mineral and energy resources, timber resources and aquatic resources). Through the measurement of these resources it is possible to construct measures of the depletion of natural resources in physical and monetary terms. Further, in monetary terms adjustments can be made to measures of economic activity, for example Net National Income, so as to not only account for depreciation of produced assets but also to account for the depletion of natural resources. Such adjusted measures start to bring into stronger focus the relationship between the economy and the environment that is not taken into account in traditional measures of economic activity.
- Sixth, the SEEA provides the framework for the description of environmental activities, products and producers. Functional accounts cover the production of goods and services and the expenditures for purposes of environmental protection and resources management. These accounts allow for the analysis of the impacts of policy instruments to prevent and eliminate environmental pressures and preserve and maintain the stock of natural resources.
- Seventh, the SEEA framework can be used to monitor the extent to which patterns of production, consumption and accumulation are becoming more sustainable. The SEEA

also provides the tools to gauge the effects on economic growth and employment that are associated, for example, with the environmental goods and services sector.

- Eighth, the SEEA provides a catalyst and mechanism for the engagement of experts from across the multiplicity of fields that relate to sustainable development.

1.15 In an increasingly integrated and connected world the SEEA framework provides the conceptual framework and information source on which discussion, research and policy on environmental and economic issues can be based.

1.3 The SEEA as a system

1.16 The SEEA consists of a coherent, consistent and integrated set of tables and accounts which each focus on different aspects of the interaction between the economy and the environment or on the changing state of the environment. The tables and accounts are based on internationally agreed concepts, definitions, classifications and accounting rules.

1.3.1 Scope and coverage of the SEEA

1.17 Generally, the accounts are compiled in respect of a national economy and its environment and therefore present, in a condensed way, a great amount of information reflecting the different economic and environmental stocks and flows that take place within a country.

1.18 The national economy is defined in accordance with the SNA. In geographic terms, the economy is defined by the economic territory of a country (which generally aligns closely in physical terms with its national boundaries as commonly recognised). The economic units of interest are those enterprises, households and governments that have a centre of interest in the economic territory (a concept known as residence). The economy is defined by the production, consumption and accumulation activity undertaken within the economic territory by the relevant economic units.

1.19 The relevant scope of the environment is also bounded by these territorial considerations. Thus, all natural resources and terrestrial ecosystems within a country's economic territory are within scope of the SEEA framework. Within the SEEA the environment of a country is conceptualised as a single, physical entity that can be viewed from two primary perspectives. First, it can be viewed as a combination of individual components such as trees, animals, lakes, minerals, soil, land, etc. Many of these individual components may be regarded as environmental assets that provide materials and space to all economic activities.

1.20 Second, a country's environment can be viewed as a collection of ecosystems, each defined within a given area. Ecosystems provide not only materials and space but also non-material benefits to the economy through ecosystem services such as water purification and pollination. Ecosystems may be of many different types depending on the climate, topography, the degree of human intervention, and other factors. Ecosystems function through the interaction between the various individual components and hence, in concept, both perspectives are complementary rather than competing views of the same physical environment.

1.3.2 Types of SEEA accounts

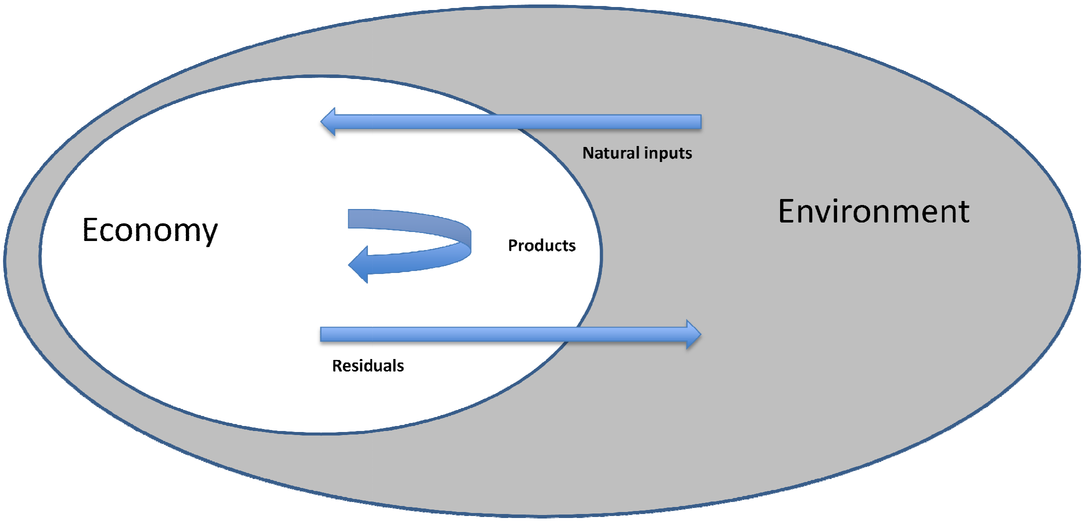
1.21 There are five main types of accounts and tables in the SEEA framework: (i) physical flow accounts presented in supply and use tables, (ii) asset accounts in physical and monetary terms, (iii) the sequence of economic accounts, (iv) functional accounts for environmental transactions, and (v) tables containing demographic and employment information. The description of these types of accounts and tables forms the core of the SEEA Central Framework that is contained in Chapters 2 – 6.

Physical flow accounts

1.22 The first type of account is the physical flow accounts. Three sub-systems of physical flows are considered: flows relating to energy, flows relating to water and flows relating to materials. Flows for each sub-system are recorded in different physical units (joules, cubic metres and tonnes as appropriate) and, aim to account for all flows from the environment into the economy, within the economy, from the economy to the environment.

1.23 In broad terms, the flows from the environment to the economy are recorded as natural inputs. Flows within the economy are recorded as product flows and flows from the economy to the environment are recorded as residuals. Figure 1.3.1 presents these flows.

Figure 1.3.1 Physical flows between the economy and the environment



1.24 Accounting for these various physical flows applies basic laws concerning the conservation of mass and energy. Thus the supply of natural inputs by the environment must be matched by the use of those inputs by the economy or the immediate return of those inputs to the environment (e.g. discarded catch in fishing or felling residues in timber operations). Also, the supply of products (i.e. goods and services) within the economy must equal the use of products within the economy (with relevant adjustments for the trade in goods and services between countries). Finally, the generation of residuals by the economy must be matched by either the collection of these residuals by other economic units (for example solid waste collected by landfill sites) or the release of the residuals to the environment.

1.25 As a result of accounting for the various physical flows in this way, a framework, known as a physical supply and use table (PSUT), can be constructed in which each of the various types of physical flows is recorded. The PSUT in the SEEA is based on supply and use tables that have been developed for economic analysis (which has a focus on products) and is extended to included consideration of flows between the environment and the economy.

1.26 Conceptually, the PSUT framework allows all physical flows to be recorded and presented in one account. However, not only is this very data demanding, it may be difficult to interpret information on all physical flows at the same time. Consequently, sub-systems for flows of energy, water and materials are introduced that focus on recording flows related to each sub-system. Further within the materials sub-system more restricted sets of flows may be targeted. For example, accounts may be compiled for flows of forest products or nutrients, or for specific types of flows (e.g. air emissions, solid waste or emissions to water).

Asset accounts in physical and monetary terms

1.27 Measuring the state of the environment and changes in it is a central feature of the SEEA. Asset accounts focus on the key individual components of the environment namely mineral and energy resources, timber resources, aquatic resources, other biological resources, soil resources, water resources, and land. They include measures of the stock of each environmental asset at the beginning and end of an accounting period and record the various changes in the stock due to extraction, natural growth, discovery, catastrophic loss or other factors.

1.28 The compilation of asset accounts in physical terms can provide valuable information on resource availability and may help in the assessment of sustainability. A particular feature of the SEEA asset accounts is the estimation of depletion of natural resources in physical terms. For non-renewable resources the quantity of depletion is equal to the quantity of resource extracted but for renewable resources the quantity of depletion must take into account the underlying population, its size, rate of growth and associated sustainable yield.

1.29 The compilation of asset accounts in monetary terms can also provide valuable information to assist in the understanding of the relationship between rates of extraction and current economic activity and in understanding the economic costs of extraction on future incomes. In particular it is possible to place a value in monetary terms on depletion and hence derive depletion adjusted measures of income and saving.

1.30 The valuation of environmental assets may be used to compile estimates of national economic wealth and hence provide a more complete picture of a country's economic structure and the way in which a country's natural endowments are being used in comparison to the use of other types of assets.

1.31 Because there is no market for many environmental assets (i.e. the environmental assets in situ are rarely bought and sold), alternative valuation methods often need to be used to compile asset accounts in monetary terms. The method described in the SEEA is the net present value (NPV) method which calculates the value of an asset based on the future income streams that are expected to accrue from the use of the asset.

1.32 The underlying basis for valuation in the SEEA is market prices, the same basis as used in the SNA. The use of this valuation basis allows environmental assets to be readily compared to produced and financial assets. At the same time, this valuation basis does not take into account all of the benefits that may arise from environmental assets - for example, timber resources are valued for the wood that can be extracted and not for the recreational benefits provided by the forests in which timber resources are found. The measurement and valuation of the full range of environmental benefits is incorporated in ecosystem accounts.

The sequence of economic accounts

1.33 In monetary terms, monetary supply and use tables and asset accounts record much of the information of interest in the assessment of the interactions between the economy and the environment. However, there are a range of other monetary transactions and flows that are of interest in environmental-economic accounting such as payments of rent for the extraction of natural resources, payments of environmental taxes, and payments of environmental subsidies and grants from government units to other economic units to support environmental protection activity.

1.34 These flows are presented in the sequence of economic accounts. It is compiled only in monetary terms because these accounts record transactions that do not have an underlying physical base, for example interest payments. The sequence of economic accounts follows the structure of the sequence of accounts in the SNA. Of particular importance is the derivation of measures of depletion adjusted income and saving within the sequence of economic accounts. The entries in the sequence of economic accounts also provide the information required for an assessment of the full economic costs and benefits of environmental activity.

Functional accounts for environmental transactions

1.35 There are many transactions between different economic units (i.e. enterprises, households, governments) that concern the environment. All transactions between economic units are recorded in the SNA. One part of the SEEA framework is targeted at identifying and collating separately the sub-set of transactions that can be considered environmental.

1.36 Environmental transactions are identified by first defining the set of environmental activities – i.e. those activities that reduce or eliminate pressures on the environment and that aim at making more efficient use of natural resources. Examples include investing in technologies designed to prevent or reduce pollution; restoring the environment after it has been polluted; and recycling, conservation and resource management. Environmental activities are classified as being either environmental protection activities or resource management activities.

1.37 Since the information is sourced from the standard structures and definitions of the SNA, the information can be organised along similar lines. Thus, in effect, an alternative or satellite presentation of the SNA is developed. Because the logic behind the selection of transactions is on the basis of the function or purpose of the transactions, these accounts are commonly referred to as functional accounts.

1.38 The most developed functional accounts for environmental transactions concern activities for environmental protection - Environmental Protection Expenditure Accounts (EPEA). Another particular area of focus may be on flows to and from government for environmental purposes and in this context the measurement of environmental taxes and environmental subsidies and similar flows (such as investment grants) is appropriate.

1.39 Although not considered environmental activities, there are other economic activities related to the environment, in particular natural resource use activities and activities aimed at minimising the impact of natural hazards, that may be of interest. As for environmental activities, different accounts can be developed for these activities depending on the transactions of interest.

1.40 For natural resource use activities information on extraction and exploration activity including measures of value added, and payments of rent for access to resources may be particularly relevant. There may also be a focus on the level of investment in extraction equipment and the state of the associated produced assets (for example concerning the condition of a country's fishing fleet). All of this information can be organised into relevant functional accounts following the structures and definitions of the SNA.

Demographic and employment information

1.41 The usefulness of information within the SEEA can be enhanced by relating different environmental and economic data to estimates of population and various demographic breakdowns such as by household income levels and other detailed information by household characteristics related to material well-being. This information may be useful in assessing issues such as resource availability, changes in energy use and sources of emissions. Accounting for differences in population size and structure is also important for international comparisons of environmental and economic data.

1.42 Employment information such as the number of people employed, the number of jobs and the number of hours worked may be of particular interest in the assessment of environmental activity from an industry perspective. In particular, there is likely to be interest in employment indicators related to the production of environmental goods and services.

Accounting for Ecosystems

1.43 Ecosystems are areas containing a dynamic complex of biotic communities (for example, plants, animals and micro-organisms) and their non-living environment interacting as a functional unit to provide environmental structures, processes and functions. The environmental structure is the organisation in which the living and non-living components interact. Ecosystems provide benefits to humanity known as ecosystem services through environmental processes and functions. The benefits are supplied in many ways and vary from ecosystem to ecosystem. Ecosystem services are generally grouped into four main types – provisioning services (such as the provision of timber from forests), regulatory services (such as when forests act as a sink for carbon), supporting services (such as in the formation of soils), and cultural services (such as the enjoyment provided to visitors to a national park).

1.44 The objective of ecosystem accounting is to record the provision of all types of ecosystem services from the different types of ecosystems in a systematic manner. A related measurement issue is the assessment of the capacity of ecosystems to continue to produce ecosystem services into the future. The extent to which this capacity is reduced as a result of human activity is considered to be degradation.

1.45 A particular aspect of ecosystem accounting is that data are often compiled at finer levels of geographic detail since it is the delivery of services by a specific area that is of particular interest.

1.46 It is possible to place monetary values on flows of ecosystem services and the changing capacity of ecosystems to provide these services. However, there is no clear agreement on the valuation approach that should be used. SEEA Experimental Ecosystem Accounts describes the main valuation approaches and their advantages and disadvantages.

1.47 In broad terms the accounting structures of physical supply and use tables and asset accounts are also applied in ecosystem accounting. However, the structures are applied somewhat differently because the focus of measurement is on specific areas within the environment, the ecosystems, and hence the environment has a central and active focus rather than having a more passive role alongside the main economic units as it does in the accounts of the Central Framework.

The relationships between the accounts

1.48 Each of these different accounts is connected to the other within the SEEA framework but each one focuses on a different part of the interaction between the economy and the environment. Examples of the relationships between the different accounts include:

- Asset accounts describe the stock and changes in the stock of environmental assets. Asset accounts in the Central Framework focus on the individual components and can be extended to describe the interactions between the economy and the environment and the capacity of ecosystems to provide ecosystem services.
- Changes in the stock are most often the result of economic activity, which in turn is the focus of physical flow accounts. Measurement of flows of natural inputs in the PSUT is consistent with the measurement of extraction in the asset accounts and the interaction with ecosystems.
- Measurement of flows of residuals to the environment as recorded in PSUT is an important consideration in the measurement of the capacity to produce ecosystem services.
- Measures of the flows of natural inputs and residuals can also be related to transactions recorded in functional accounts for environmental protection and resource management, including investment in cleaner technologies and flows of environmental taxes and subsidies. For example, payments for emission permits recorded in functional accounts can be related to the flows of emissions recorded in the PSUT.
- The effectiveness of the expenditure for environmental purposes may, ultimately, be assessed by changes in the capacity of ecosystems to continue their delivery of ecosystem services as recorded in ecosystem accounts.

1.49 These examples serve to highlight the many and varied relationships between the accounts, each taking a different perspective. Throughout the SEEA these relationships are supported by the use of common concepts, definitions and classifications as described and explained in this book.

1.3.3 Combining information in physical and monetary terms

1.50 One of the most powerful features of the SEEA is its organisation of information in both physical and monetary terms following the same scope, definitions and classifications. This feature is often utilised in the compilation of accounts and tables that combine information in physical and monetary terms. The structure of combined presentations depends on the topic of measurement (e.g. water, energy, air emissions, forest products), the questions of interest and the availability of data. Nonetheless there are certain common features and benefits.

1.51 First, combined presentations allow users to find relevant information in a single location with statistical coherence and consistency already completed through the confrontation of the source data in the SEEA framework.

1.52 Second, combined presentations promote a discussion between those familiar with data organised following economic accounting structures and those familiar with information organised with reference to specific physical flows.

1.53 Third, combined presentations structure information in a manner that supports the derivation of combined indicators – for example, decoupling indicators that track the link between the use of resources and growth in production and consumption.

1.54 Fourth, combined presentations s provide an information base for the development of models and detailed analysis of interactions between the economy and the environment.

1.55 Overall, the power of the SEEA and its standard concepts and definitions is best exploited in the development of presentations that combine physical and monetary data.

1.3.4 SEEA as a co-ordinating framework for environmental-economic statistics

1.56 As an integrated accounting system, the SEEA stands apart from individual sets of environmental statistics. While sets of environmental statistics are usually internally consistent, there is, for good reason, often no strict consistency between one set of statistics and 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.

1.57 In contrast, the SEEA is an integrated system of accounts which, to the fullest extent possible, provides consistency between one account and another in terms of concepts, definitions and classifications. In addition, implementation of such an integrated system aims for consistency over time. This is of the utmost importance in developing the comparable time-series estimates that are necessary in the policy process.

1.58 A final important difference between environmental statistics and the SEEA is the latter's explicit goal of achieving compatibility with the economic information of the SNA. This adds considerable value to both the environmental and the economic information, as it facilitates their analysis within a common framework.

1.59 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 air emissions from industrial sources would ideally be classified according to the industrial classification used in the SEEA. This would allow their simple incorporation into physical flow accounts and combined accounts.

1.60 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 programme. The latter group must be convinced of the importance of having highly structured and consistent data within an accounting framework. The SEEA can serve as a guiding framework for the development of environmental information systems that are more compatible with economic statistics.

1.3.5 Flexibility in implementation

1.61 Although the SEEA is conceived as a complete system which is internally consistent, its design is 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 that it wishes to address.

1.62 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 that are resource-rich may wish to concentrate first on those resources that are perceived to represent a risk to sustainability or that are the subject of discussion regarding the way in which government appropriates revenue from their extraction.

1.63 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, by working first on accounts for specific materials.

1.64 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 measurement of flows of residuals and their impact in order to determine how urgent the problem of introducing environmental protection is.

1.65 These examples illustrate the flexibility of application of the SEEA, which its structure is intended to permit. It is important to bear in mind, however, that no matter which parts of the system are implemented, these parts should be implemented in such a way as to be internally consistent and complementary.

1.66 While there is flexibility in the implementation of the system, much benefit from the SEEA comes from it being an internationally agreed statistical framework. Consequently, the ability to compare and contrast relevant information from a range of countries is a significant advantage supported by the wide-spread adoption of the SEEA for specific modules, particularly with regard to environmental issues that are multi-national or global in nature.

1.4 History of environmental - economic accounting

1.4.1 Precursors to the SEEA

1.67 The recognition of environmental assets as essential components in the generation of economic income and wealth has been appreciated for centuries. In particular the writings of Smith, Ricardo, Mills and others recognised the role of land and land owners as distinct from labour and produced assets. The separation of total income between wages, profits and rent as returns to the various factors of production was well established at that time.

1.68 These writers also recognised that varying qualities of land (including variation introduced as a result of economic activity) and the overall supply of land were important considerations in determining the functioning of an economy. And it was recognised that those countries with particular endowments of natural resources had distinct advantages in earning incomes. One reason for the recognition of land in particular was that an observable market existed and areas of land could be bought and sold with prices fluctuating over time.

1.69 Early work on national accounting in the 20th century, largely ignored the significance of non-produced assets. Focus instead was placed on the measurement of economic growth which required the measurement of production, consumption and the accumulation of produced assets. These activities drove the growth in income that could facilitate higher standards of living.

1.70 From a measurement perspective one factor in the lack of focus on non-produced assets was that no monetary transactions were made with the environment for the resources extracted or for the use of the environment as a sink. The resulting conceptualisation is that the depletion and degradation of natural resources does not represent a cost of production.

1.71 While the SNA did not recognise these costs the broader economics profession did. The concept of externalities as the unpriced impacts of economic activity became well established in the economic literature. Related work on the setting of appropriate taxes and subsidies was also prevalent.

1.72 Thus, accounting for the environment at an aggregate, national economy level become an active consideration of many researchers. A particular focus was the confrontation of physical, environmental data and monetary, economic data within extended input-output frameworks. The basic principles behind this work were developed in the late 1960s by Leontief (1970) and others1. It was these researchers who introduced the analysis of the “physical economy” by way of input-output modelling. They represented residuals as a by-product of regular production activities and showed how this

[1] See, for example, Cumberland (1966); Daly (1968); Isard (1969); Ayres and Kneese (1969); and Victor (1972).

could be incorporated in the conventional, monetary input-output framework. These data systems could be regarded as forerunners of PSUT and combined accounts in the SEEA.

1.73 Around the same time there was increasing recognition that natural resources themselves may not last forever, especially in the wake of the first oil crisis. Although early work on this topic, especially by Hotelling, had occurred some time before, in the 1970s increasingly, attention turned to the measurement of natural resources in both physical and monetary terms. Despite the difficulties in valuation, efforts were made to account for the cost of depletion as an adjustment to the core national accounts measures such as GDP.

1.74 Also in response to the impact of economic activity on the environment, a number of countries commenced the collection and publication of data on environmental protection expenditures thus recognising the increasing importance of these expenditures as part of government and business operations.

1.75 All of these and many other efforts, as indicated in the list of references at the end of this book, provided the theoretical foundation for the SEEA framework.

1.4.2 History of the SEEA

1.76 In 1987 the report of the Brundtland Commission, Our Common Future, made clear the links between economic and social development and the environment's capacity. Shortly afterwards, in 1992, the recommendations of the UN Conference on Environment and Development "Earth Summit" contained in Agenda 21 (UN 1992) recommended that countries implement environmental-economic accounts at the earliest date.

1.77 In response, the United Nations Statistical Division (UNSD) published the handbook of national accounting – Integrated Environmental and Economic Accounting (UN 1993) and commonly referred to as SEEA. This handbook was issued as an "interim" version of work in progress since the discussion of concepts and methods had not come to a final conclusion.

1.78 As a result of the publication of the SEEA handbook, several developing and developed countries started experimenting on the compilation of SEEA. The London Group on Environmental Accounting was created in 1994 under the auspices of the United Nations Statistical Commission (UNSC) to provide a forum for practitioners to share their experiences on developing and implementing environmental accounts. Increased discussion on concepts and methods of environmental accounting, accompanied with country experiences led to an increasing convergence of compilation methods for selected modules of the SEEA.

1.79 The publication – Integrated Environmental and Economic Accounting – An Operational Manual (UN 2000), was published by UNSD and the United Nations Environment Programme (UNEP) based on material prepared by the Nairobi group (a group of experts from national and international agencies and non-governmental organisations established in 1995). This publication reflected the on-going discussion since the publication of the SEEA in 1993 and provided step-by-step guidance on the implementation of the more practical modules of the SEEA and elaborated the uses of integrated environmental and economic accounting in policy making.

1.80 In parallel with the work of the Nairobi Group, the international agencies in co-operation with the London Group worked on a revision of the 1993 SEEA. The revision process was carried out through a series of expert meetings and was built upon a wide consultation process. The revised SEEA, SEEA-2003, represented a considerable step forward in terms of breadth and harmonisation of concepts, definitions and methods in environmental and economic accounting.

1.81 However, in a number of places the SEEA-2003 presented a number of different methodological options and also presented a range of country examples showing varying country practices. Thus the SEEA-2003 was never formally adopted as an international statistical standard and the SEEA was not recognised as a statistical system in its own right. Nonetheless, in general the SEEA-2003 has provided a well accepted and robust framework for the compilation of environmental and economic accounts that has been used by many countries around the world.

1.82 Recognising the ever increasing importance of information on the environment and the need to place this information in an economic context understood by central policy makers, the UNSC agreed at its meeting in 2007 to start a second revision process with the aim of adopting the SEEA as an internationally agreed statistical framework for environmental and economic accounting within five years.

1.83 This process was to be managed under the auspices of the newly formed UN Committee of Experts in Environmental and economic Accounting (UNCEEA). It was recognised that the content of the SEEA-2003 was substantially agreed in terms of both scope and treatment and hence the focus of the revision was to remain largely on those specific areas of the SEEA-2003 in which the level of understanding and agreement needed to be increased and agreed treatments determined. The London Group was given carriage of the 21 issues identified for the revision of the SEEA. The newly formed Oslo Group on Energy Statistics was also involved in the discussion of issues pertaining to energy.

1.84 It became clear that there remained certain aspects of the SEEA-2003 on which it was unlikely that agreement could be found, in particular the measurement of degradation and its valuation. In large part this reflected the lack of broad national statistical efforts at assessing degradation and the existence of a range of different approaches to measurement and valuation. Consequently, the UNSC determined that the revision of the SEEA should proceed in two related but distinct areas. The first area was the development of a central framework which would cover the bulk of the SEEA-2003 concerning primarily the measurement of natural resources, the recording of physical flows and the accounting for environmental expenditure and other related transactions. This material was to become an internationally agreed conceptual framework.

1.85 The second area was to cover those aspects on which agreement was not likely to be reached within the timeframes available and on which ongoing research and discussion would be required. Over time, this second area of focus has become focused on accounting for the environment from the perspective of ecosystems. Ecosystem accounting is becoming an increasingly important perspective but it is also clear that further research and practical implementation is required before the relevant techniques and methods can be considered for adoption as international standards. Thus, SEEA Experimental Ecosystem Accounts will describe the current state of the art in ecosystem accounts and provide a basis for the integration of work on ecosystems with the core accounting approach that underpins the SEEA Central Framework.

1.86 A third area for the revision of the SEEA was also included to cover potential extensions and applications of SEEA based datasets with the aim of promoting and supporting the widespread adoption of the SEEA among both official statisticians, researchers and policy makers.

1.5 The SEEA in the context of other international statistical standards

1.87 The breadth of the SEEA and in particular its coverage of data in both physical and monetary terms means that it has many relationships to other international statistical standards and frameworks. These relationships are of four main types: relationships to the SNA and related economic accounts standards; relationships to sub-systems of the SEEA and other manuals on environmental-economic accounts; relationships to standards for environmental statistics; and relationships to standard international classifications. Each of these is described in turn.

1.5.1 SEEA and the 2008 SNA

1.88 The relationship between SEEA and the SNA is fundamental. The SNA is the primary source for many of the concepts, definitions and accounting rules on which the SEEA is based. Indeed while the SEEA itself is conceived as an independent accounting system and framework, in many respects it is, at the same time, an extension of the SNA.

1.89 The SEEA follows very closely the accounting concepts and definitions outlined in the SNA and users of the SEEA may be required to consult the 2008 SNA for more detailed guidance on particular accounting issues. The two primary areas of distinction between the systems concern the scope of the recording of physical flows compared to monetary flows (which is somewhat broader in the SEEA) and the incorporation in the SEEA of depletion as a cost against the income earned from the extraction of natural resources rather than as only a reduction in the value of natural resources.

1.90 The relationship between the SEEA and the SNA extends to the other statistical standards that form the broader set of standards for economic accounting. These are the 6th Edition of the Balance of Payments and International Investment Position Manual (BPM6) and the 2001 Government Finance Statistics Manual (2001 GFSM). Other relevant materials and references concerning economic accounting are listed at the back of this book.

1.5.2 SEEA and other environmental accounts manuals

1.91 Since the release of the SEEA-2003 a number of manuals have been developed or are under development that focus on particular topics within scope of the SEEA framework. They are the Integrated Environmental and Economic Accounting for Fisheries (SEEAF) – final draft circulated in 2004; the System of Environmental-Economic Accounting for Water (SEEA Water) – released as an interim standard in 2007; and the System of Environmental and Economic Accounting for Energy (SEEA Energy) - released in 2012. The development of other sub-systems of the SEEA is also under consideration including a SEEA for land and ecosystems and a SEEA for agriculture.

1.92 It is intended that the SEEA Central Framework will provide the overarching framework within which all thematic SEEA frameworks should be aligned. Inevitably, the

SEEA sub-systems will contain more detailed structures and explanations. Nonetheless, in all cases the starting point for the development of the accounting approaches will be the SEEA Central Framework and any changes and extensions to suit specific and targeted purposes will be fully explained.

1.93 In addition to environmental accounting publications within the SEEA "family", there is a range of other handbooks and manuals on environmental accounting and related topics that are of importance in considering the practice of environmental and economic accounting. Since these handbooks and manuals have been developed before the finalisation of the SEEA Central Framework there will be differences between some of the definitions, structures and accounting treatments that are presented in this book and those presented in these other publications. Nonetheless, these other publications may provide useful guidance for compilers since they are focused on particular environmental accounting topics rather than competing with the breadth of the SEEA. Future releases of specialised handbooks and manuals will be based on the definitions, structures and accounting treatments outlined in the SEEA.

1.94 Examples of the handbooks include the SERIEE – European system for the collection of economic information on the environment (Eurostat, 1994) and the Manual for Air Emission Accounts (Eurostat, 2009). Other relevant materials and references concerning environmental accounting are listed at the back of this book.

1.5.3 SEEA and other standards for environmental statistics

1.95 The compilation of accounts within the SEEA framework requires the use of information from a wide variety of data sources. Of particular relevance is information on various aspects of the environment, generically referred to as environmental statistics. Increasingly, standards are being developed for various areas within environmental statistics and wherever possible alignment is being incorporated between the specific requirements for data in these areas and the general framework requirements of the SEEA.

1.96 Two examples of environmental statistical standards are the International Recommendations for Water Statistics (IRWS) released in 2010 and the International Recommendations for Energy Statistics (IRES) released in 2011. In both cases the recommendations describe the requirements for the compilation of data on water and energy for a range of purposes including the compilation of data to suit the preparation of physical flow accounts for water and energy within the SEEA framework. Other relevant materials and references concerning environmental statistics are listed at the back of this book.

1.5.4 SEEA and standard international classifications

1.97 The consistent use of classifications in the compilation of data in physical and monetary terms is a central feature of the SEEA. Further, international comparability of data is enhanced through the collective use of standard international classifications wherever they are available.

1.98 Of particular importance are the classifications that are central to economic analysis – the classification of economic production units to industries, the International Standard Industrial Classification for All Economic Activities Revision 4 (ISIC Rev 4), and the classification of goods and services, the Central Product Classification Version 2 (CPC Ver 2.). In addition, the SEEA follows the SNA definitions of institutional sectors of the economy, for example Households, Government and Non-financial and Financial corporations. These three classifications are used throughout the SEEA.

1.99 Additional classification exist in relation to specific topics within the SEEA. For example, in the measurement of environmental protection and resource management activities the Classification of Environmental Activities (CEA) is relevant. In the measurement of energy products the Standard International Energy Product Classification (SIEC) is used. In the assessment of the status of different mineral and energy resources, the UN Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009) is the relevant international standard. The underlying basis for the organisation of information on land cover is the Land Cover Classification System Version 3 (LCCS3) developed by the UN Food and Agriculture Organisation.

1.100 In addition, in the SEEA there are a range of other lists and sets of classes on different topics that are aimed at providing support for the compilation of data in a similar way. Examples include the classification of environmental assets, the classes of natural inputs, the classification of land use and land cover types, the list of solid waste categories and various classes for different natural resources. These are not standard statistical classifications but do provide a structure for compilation and international comparison.

1.101 The organisation of data following standard classifications is an important step that facilitates the development of accounts that are as coherent, consistent and comparable over time and across countries.

1.6 Overview of the SEEA

1.6.1 Introduction

1.102 The SEEA is described in the SEEA Central Framework, the SEEA Experimental Ecosystem Accounts, and the SEEA Extensions and Applications. The material in the SEEA Central Framework reflects the internationally agreed conceptual framework relating to environmental-economic accounting and is considered a statistical standard. Based on the accounting concepts, definitions and principles of the SNA, the SEEA Central Framework describes the relevant accounting concepts and structures that are needed for to present a variety of environmental-economic accounts including physical supply and use tables, functional accounts like the environmental protection expenditure account and asset accounts for natural resources.

1.103 The SEEA Experimental Ecosystem Accounts is not a statistical standard but rather describes a range of best practice approaches to the measurement of the condition and health of ecosystems through the changes in the capacity of ecosystems to deliver ecosystem services and the flows of material and non-material benefits between ecosystems and the economy. It describes both the measurement of ecosystems in physical terms and the broader valuation of ecosystems and the environmental assets within them. In accounting terms, many of the components within ecosystem accounts are drawn from the SEEA Central Framework but they are applied with a focus on ecosystems and their interaction with the economy rather than starting from the perspective of economic units and their interaction with the environment.

1.104 The SEEA Extensions and Applications is also not a statistical standard. It aims to build a bridge between those people conducting specific research on environmental-economic topics who may be able to use SEEA based data sets, and those people compiling and building the data sets themselves. The material aims to introduce various extensions and techniques that can be based on information from the SEEA Central Framework or the SEEA Experimental Ecosystem Accounts. Examples include the development of extended input-output and trade models; the measurement of geospatial data for detailed geographic areas; and the measurement of the interaction of specific economic sectors with the environment (e.g. the household sector).

1.6.2 Reader's guide to SEEA Central Framework

1.105 The SEEA Central Framework comprises six chapters. The first chapter introduces the SEEA providing an indication of the policy relevance of the SEEA and the general structure, purpose and context of environmental and economic accounting. The content and style is intended to suit a non-statistical audience and thus explain to those not intimately involved in the compilation or analysis of SEEA type data the rationale for undertaking this type of statistical work. The chapter provides a brief outlines of the components of the SEEA framework, its historical background and its place in the broader suite of statistical information and conceptual frameworks on environmental and economic measurement.

1.106 The second chapter, “Accounting framework”, outlines in some depth the key parts of the Central Framework and the accounting approach that is used. It uses as its base the accounting approach of the SNA and hence in many ways is likely to be more accessible for those familiar with national accounts concepts and terms. Nonetheless, it aims to explain in a clear fashion the types of accounts and tables that are contained in the Central Framework and the basic principles of accounting for stocks, flows, the definition of economic units and the principles of recording and valuation.

1.107 An important aspect of the SEEA that Chapter 2 aims to highlight is the integrated nature of the SEEA with all of the different parts being founded within a common accounting structure.

1.108 The third chapter, “Physical flow accounts”, explains in detail the recording of physical flows in the SEEA. The different physical flows, natural inputs, products and residual, are placed in the construct of a physical supply and use table and this framework can be expanded and reduced to focus on a range of different materials or on specific flows.

1.109 The second half of chapter 3 describes in detail the structure of physical supply and use tables for energy (Section 3.4), water (Section 3.5) and various materials including tables for air emissions, water emissions and solid waste (Section 3.6).

1.110 The fourth chapter, “Monetary flow accounts” focuses on the identification of economic transactions within the core SNA that may be considered environmental. Of particular interest are those transactions that relate to environmental activities, i.e. those economic activities whose primary purpose is to reduce or eliminate pressures on the environment or to make more efficient use of natural resources. These types of transactions are summarised in Environmental Protection Expenditure Accounts (EPEA) and in statistics on the Environmental Goods and Services Sector (EGSS).

1.111 The fourth chapter also covers the topics of environmental taxes, environmental subsidies and similar transfers and a range of other payments and transactions related to the environment that are all recorded in the SNA framework but are often not explicitly identified as related to the environment.

1.112 The fifth chapter, “Asset accounts”, focuses completely on the recording of stocks and flows associated with environmental assets. The environmental assets within scope are referred to as individual environmental assets, i.e. mineral and energy resources, land, soil resources, timber resources, aquatic resources, other biological resources and water resources. The chapter commences with a discussion of asset accounting in general terms with a particular focus on the measurement of the depletion of natural resources and the valuation of environmental assets.

1.113 Sections 5.5 – 5.11 of the chapter describing the measurement of stocks and flows for each of the individual environmental assets. For each asset type the measurement scope is defined and accounting in physical and monetary terms is described.

1.114 There are a number of annexes to Chapter 5 including a detailed explanation of the net present value (NPV) approach to the valuation of environmental assets and a discussion on discount rates which are an important component of the NPV formulation.

1.115 The sixth chapter, "Integrating and presenting the accounts", highlights the integrated nature of the SEEA framework and links the detailed measurement guidelines of chapters 3-5 with the presentation of information for users. Of particular focus in chapter 6 is the explanation of combined presentation of physical and monetary data and a range of examples of such presentations are described. The chapter also introduces the range of indicators that may be compiled from the SEEA dataset.

REVISION OF THE SYSTEM OF ENVIRONMENTAL - ECONOMIC ACCOUNTS (SEEA)

United Nations Committee of Experts on Environmental Economic Accounting (UNCEEA)
Statistics Division / Department of Economic and Social Affairs, United Nations

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Chapter 2: Accounting framework

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2.1 Introduction

2.1 The SEEA framework describes the interaction between the economy and the environment and on the changing state of environmental assets. It expands the conventional economic measurement framework, the System of National Accounts (SNA), to incorporate flows between the economy and the environment, and highlight environmental activities and expenditures that are not shown explicitly in conventional national accounts presentations. The SEEA framework also incorporates environmental assets both inside and outside of the scope of conventional economic measurement, and records stocks of environmental assets and changes in these stocks over time.

2.2 The framework of the SEEA is based on the accounting framework of the SNA. Consequently, the description of the framework and the associated terminology and language has a strong national accounts basis. At the same time, the SEEA represents a melding of many disciplines (e.g. economics, statistics, energy, hydrology, forestry, fisheries, environmental science) each with its own concepts and structures. Thus while the underlying structure is from the national accounts, the SEEA aims to integrate perspectives from other disciplines, and where relevant, adjust the national accounts perspective to provide an improved set of information for environmental-economic analysis.

2.3 This chapter provides an overview of the SEEA accounting structure and its rules and principles of recording. This overview of the SEEA framework places the various aspects of the economy and the environment in a measurement context. Using the broad framework described in Section 2.2, Section 2.3 presents the accounting framework of the SEEA Central Framework, which is reflected in supply and use tables, asset accounts, the sequence of accounts, functional accounts, and demographic and employment information. Section 2.4 introduces one of the key outputs from the SEEA framework - combined presentations of physical and monetary data.

2.4 Section 2.5 describes stocks and flows in physical and monetary terms and Section 2.6 describes the economic units that are involved. Section 2.7 presents a range of specific accounting rules and principles that form the basis of the recording and compilation of the SEEA accounts.

2.2 Overview of the SEEA Framework

2.5 The SEEA framework describes the measurement of three main areas: (i) the physical flows of materials and energy within the economy and between the economy and the environment; (ii) the stock of environmental assets and changes in these stocks (including information on the condition of ecosystems); and (iii) economic activity and transactions related to the environment (including relevant fixed assets and inventories).

2.6 Central to measurement in these areas are definitions of the economy and the environment. Measurement boundaries are defined such that information can be organised in a consistent way over time, across countries and between different areas of analysis.

2.7 Broadly, the economy functions through the production and importation of goods and services that in turn must be consumed by enterprises, households or government; be exported to the rest of the world; or accumulate to be consumed in the future. Accumulation in this context includes the storage of materials for use in the future and the acquisition of machines and other types of produced assets that are used on an ongoing basis.

2.8 For measurement purposes the economy is represented by both stocks and flows. Stocks of economic assets provide capital inputs to production processes and are a source of wealth for economic units, including households. Many economic assets are produced from economic activity (e.g. buildings and machines) but many are non-produced (e.g. land, mineral resources, water resources).

2.9 The economic value of stocks of assets (e.g. buildings, natural resources, bank deposits) changes over time. These changes are reflected in flows. The flows relating to non-produced assets (for example, discoveries of mineral resources, and losses of timber resources due to fire) are considered to be flows outside the production boundary since the assets themselves are not the output from production processes undertaken by economic units (enterprises, households and government).

2.10 Thus, while the scope of the economy may be considered in terms of the total stock of economic assets (i.e. including both produced and non-produced assets) for the purposes of measuring the interaction between the economy and the environment, the scope of the economy is defined in terms of the production boundary. The production boundary defines the scope of those economic activities that are carried out under the control and responsibility of economic units and that use labour, assets and goods and services to produce outputs of goods and services (collectively known as products).

2.11 The production boundary is significant for the SEEA since all goods and services that are considered to be produced are effectively considered "inside the economy", while materials that are considered non-produced are "outside the economy". As an example, timber in natural forests is considered non-produced while timber in plantations forests is considered produced. In the SEEA, flows between the economy and the environment are determined by whether they cross the production boundary.

2.12 For measurement purposes, the environment may also be considered in terms of stocks and flows. In the SEEA, environmental stocks and flows are considered in a holistic way. From a stock perspective, the environment includes all living and non-living components that comprise the bio-physical environment, including all types of natural resources and the ecosystems within which they are located. From a perspective of environmental flows, the SEEA sees the environment as the source of all natural inputs to the economy including natural resource inputs and inputs absorbed by the economy, for example the air used in combustion processes and energy from solar and wind sources.

2.13 The remainder of this section provides additional description on the nature of the measurement of the economy and the environment in the SEEA.

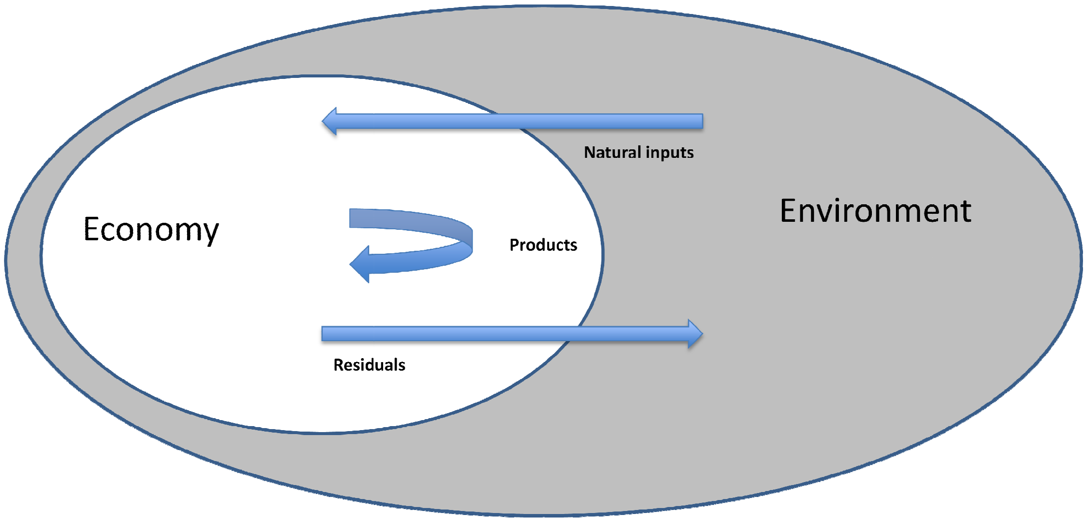
The measurement of physical flows

2.14 A key focus of measurement in the SEEA is the use of physical units to record flows of materials and energy that enter and leave the economy and flows of materials and energy within the economy itself. These measures are called physical flows. In broad terms, <u>natural inputs</u> flow from the environment into the economy (e.g. minerals, energy, timber, fish, water); <u>products</u> circulate within the economy (e.g. electricity, food, clothes); and <u>residuals</u> i.e. the materials and energy discarded, discharged or emitted as a result of production, consumption and accumulation activity – flow to the environment (e.g. solid waste, air emission, return flows of water)[2]. This broad characterisation is presented in Figure 2.2.1.

2.15 Physical flows are recorded in physical supply and use tables. These tables are extensions of the monetary supply and use tables used for the recording of flows of products in monetary terms in the SNA. Sections 2.5 and Chapter 3 provide detailed descriptions of the measurement of physical flows.

[2] It is noted that many residuals also remain within the economy for example solid waste collected in landfill sites.

Figure 2.2.1 Physical flows between the economy and the environment



The measurement of environmental assets

2.16 The use of natural inputs by the economy is linked to reductions in the stock of environmental assets that generate those inputs. Asset accounts for environmental assets in both physical and monetary terms are an important feature of the SEEA.

2.17 ***Environmental assets are the naturally occurring living and non-living components of the Earth, together comprising the bio-physical environment, that may provide benefits to humanity.*** In the SEEA, environmental assets are considered from two perspectives. In the Central Framework the focus is on individual components of the environment that provide materials and space to all economic activities. Examples include mineral and energy resources, timber resources and water resources.

2.18 This focus reflects the material benefits from the use of environmental assets as natural inputs for the economy but does not consider the non-material benefits from the use of environmental assets (for example, benefits from environmental services such as water purification, storage of carbon, and flood mitigation).

2.19 The coverage of individual assets in the Central Framework does not extend to the individual elements that are embodied in the various natural and biological resources listed above. For example, carbon and various soil nutrients are not explicitly considered as individual environmental assets in the Central Framework.

2.20 A complete description of the measurement of environmental assets in terms of the various individual environmental assets is presented in Chapter 5.

2.21 The second perspective on environmental assets is described in SEEA Experimental Ecosystem Accounts. These accounts consider the non-material benefits of the environment, in addition to the material benefits. The measurement focus is on ecosystems. ***Ecosystems are areas containing a dynamic complex of biotic communities (for example, plants, animals***

and micro-organisms) and their non-living environment interacting as a functional unit to provide environmental structures, processes and functions. Examples are terrestrial (e.g. forests) and marine ecosystems that interact with the atmosphere. Often there are interactions between different ecosystems at local and global level.

2.22 Within a given ecosystem, ecosystem accounts consider the capacity of living components within their non-living environment to work together to deliver ecosystem services. ***Ecosystem services are the benefits supplied by the functions of ecosystems and received by humanity.*** The benefits are supplied in many ways and vary from ecosystem to ecosystem. Ecosystem services may be grouped into four types (i) provisioning services (such as the provision of timber from forests); (ii) regulatory services (such as when forests act as a sink for carbon); (iii) supporting services (such as in the formation of soils); and (iv) cultural services (such as the enjoyment provided to visitors to a national park). Generally, provisioning services are related to the material benefits of environmental assets, whereas the other types of ecosystem services are related to the non-material benefits of environmental assets.

2.23 Economic activity may degrade environmental assets such that they are not able to deliver the same range, quantity or quality of ecosystem services on an ongoing basis. A focus on ecosystems that includes both material and non-material benefits of environmental assets provides a basis for analysis of the extent to which economic activity may reduce ecosystem capacity to produce ecosystem services.

The measurement of economic activity related to the environment

2.24 In addition to the measurement of stocks of environmental assets and flows between the environment and the economy, the SEEA framework records flows associated with economic activities related to the environment. Examples of economic activity related to the environment include expenditures on environmental protection and resource management, and the production of environmental goods and services such as devices to reduce air pollution. Using the measurement framework of the SNA, economic activity undertaken for environmental purposes can be separately identified and presented in what are known as functional accounts.

2.25 The SEEA provides a more complete view of the environmental aspects of the economy by considering environmentally related transactions such as taxes, subsidies, grants, and rent. These transactions of the SEEA framework are recorded in the sequence of economic accounts and in functional accounts (such as environmental protection expenditure accounts).

2.3 Main accounts and tables of the SEEA Central Framework

2.3.1 Introduction

2.26 The SEEA organises and integrates the information on the various stocks and flows of the economy and the environment in a series of tables and accounts. The SEEA Central Framework is comprised of the following types of tables and accounts: (i) supply and use tables in physical and monetary terms showing flows of natural inputs, products and residuals; (ii) asset accounts for environmental assets in physical and monetary terms showing the stock of environmental assets at the beginning and end of each accounting period and the changes in the stock; (iii) a sequence of economic accounts showing all economic flows between economic units; (iv) functional accounts which highlight economic activities undertaken for environmental purposes; and (v) demographic and employment information relevant for the analysis of environmental issues.

2.27 The strength of the organisational framework of the SEEA comes from consistently applying definitions and classifications for stocks, flows and economic units across different types of environmental assets and different environmental themes (e.g. across water and energy). Further strength comes from these various definitions and classifications being consistently applied in physical and monetary terms and in being consistent with the same definitions and classifications used in the SNA and economic statistics.

2.28 Implementation of the SEEA does not require compilation of every table and account for all types of environmental asset or environmental theme. The SEEA can be implemented in a modular way taking into account those aspects of the environment of a country that are most important. At the same time, the ambition should be to fully account for the environment-economic structure within a country and to provide information on issues of global concern using a common measurement framework.

2.29 This section introduces the different tables that are part of the SEEA framework and shows the nature of the integration between them. The explanation is stylised, as the reality is more complex, but the basic logic and intent of the approach explained in this section applies throughout the SEEA.

2.3.2 Supply and use tables

Monetary supply and use tables

2.30 Monetary supply and use tables fully articulate the flows of products in an economy between different economic units in monetary terms. They are compiled to describe the structure of an economy and the level of economic activity. Many of the flows of products recorded in monetary terms relate to the use of natural inputs from the environment, for example the manufacture of wood products, or to activities and expenditures associated with the environment, for example environmental protection expenditure. Highlighting the relevant flows in monetary terms and developing finer breakdowns as required for analysis of specific topics is therefore an important part of the SEEA.

2.31 In the SEEA, the recording of the products that flow within the economy is the same as the recording of these flows in the SNA. Products are "supplied" within the economy when they are

i. produced by industries in the national economy (a flow known as output)

ii. brought in from the rest of the world (a flow known as imports).

2.32 All products that are supplied must be recorded as being "used". Use can occur in a number of ways:

i. the products can be used by other industries to make different products (a flow known as intermediate consumption);

ii. the products can be consumed by households (a flow known as household final consumption);

iii. the products can be consumed by governments (a flow known as government final consumption);

iv. the products can be sold to the rest of the world (a flow known as exports);

v. the products can be held as inventories for later use;[3] or

vi. the products can be used as assets (e.g. machines) over a longer period of time to produce other products (these longer term uses are flows known as gross fixed capital formation)

2.33 As shown in Table 2.3.1, these flows are classified by type of product in the rows and by type of economic unit (enterprises, households, government) and the rest of the world in the columns. Enterprises are classified to Industries on the basis of their principal activity. The exception in the naming of the columns is "Accumulation". Accumulation flows are recorded separately since while they concern supply in the current accounting period, they are not used in the current period and instead accumulate for future use or sale by economic units and the rest of the world – either in the form of inventories or in the form of fixed assets.

2.34 The table is divided into two parts – the supply table and the use table. Overall, the total supply of each product must equal the total use of each product. This equality between the total supply and total use of each product is known as the supply and use identity and is a fundamental equation in both the monetary supply and use tables and in the physical supply and use tables that together form the basis of much data compilation and analysis in the SEEA.

2.35 The row of the supply table shows that for each product Total supply is equal to Output plus Imports. The row of the use table shows that Total use is equal to Intermediate consumption plus Household final consumption expenditure plus Government final consumption expenditure plus Gross capital formation plus Exports.

[3] When products are withdrawn from inventories in subsequent accounting periods they are effectively re-supplied to the economy at that time. By accounting convention, the net change in inventories (additions to inventories less withdrawals) during an accounting period is recorded as a "use" of products.

Table 2.3.1 Basic form of a Monetary Supply and Use Table

SUPPLY TABLE						
	Industries				**Rest of the world**	**Total**
Products	Output				Imports	Total supply
USE TABLE						
	Industries	**Households**	**Government**	**Accumulation**	**Rest of the world**	**Total**
Products	Intermediate consumption	Household final consumption expenditure	Government final consumption expenditure	Gross capital formation	Exports	Total use
	Value added					

2.36 A feature of monetary supply and use tables is that key economic aggregates can be derived using the various components. In particular, the aggregate gross value added by industry can be calculated as the difference between that industry's output and its intermediate consumption. This aggregate forms the starting point for the sequence of accounts described in Section 2.3.4.

2.37 Full details on the definitions of the different variables that comprise the monetary supply and use tables are described in the 2008 SNA, Chapter 14.

Physical supply and use tables (PSUTs)

2.38 Physical flows are recorded in the SEEA by compiling supply and use tables in physical units of measurement. These tables are commonly known as physical supply and use tables, or PSUT. The focus of PSUT is on flows of energy, water or materials. PSUT are used to assess how an economy supplies and uses energy, water and materials, and are also used to examine changes in production and consumption patterns over time. In combination with data from monetary supply and use tables, changes in productivity and intensity in the use of natural inputs and the release of residuals can be examined.

2.39 The PSUT structure is based on the monetary supply and use tables described above with extensions to incorporate rows for natural inputs and residuals and a column for the environment. Table 2.3.2 shows these extensions. The column for Government is removed from the PSUT because, in physical terms, government activity is completely recorded within the first column, Industries. In the monetary supply and use table the column for government consumption reflects the purchase by government of its own output which is a purchase of services rather than a purchase of physical goods.

2.40 The column for Households relates purely to the consumption activity of households. Many households also undertake a range of production activity including the collection of water and fuelwood, the generation of energy through the installation of solar panels, etc. All of this production activity and the associated natural inputs and residuals should be recorded in the first column, Industries.

2.41 The broad structure and underlying principles of PSUT are the same regardless of whether the PSUT is measuring flows of energy, water or materials but for each of these sub-systems of physical flows different rows and columns may be used.

2.42 Table 2.3.2 only provides an introduction to PSUT. There are a range of additions and refinements that are required to this basic PSUT to cover all relevant flows of natural inputs, products and residuals. These are explained in detail in Chapter 3.

Table 2.3.2 Basic form of a Physical Supply and Use Table*

SUPPLY TABLE						
	Industries	**Households**	**Accumulation**	**Rest of the World**	**Environment**	**Totals**
Natural inputs					Flows from the environment	Total supply of natural inputs
Products	Domestic production			Imports		Total supply of products
Residuals	Residuals generated by industry	Residuals generated by household final consumption	Residuals from scrapping and demolition of produced assets			Total supply of residuals
USE TABLE						
	Industries	**Households**	**Accumulation**	**Rest of the World**	**Environment**	**Totals**
Natural inputs	Extraction of natural inputs					Total use of natural inputs
Products	Intermediate consumption	Household final consumption	Gross Capital Formation	Exports		Total use of products
Residuals	Collection & treatment of waste and other residuals		Accumulation of waste in controlled landfill sites		Residual flows direct to environment	Total use of residuals

* Note: Grey cells are null by definition. Blank cells may contain relevant flows. These flows are articulated in detail in Chapter 3.

2.43 Within the PSUT, the supply and use identity that applies in monetary terms also applies in physical terms. Thus, for each product measured in physical terms (for example cubic metres of timber) the quantity of domestic production and imports (total supply of products) must equal the consumption, capital formation and exports (total use of products). The equality between supply and use also applies to the total supply and use of natural inputs and the total supply and use of residuals.

2.44 In addition to the supply and use identity, the PSUT incorporates an additional identity concerning flows between the environment and the economy. This second identity, known as the input-output identity, requires that the total flows into the economy, or an enterprise or household are, over an accounting period, either returned to the environment or accumulate in the economy. For example, flows of energy into an enterprise in the form of electricity and petroleum products must be released to the environment after using the energy (as losses of residual heat); stored (as inventories for future use); or incorporated into non-energy products (e.g. petroleum products used to manufacture plastics).

2.45 Both the supply and use identity and the input-output identity are an integral part of the SEEA framework. They are premised on the law of the conservation of mass and energy which states that the mass and energy of a closed system will remain constant. The implication for accounting is that, in theory, mass and energy flows must balance across natural inputs, products and residuals.

2.46 Further details on the compilation of PSUT are presented in Chapter 3 including the presentation of specific PSUT for energy, water and various material flows. Of note is that, unlike monetary flows, physical flows are generally measured in different units depending on the material. Thus, while it is conceptually possible to compile a complete PSUT for all materials using a single measurement unit (e.g. tonnes), it is a complex task.

Classifications for supply and use tables

2.47 In the compilation of supply and use tables in both physical and monetary terms, an important factor is the use of consistent classifications for the main economic units and products. In the SEEA, industries are consistently classified using the *International Standard Industry Classification of All Economic Activities* (ISIC), products are consistently classified using the *Central Product Classification* (CPC), and the determination of whether particular economic units are within a particular national economy is based on the concept of residence (explained further in Section 2.6).

2.3.3 Asset accounts

2.48 The intent of asset accounts is to record the opening and closing stock of environmental assets and the different types of changes in the stock over an accounting period. One motivation for accounting for environmental assets is to assess whether current patterns of economic activity are depleting and degrading the available environmental assets. Information from asset accounts can be used to assist in the management of environmental assets and valuations of natural resources and land can be combined with valuations of produced and financial assets to provide broader estimates of national wealth.

2.49 An asset account is structured as shown in Table 2.3.3. It starts with the opening stock of resources and ends with the closing stock of resources. In physical terms, the changes between the beginning and end of the accounting period are recorded as either additions to the stock or reductions in the stock and wherever possible the nature of the addition or reduction is recorded. In monetary terms, the same entries are made but an additional term is included to record the revaluation of the stock of resources. This entry accounts for changes in the value of assets over an accounting period that are due to movements in the price of resources.

Table 2.3.3 Basic form of an asset account

Opening stock of resources		
Additions to stock of resources		
	Growth in stock	
	Discoveries of new stock	
	Upwards reappraisals	
	Reclassifications	
	Total additions to stock	
Reductions in stock of resources		
	Extractions	
	Normal loss of stock	
	Catastrophic loss	
	Downwards reappraisals	
	Reclassifications	
	Total reductions in stock	
Revaluation of the stock of resources *		
Closing stock of resources		

* Only applicable for asset accounts in monetary terms

2.50 There are many and varied reasons for changes in the quantity and value of a stock of resources over an accounting period. Many of these changes are due to interactions between the economy and the environment – for example due to the extraction of minerals or the replanting of timber resources.

2.51 Other changes in environmental assets are caused by natural phenomena, for example, natural losses of water from reservoirs due to evaporation or catastrophic losses of timber resources due to forest fires. Some changes between the opening and closing stock are more purely accounting in nature and reflect changes due to improved measurement (reappraisals) or due to differences in the definition or composition of the asset (reclassifications). The reassessment of the size and quality of mineral resources is an example of a reappraisal and reclassifications are recorded when there are changes in land use for example between agriculture and urban areas.

2.52 Generally, asset accounts are compiled for individual types of environmental assets. In monetary terms, there may be interest in aggregating the values of all environmental assets at the beginning and end of the accounting period. Such aggregations can be presented in balance sheets, and when combined with the value of other assets (e.g. produced assets and financial assets) and liabilities an overall measure of net worth of an economy can be obtained.

2.53 The capacity to account for and analyse the state of environmental assets and changes in them is a fundamental component of the SEEA. There are however many conceptual and practical measurement challenges, often unique to particular environmental assets. These measurement issues are discussed in detail in SEEA Chapter 5.

The connections between supply and use tables and asset accounts

2.54 The different tables of the central framework are compiled for different purposes and highlight different aspects of the relationship between the economy and the environment. At the same time, there are close links between the supply and use tables and the asset accounts as shown in Table 2.3.4. These connections highlight that the central framework is an integrated system.

2.55 The upper left hand part of Table 2.3.4 shows the supply and use of products measured in monetary terms. The bottom left hand part shows the supply and use of products, natural inputs and residuals in physical terms. In both cases the set of economic units are the same (i.e. enterprises represented in industries, households, government and the rest of the world). It can be seen that the supply and use of products is recorded in the framework in both monetary and physical terms.

2.56 The major change in Table 2.3.4 from a supply and use perspective, is that the flows recorded in the Accumulation and Environment columns of the supply and use tables have been reworked into an asset accounts framework. This is shown in the two right hand columns. The distinction between produced assets and environmental assets highlights the different recording of these flows in the supply and use tables – in particular that the extraction of natural resources is not recorded in the monetary supply and use tables but is recorded in the PSUT as natural inputs.

2.57 The opening and closing stocks for a given period are at the top and bottom of the table respectively. Some of the changes in the stocks are also recorded in the supply and use tables. For example, gross capital formation and natural inputs are included in both tables. Some changes in stocks are not recorded in the supply and use tables and these are grouped together in the cells labelled “other changes in assets”. Examples of these changes include discoveries of mineral resources, losses of assets following catastrophic natural events and changes in the values of assets due to price changes.

Table 2.3.4 Connections between supply and use tables and asset accounts

						ASSET ACCOUNTS (Physical & Monetary terms)	
		Industries	**Household**	**Government**	**Rest of the world**	**Produced assets**	**Environmental assets**
						Opening stock	
MONETARY SUPPLY AND USE TABLE	**Product - supply**	Output			Imports		
	Product - use	Intermediate consumption	Final consumption	Final consumption	Exports	Gross Capital Formation	
PHYSICAL SUPPLY AND USE TABLE	**Natural inputs – supply**						Extracted natural resources
	Natural inputs – use	Inputs of natural resources					
	Product - supply	Output			Imports		
	Product - use	Intermediate consumption	Final consumption		Exports	Gross Capital Formation	
	Residuals - supply	Residuals generated by industry	Residuals generated by household final consumption			Residuals from scrapping and demolition of produced assets Emissions from landfills	
	Residuals - use	Collection & treatment of waste and other residuals				Accumulation of waste in controlled landfills	Residuals flowing to the environment **
						Other changes in assets (e.g. natural growth, discoveries, catastrophic losses, revaluations)	
						Closing stock	

* Note: Grey cells are null by definition. Blank cells may contain relevant flows. These flows are articulated in detail in Chapter 3.
** While these residual flows are not flows of environmental assets they may impact on the capacity of environmental assets to deliver benefits.

2.58 Special mention is required of the final row concerning the use of residuals. Strictly, neither the accumulation of waste in controlled landfills nor the flows of residuals to the environment are recorded in asset accounts for individual environmental assets. However, more broadly, the accumulation of waste in the economy does represent an increase in a stock and flows of residuals to the environment which may well impact on the capacity of environmental assets to deliver ecosystem services. Thus with a different focus for asset accounting, for example with a focus on ecosystems, these flows are relevant.

2.3.4 The sequence of economic accounts

2.59 In monetary terms, monetary supply and use tables and asset accounts record much of the information of interest in the assessment of the interactions between the economy and the environment. However, there are a range of other monetary transactions and flows that are of interest such as payments of rent for the extraction of natural resources, payments of environmental taxes, and payments of environmental subsidies and grants from government units to other economic units to support environmental protection activity.

2.60 These flows are shown in the sequence of economic accounts, shown in a stylised form in Table 2.3.5. It is compiled only in monetary terms because these accounts record transactions that do not have an underlying physical base, for example interest payments. The sequence of accounts follows the structure of the sequence of accounts in the SNA. Of particular importance is the derivation of measures of depletion adjusted income within the sequence of accounts. The sequence of accounts also provides the information required for an assessment of the full economic costs and benefits of environmental activity.

2.61 A particular feature of the sequence of accounts is the presentation of balancing items. Balancing items are calculated as the total value of all inflows to a group of economic units less the total value of all outflows from the same group of economic units. The balancing items provide information in their own right but also link the sequence of accounts together. Key balancing items include value added, operating surplus and saving. Economy wide aggregates can also be constructed such as gross domestic product and gross national income.

2.62 In the SNA, the balancing items and aggregates can be shown after the deduction of the cost of using fixed assets, consumption of fixed capital, to form "net" measures, e.g. net value added, net operating surplus and net domestic product. In the SEEA, the "net" balancing items and aggregates are further adjusted to show a deduction for the using up of natural resources, i.e. depletion. The resulting SEEA balancing items and aggregates are referred to as "depletion adjusted".

Table 2.3.5 Basic SEEA sequence of economic accounts

Production account		
	Main entries	Output, Intermediate consumption, Depletion
	Balancing items	**Gross Value Added, Gross Domestic Product, Depletion adjusted Value added, Depletion adjusted GDP**
Distribution and use of income accounts		
	Main entries	Compensation of employees, Taxes, Subsidies, Interest, Rent, Final consumption, Depletion
	Balancing items	**Depletion adjusted Operating surplus, Depletion adjusted Saving**
Capital account		
	Main entries	Acquisitions and disposals of produced and non-produced assets
	Balancing item	**Net lending/borrowing**
Financial account		
	Main entries	Transactions in financial assets and liabilities
	Balancing item	**Net lending/borrowing**

2.63 The sequence of accounts starts in the production account that is formed using the entries of output and intermediate consumption from the monetary supply and use table. In the case of the production account, the balancing item is value added (output less intermediate consumption). At an economy wide level the main related aggregate from the production account is Gross Domestic Product (GDP). Depletion is deducted from the balancing item of value added and the aggregate GDP to form measures of depletion adjusted value added and depletion adjusted GDP.

2.64 The sequence continues in the distribution and use of income accounts. These accounts contain information on the manner in which value added, i.e. the income directly obtained from production, is allocated to economic units as either compensation of employees or gross operating surplus and on flows of other income and related payments such as flows of taxes, subsidies, interest and rent for the use of land or other environmental assets. A total amount of disposable income (all income received less all income paid) is available for final consumption. The balancing items for the income accounts are operating surplus (value added less compensation of employees and taxes less subsidies) and saving (disposable income less consumption).

2.65 As in the production account, depletion is deducted from the balancing items of operating surplus and saving. The key aggregates from these accounts are national income and national saving and these can both be adjusted for depletion within the sequence of accounts framework.

2.66 The third account is the capital account. This account records how saving is used to purchase assets including produced assets and environmental assets. Thus it records the acquisition and disposal of environmental assets – in particular transactions in land and cultivated biological resources such as plantations and livestock. If the expenditure on assets is less than the amount of saving (assuming saving is positive) then an economy will have resources available to lend to the rest of the world. If the expenditure on assets is more than the amount of saving, then an economy will need to borrow from the rest of the world. The balancing item for the capital account is therefore known as net lending/borrowing.

2.67 The sequence of accounts is completed in the financial account which records the transactions involved in lending and borrowing. The financial account shows all transactions in financial assets and liabilities (e.g. deposits, loans, shares and equities). The balance of these transactions is net lending/borrowing, the same as the capital account balancing item.

2.68 The sequence of accounts can be complemented by balance sheets that record the values of all assets and liabilities at the beginning and end of an accounting period. The balancing item for a balance sheet is net worth representing the total value of all assets less the value of all liabilities.

2.69 A more detailed description of the sequence of accounts and the derivation of depletion adjusted measures is presented in Chapter 6. The definition and measurement of depletion is discussed in Chapter 5.

2.3.5 Functional accounts

2.70 While monetary supply and use tables can be used to organise and present certain types of transactions of particular relevance to the environment, environmentally related transactions within supply and use tables usually require additional disaggregation because the conventional industry and product classifications do not necessarily highlight environmental activities or products.

2.71 The approach taken in the SEEA is first to define the activities, goods and services that have an environmental purpose (i.e. their primary purpose is to reduce or eliminate pressures on the environment or to make more efficient use of natural resources). And second, to reorganise relevant information in scope of the monetary supply and use table and the sequence of accounts to clearly identify the environmentally related transactions associated with the environmental activities and environmental goods and services.

2.72 By highlighting environmental activities and products, information can be presented on the economic response to environmental issues. Particular flows of interest are the output of environmental goods and services, expenditures on environmental protection and resource management as well as environmental taxes and subsidies.

2.73 The construction of functional accounts and associated information is discussed in detail in Chapter 4.

2.3.6 Demographic and employment information

2.74 The usefulness of information within the SEEA can be enhanced by relating different environmental and economic data to estimates of population and various demographic breakdowns such as by household income levels and other detailed information by household characteristics related to material well-being. This information may be useful in assessing issues such as resource availability, changes in energy use and sources of emissions. Accounting for differences in population size and structure is also important for international comparisons of environmental and economic data.

2.75 Employment information such as the number of people employed, the number of jobs and the number of hours worked may be of particular interest in the assessment of environmental activity from an industry perspective. In particular, there is likely to be interest in employment indicators related to the production of environmental goods and services.

2.76 Data on population and labour inputs may need to be adjusted in order to be consistent with the concepts, definitions and classifications of the SEEA, in particular to align with the concept of residence. Relevant information can be found in the 2008 SNA, Chapter 19.

2.4 Combining physical and monetary data

2.4.1 Introduction

2.77 The presentation of information in a consistent format that combines integrated physical and monetary data is one of the strongest features of the SEEA. This feature enables the SEEA to provide a wide range of information on specific themes (e.g. water, energy, air emissions) to compare related information across different themes and to derive indicators that require the use of both physical and monetary data.

2.78 Given the integrated accounting structures for physical and monetary accounts and statistics, it is logical to use these structures and the common underlying accounting rules and principles to present both physical and monetary information. Such integrated formats have sometimes been referred to as "hybrid" presentations or accounts because they contain data in different units. However, even though the measurement units are different, the data sets are presented following common classifications and definitions, and hence these presentations are referred to as combined physical and monetary presentations in the SEEA.

2.79 Different forms of combined physical and monetary presentations are possible and, indeed, there is no standard form for these presentations or accounts. Commonly, physical flow data is presented alongside information from monetary supply and use tables but even for this basic structure different combinations are possible. Ultimately, the structures of combined presentations of monetary and physical data are dependent on the availability of data and the question under investigation.

2.80 While no standard structure can be defined, compiling and contrasting monetary and physical data in meaningful ways is at the heart of the SEEA philosophy. This section provides a general introduction to combined physical and monetary presentations. Chapter 6 discusses the compilation of these presentations and provide examples of potential presentations on particular themes, such as energy and water. More detailed presentations involving structures such as input-output tables, the full sequence of economic accounts or presentations that cover a particular theme or topic, for example fisheries, are considered in SEEA Extensions and Applications and in targeted thematic SEEA publications (such as on water and energy).

2.4.2 The concept of combining physical and monetary data

2.81 At the core of combining physical and monetary data is the logic of recording physical flows in a manner compatible with economic transactions as presented in the SNA. This linkage guarantees a consistent comparison of environmental burdens with economic benefits, or environmental benefits with economic costs. This linkage could, in principle, be examined not only at the national level but also at disaggregated levels, for example, in relation to regions of the economy, or specific industries, or for the purpose of examining the flows associated with the extraction of a particular natural resource or the emissions of a particular material.

2.82 Because these presentations combine physical data that may be of more immediate use to scientists, with monetary data familiar to economists, they also have the potential to form a bridge between these two schools of concern about the environment.

2.83 It is reinforced that it is quite legitimate to include only a limited set of variables, depending on the most urgent environmental concerns to be taken into consideration and it is not necessary to complete an exhaustive physical supply and use table to be able to present combinations of physical and monetary data.

2.84 A combined physical and monetary presentation thus represents an analytical framework showing which parts of the economy are most relevant to specific indicators and how changes in the economic structure influences 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.

2.85 At finer levels of disaggregation, combined presentations can provide the research community with access to a structured database for further research into the role of these indicators in monitoring the overall environmental performance of national economies. In particular datasets with combinations of physical and monetary data may be of direct use in the development of environmental-economic models.

2.5 Accounting for flows and stocks

2.5.1 Introduction

2.86 The compilation of supply and use tables, asset accounts, the sequence of economic accounts, functional accounts, and the incorporation of demographic and employment information, requires an understanding of the concepts of stocks and flows in both physical and monetary terms. This section presents the general framework for the recording of stocks and flows in both physical and monetary terms.

2.5.2 Flows

Flows in physical terms

2.87 Physical flows are reflected in the movement and use of materials, water and energy. As introduced earlier in this chapter, the three types of physical flows are natural inputs, products or residuals.

2.88 Natural inputs are all physical inputs from the environment that are moved from their location in the environment as a part of economic production processes or are directly incorporated into economic production processes. They may be (i) natural resource inputs, such as mineral and energy resources or timber resources, (ii) inputs from renewable energy sources, such as solar energy captured by economic units, or (iii) other natural inputs such as inputs from soil (e.g. soil nutrients) and inputs from air (e.g. oxygen absorbed in combustion processes).

2.89 During the extraction of some natural resource inputs not all extraction is retained in the economy. For example in fishing operations there is an amount of discarded catch and in timber harvesting there is an amount of felling residues. The extraction that is not retained in the economy is considered to immediately return to the environment and is considered a natural resource residual.

2.90 Products are goods and services that result from a process of production in the economy. They are defined consistently with the definition of products in the SNA. Generally, products are evidenced by a transaction of positive monetary value between two economic units – for example the production and sale of a car from manufacturer to a purchaser. For accounting purposes, generally only flows of products between economic units are recorded and flows internal to the operation of an enterprise are ignored. However, depending on the purpose and field of analysis, it may be relevant to record these internal flows. For example, in the analysis of energy flows it may be relevant to record the generation of energy by an enterprise by burning its own solid waste.

2.91 Residuals are physical flows of solid, liquid and gaseous materials and energy that are discarded, discharged or emitted by establishments and households through processes of production, consumption or accumulation. Residuals may be discarded, discharged or emitted to the environment (for example emissions to air) but may also flow within the economy – such as when solid waste is collected as part of a waste collection scheme.

2.92 Physical flows are often separated into three categories for the purpose of constructing physical supply and use tables. These three categories are energy, water and materials. Materials themselves are often analysed by type of material or specific groups of materials for example flows of solid waste or carbon emissions. The three categories of physical flows from three distinct but related accounting sub-systems which each take a different perspective on physical flows. For example, analysis of coal and oil may focus on the energy content or on the mass and volume of the materials. Thus, there are connections between each sub-system. The three sub-systems are described in more detail in Chapter 3.

2.93 Physical flows are also recorded in asset accounts where they represent changes in the stocks of assets between one period and another. These flows may consist of natural inputs, products and residuals as defined but other physical flows may also be recorded in asset accounts. For example, flows of evaporation from natural lakes and precipitation into natural lakes will alter the stock of water resources in the lakes and hence must be recorded in the asset account. However, these natural processes are considered environment to environment flows and hence are not within the scope of the supply and use tables as natural inputs, products or residuals.

2.94 An important flow in physical terms that is recorded in the asset accounts is depletion. Depletion relates to the physical using up of environmental assets through extraction, abstraction and harvest by economic units such that there is a reduced availability of the resource in the future at current extraction rates. Estimates of the flow of depletion must consider whether the natural resource is non-renewable (such as mineral and energy resources) or renewable (for example, timber and fish resources). For non-renewable resources, the physical flow of depletion relates directly to the quantity of resource extracted. However, in the case of renewable resources, the capacity for the natural resource to regenerate over time must be taken into account. Depletion is discussed in detail in Chapter 5.

Flows in monetary terms

2.95 Flows in monetary terms are recorded in a manner completely analogous to the SNA definition of economic flows. Two broad types of economic flows are defined in the SNA – transactions and other flows. A transaction is an economic flow that is an interaction between economic units by mutual agreement such as sales of timber products or purchases of environmental protection services. Other flows relate to changes in the value of assets and liabilities that do not result from transactions. Examples are new discoveries of assets or losses of assets due to natural disasters and the effect of price changes on the value of assets and liabilities.

2.96 Many transactions relate to exchanges of products between economic units. Products may be sold on markets for intermediate or final use, they may be produced for own final use by economic units (either for consumption or investment purposes) or they may be services produced by governments that are not sold on markets. The products not sold on markets are called non-market products.

2.97 Product flows are recorded in monetary terms in the monetary supply and use table. Flows in monetary terms are also recorded in the asset accounts and the other accounts that comprise the full sequence of accounts following the application of certain valuation and other accounting rules. These rules are discussed in more detail in Section 2.6.

2.5.3 Stocks

Stocks in physical terms

2.98 In physical terms, stocks refer to the total quantity of assets at a given point in time. In the Central Framework, the measurement is focused on recording the physical stocks of individual environmental assets, such as tonnes of coal, cubic metres of timber and hectares of land.

2.99 Individual environmental assets comprise mineral and energy resources, land, soil resources, timber resources, aquatic resources, other biological resources and water resources. These individual assets are generally defined by their material content such as soil volume without specific reference to their individual elements such as the nutrients in soil resources.

2.100 The volume of water in the ocean is not considered in scope of water resources in the Central Framework because the stock of water is too large to be meaningful for analytical purposes. The exclusion of the ocean in terms of a volume of water resources does not in any way limit the measurement of ocean-related individual components such as aquatic resources (including fish stocks on the high seas over which a country has harvesting rights) and mineral and energy resources on the ocean floor.

2.101 In principle, for each environmental asset, the measurement scope includes all stocks that may provide benefits to humanity. In practice, a specific measurement boundary is defined for each environmental asset in the Central Framework and the relevant approaches to measurement of environmental assets in physical terms are discussed in detail in Chapter 5.

2.102 Environmental assets also encompass ecosystems and ecosystem services. The measurement of ecosystems in terms of both material and non-material benefits from the environment, and in terms of the capacity of ecosystems to provide ecosystem services, is a maturing area and relevant techniques are discussed in SEEA Experimental Ecosystem Accounts.

Stocks in monetary terms

2.103 The measurement of stocks in monetary terms focuses on the value of individual environmental assets and changes in those values over time. In the Central Framework, the valuation of these assets focuses on the benefits that accrue to economic owners of environmental assets. In this regard, the approach to measuring stocks of environmental assets in monetary terms aligns with the definition and treatment of economic assets in the SNA.

2.104 In the Central Framework, there is no aim to place a monetary value on all of the benefits that may accrue to current and future generations and hence provide what might be regarded as social valuations of environmental assets. The consideration of the value in monetary terms of a broader range of benefits from the environment is discussed in SEEA Experimental Ecosystem Accounts.

2.105 Since in physical terms, the conceptual scope for each individual component is broad extending to include all of the resources that may provide benefits to humanity, there may be some stocks recorded in the SEEA in physical terms that have a zero economic value. For example, all land within a country is within scope of the SEEA to allow for a full analysis of changes in land use and land cover, but in monetary terms some land may be considered to have zero value.

2.106 Table 2.5.1 shows the scope of the different measures of environmental assets in the SEEA.

Table 2.5.1 The scope of environmental assets in SEEA

	Central framework	**Experimental Ecosystem Accounts**
Physical terms	Individual environmental assets	All (from ecosystem perspective)
Monetary terms	Individual environmental assets with economic value consistent with SNA	All (from ecosystem perspective)

2.107 Ideally, following SNA, the preferred approach to the valuation of assets is the use of market values. However, for many environmental assets there are few markets that buy and sell the assets in their natural state and hence determining whether an asset has an economic value can be difficult. A number of approaches to estimating market prices are possible if observable market prices for assets do not exist. Most commonly in these cases, the SEEA recommends that valuation be undertaken using the Net Present Value (NPV) approach. This approach uses estimates of the expected economic benefits that can be attributed to an environmental asset, for example profits from the sale of mineral resources, and then discounts the expected economic benefits to give them a value in the current period. The NPV approach is described in Chapter 5.

2.6 Economic units

2.6.1 Introduction

2.108 In addition to defining various stocks and flows, the key component in accounting for the interaction between the economy and the environment is the definition of the economic units involved.

2.109 For the central framework, the units involved are economic units who interact with each other and that are able to make decisions about the production, consumption and accumulation of goods and services. They are classified in different ways depending on the type of analysis being undertaken. The description of these economic units is the focus of this section. The section concludes with a discussion on reporting units for statistical purposes. In this context, both economic units and "units" within the environment – for example river basins and mineral deposits, are relevant considerations.

2.6.2 Institutional sectors

2.110 The starting point for considering economic units is a focus on the purposes, objectives and behaviours of individual economic units. Institutional units are those individual economic units that are capable of owning assets, incurring liabilities, and engaging in transactions and other economic activities with other economic units. These institutional units may be either households, or legal or social entities (such as corporations) that are recognised independently of the people that own or control them. Groupings of units that are similar in their purposes, objectives and behaviours are defined as institutional sectors.

2.111 The SEEA, following the SNA, recognises five types of institutional sector. Households, Non-financial corporations, Financial corporations, General government and Non-Profit Institutions Serving Households (NPISH). Although important in the context of the SNA, the distinction between non-financial and financial corporations is not significant in the SEEA and hence, generally, these are presented as one sector, Corporations. The 2008 SNA Chapter 4 defines and describes the different institutional sectors in detail.

2.112 Institutional sectors are of particular interest in the SEEA in considering the ownership of environmental assets (an issue discussed in Chapter 5 with particular emphasis on the ownership of mineral and energy resources) and in the development of a full sequence of accounts. The full sequence of accounts records a range of transactions between economic units, for example payments of rent on environmental assets, that are usefully analysed from the perspective of institutional sectors rather than by industry or activity.

2.113 A full accounting of transactions and flows requires consideration of flows to and from the rest of the world including flows to and from international organisations. In theory, as for a national economy, the rest of the world is also composed of institutional sectors of the types listed above. Generally, however, the accounting framework defines the rest of the world as a single institutional sector for ease of compilation and presentation.

2.6.3 Enterprises, establishments and industries

2.114 An enterprise is the view of an institutional unit as a producer of goods and services. It can own assets and acquire liabilities and has the capacity to engage in transactions and other economic activities with other economic units.

2.115 An enterprise may be comprised of one or more establishments and hence may be located across multiple locations within a single economy. An establishment is a unit situated in a single location and within which only a single type of productive activity is carried out or within which a single productive activity (the primary activity) accounts for most of the value added.

2.116 The ability to define and observe establishments and enterprises and determine the types of goods and services they produce is at the heart of supply and use accounting. Meaningful analysis can be undertaken at an aggregate level by grouping units that undertake similar types of productive activity and by grouping goods and services that display similar characteristics.

2.117 In the SEEA, as in the SNA, the groupings of establishments that undertake similar types of productive activity are referred to as industries. Industries cover, broadly speaking, agriculture, mining, manufacturing, construction and services. Ideally, an industry is composed of establishments that undertake the same activity and only that activity – i.e. the grouping would be homogenous. In practice, many establishments undertake a variety of activities but must have a primary activity that can be used to classify them to a specific industry class.

2.118 In both physical and monetary terms the activities undertaken within establishments are referred to as "own-account" activities. In the SNA, own-account activity covers activity undertaken for either the final consumption or investment of the economic unit (own account final use). The SNA does allow the possibility of recording separately some own account intermediate use activity, described as ancillary activity, but this is limited to a specific set of activities.[4]

2.119 For some purposes of environmental and economic accounting, it may be relevant to identify the secondary activities of an establishment and also activities undertaken within an establishment but where output is not sold to other units. This is particularly the case in accounting for physical flows of energy where measuring all transformations of energy products is likely to be of interest. Generally however, the recording of physical flows internal to establishments is only undertaken in specific circumstances.

2.120 In the compilation of functional accounts, it may be relevant to identify the secondary and other activities of establishments that are being undertaken for environmental purposes such that a complete description of relevant activity can be made. An example of such activity is the incineration of solid waste or biogas to produce electricity for use by the firm. For the

[4] See 2008 SNA paragraphs 5.35 - 5.45.

compilation of functional accounts on environmental activities and environmental goods and services, the SEEA aims to separately identify these types of activities. They are valued in monetary terms using information on the associated input costs such as intermediate consumption of goods and services and compensation of employees.

2.121 A particular case of own-account activity in both physical and monetary terms concerns households. The activities of households, in both the use of natural resources (e.g. the collection of fuel wood and water) for own consumption and in the undertaking of environmental protection and resource management activity (e.g. the installation of solar panels on houses) are of interest in the SEEA. As in the SNA, where the activity is of significance its activity is recorded together with that of other units undertaking the same activity.

2.6.4 Geographic boundaries for economic units

2.122 A key feature of the SEEA is that it aims to account for the interaction between the economy and the environment at a national level. The geographical boundary that defines the scope of an economy is based on the concept of economic territory. Economic territory is the area under effective control of a single government. It includes the land area of a country including islands, airspace, territorial waters and territorial enclaves[5] in the rest of the world. Economic territory excludes territorial enclaves of other countries located in the reference country.

2.123 A national economy comprises the set of all institutional units that are resident in an economic territory, i.e. the unit has its centre of predominant economic interest in a particular economic territory. In general, there will be a large overlap between those units that are resident and those units located within the geographically defined boundaries of a country. There are three primary exceptions

i. Units intending to operate in a country for less than a year, for example, specialised construction firms or aid and relief agencies. These are considered residents of their home country.

ii. Resident producing units may operate outside of the national territory, for example ships and aircraft, and fishing operations in international and other nation's waters. In these cases they are considered to remain residents of their national economy regardless of their location of operation.

iii. Residents of a national territory may stay temporarily in other countries for work or leisure. The consumption undertaken by such residents in other countries is considered to be resident consumption abroad. The consumption is recorded as an import of the country in which the person is resident and an export of the country visited.

[5] Territorial enclaves include embassies, consulates and military bases and the operations of international organizations.

2.124 The use of this geographic scope of the economy aligns with the scope of the economy as defined in the SNA thus allowing a strong alignment between flows in physical and monetary terms. However, this geographic boundary is different from that commonly used for some important environmental statistics such as air emissions and energy statistics. Where these statistics are an information source for the compilation of SEEA accounts, adjustments to the statistics data are likely to be needed to account for differences in geographic coverage.

2.125 Accounting in both physical and monetary terms at sub-national levels may be appropriate for specific environmental and economic accounting issues, for example the management of water resources using information at the level of river basins. It is noted however, that while physical data may be available for such geographic areas, corresponding economic data may not be readily available.

2.6.5 Measurement units for statistical purposes

2.126 The discussion of economic units in this section has focused on the ability of these units to operate within an economy as active participants. In statistical terms, these units are often also the focus of measurement as units of observation or reporting units. Depending on the structure of information within a country, economic data are likely to be available for most types of economic unit, particularly for enterprises and, in some cases for individual establishments. However, since the ownership structures of enterprises can vary significantly and since some enterprises may produce a range of different products matching the conceptual model to the information available may not be straightforward.

2.127 In the physical supply and use table the environment is added as an additional column alongside enterprises represented as industries, households and the rest of the world. However, in the Central Framework the environment is not considered an additional type of unit akin to economic units. Rather the environment is seen as passive with decisions regarding the supply of natural inputs to the economy and the receipt of residuals from the economy being made by economic units.

2.128 At the same time, the collection of information about the environment, particularly as it concerns environmental assets, requires consideration of appropriate environmental measurement units for statistical purposes. These measurement units reflect the parts of the environment about which statistics may be collected and presented. Examples include inland water bodies (lakes, rivers, etc), mineral deposits, forests and fish stocks. In some cases, it will be possible to align the environmental measurement unit and an associated economic unit but this should not be expected.

2.129 An alternative perspective on the environment is to consider that the environment plays a more active role. From this perspective the environment can be conceived as a set of ecosystem “units” that supply ecosystem services to the economy and whose capacity to deliver those services may change over time. The development of approaches to defining and categorising ecosystem units is introduced in Chapter 5.6 and discussed in detail in SEEA Experimental Ecosystem Accounts.

2.7 Accounting rules and principles

2.7.1 Introduction

2.130 The recording of accounting entries requires the use of a consistent set of accounting rules and principles. Without these, related transactions and flows may be recorded on different bases, at different times and with different values thus making accounting and reconciliation difficult and far less useful.

2.131 The SEEA follows the same accounting rules and principles as the SNA. This section introduces the rules and principles of most relevance to the SEEA. Readers are encouraged to refer to the 2008 SNA Chapter 3 for more detail.

2.7.2 Recording rules and principles

Double and quadruple entry accounting

2.132 A key feature of accounting in the SEEA is the consistency that is applied in the recording of transactions between different economic units.

2.133 From the perspective of a single economic unit the principle of vertical double entry accounting is applied. This requires that for each transaction there are two entries. There is an entry of output, consumption, investment, property income or transfer and there is a corresponding entry showing the increase or decrease in financial assets or liabilities.

2.134 For example, the purchase of fish by a household will be reflected as both an increase in consumption and a decrease in cash (presuming the purchase was paid for in this way).

2.135 Since the focus of the SEEA is not on accounting for individual units but on accounting for all units in the economy, the double entry accounting principle must be extended to ensure that a single transaction is recorded in the same way by both parties. This is known as quadruple entry accounting.

2.136 Thus, the purchase of fish by a household is an increase in consumption and decrease in cash for the household and, at the same time, decrease in inventory and an increase in cash for the fisherman. All four entries must be recorded to ensure that the accounting is complete.

2.137 While all of these entries are required for accounts in monetary terms, in physical terms the associated transactions in financial assets (cash in this example) are not recorded.

Time of recording

2.138 One requirement of the quadruple and horizontal double entry accounting principles is that transactions and other flows must be recorded as occurring at the same point in time in the various accounts for both units involved.

2.139 In monetary accounts, the general principle is that transactions are recorded when ownership changes and the corresponding claims and obligations arise, are transformed or are cancelled. Transactions internal to one unit are recorded when economic value is created, transformed or extinguished. This time of recording is called an accrual basis.

2.140 The key distinction to be monitored with respect to timing is that the time of the transactions under an accrual basis of recording may not align to the time the cash flow associated with the transaction occurs. For example, if a good is purchased and the purchaser is invoiced for payment within 30 days, the time of recording under an accrual approach is the date of the purchase not the date when the invoice is paid.

2.141 Ideally, the time of the recording of physical flows should align with the time of recording of the flows in monetary terms on an accrual basis. However, in practice environmental processes may operate on quite different cycles and timeframes compared to the standard calendar and financial years used in monetary accounting. For example, in the case of water resources, the hydrological year does not correspond to a calendar year.[6] Adjustments to account for different underlying cycles of data in physical and monetary terms should be made as required.

Units of measurement

2.142 For accounts compiled in monetary terms, all entries in the accounts must be measured in terms of money and therefore the components from which the entries are built up must be measured in terms of money. In most cases, the amounts entered are the actual transactions that form part of flows that involve money. In other cases the amounts entered are estimated by reference to other equivalent monetary values (for own-account consumption) or valued at the cost of production (for non-market output).

2.143 For accounts compiled in physical terms, the unit of measurement will vary depending on the type of asset concerned. Thus flows of energy are generally measured in energy content, such as joules, stocks and flows of water are generally measured in volume, such as cubic metres, and stocks and flows of other materials are generally measured in mass units such as tonnes. The details regarding the choice of measurement unit are outlined in the description of specific accounts.

2.144 A common principle is that within a single account in physical terms only one unit of measurement should be used such that aggregation and reconciliation is possible across all accounting entries. It is noted however, that in combined presentations of physical and monetary data a range of measurement units might be involved.

[6] A hydrological year is a 12 month period such that the overall changes in storage are minimal and carryover is reduced to a minimum (International Glossary of Hydrology, 2nd ed., UNESCO/WMO 1992)

2.7.3 Valuation rules and principles

Valuation at market prices

2.145 For accounts in monetary terms the question of valuation is central. In the SEEA, as in SNA, the values reflected in the accounts are, in principle, the current transaction values or market prices for the associated goods, services, labour or assets that are exchanged.

2.146 Strictly, market prices are defined as amounts of money that willing buyers pay to acquire something from willing sellers. The exchanges should be made between independent parties on the basis of commercial considerations only, sometimes called “at arm’s length”.

2.147 Defined in this way, a market price should be distinguished from a general market price that gives an indication of the “average” price for exchanges in a type of good, service or asset. In most cases, market prices based on the totality of transactions that actually occur will be equal to the general “average” market prices just described. However, there are some transactions where this is not the case, for example in the case of transfer pricing between affiliated enterprises and concessional pricing by government units. Corrections should be considered in such situations in order to get closer to normal market price equivalents.

2.148 When market prices are not observable, valuation according to market-price-equivalents should be used to provide an approximation to market prices. A particular example of the need to apply market price principles is the recording of goods and services produced and used on own-account and more generally the valuation of non-market production. Following the SNA, such production should be valued as the sum of the costs of production namely: intermediate consumption, compensation of employees, consumption of fixed capital, a net return to fixed capital and other taxes less subsidies on production.

2.149 Special considerations are required in the application of the market price principle to the valuation of assets, particularly non-produced assets such as mineral and energy resources, natural aquatic resources and natural timber resources. A number of techniques are suggested in the SNA[7] for the estimation of market prices of assets in situations where there are no developed asset markets. A full description of the different techniques and approaches relevant to environmental and economic accounting, including discussion on the use of Net Present Value (NPV) approaches, is in SEEA Chapter 5.

2.150 The use of market prices in the SEEA must be distinguished from the potential to adopt social valuations in the pricing and valuation of environmental assets. Social valuations take into account a broader range of benefits and costs than are considered in the individual, exchange level, market prices used in the SEEA. The measurement of this broader set of social benefits and costs is not standardised and is not discussed directly in the context of the central framework of the SEEA although the issue does arise in the consideration of the choice of discount rate to be used in the application of the NPV approach. This is discussed in detail in Annex A5.2.

[7] See 2008 SNA Chapters 10 and 13.

Basic, producer and purchaser's prices

2.151 Transactions in products involve two economic units. For a number of reasons, the amount ultimately received by the producer or supplier of the product is likely to differ from the amount paid by the purchaser. These reasons include the addition of taxes to the price of a product, the addition of transport costs to deliver the product from producer to final purchaser, the inclusion of wholesale and retail margins and the receipt of subsidies by the producer. To take these different factors into account three different kinds of prices are defined reflecting the prices from supply and use perspectives. The relationship between these three prices is shown in Figure 2.6.1.

Figure 2.6.1: Basic, producers' and purchasers' prices

Basic prices *plus*
Taxes on products excluding invoiced VAT *less*
Subsidies on products *equals*
Producers' prices *plus*
VAT not deductible by the purchaser *plus*
Separately invoiced transport charges *plus*
Wholesalers' and retailers' margins *equals*
Purchasers' prices

2.152 Two kinds of prices are used from a supply perspective, basic prices and producers' prices. The basic price is the amount receivable by the producer from the purchasers for a unit of a good or service produced as output, minus any taxes payable on the product plus any subsidy receivable by the producer as a consequence of its production or sale. The basic price excludes any transport charges invoiced separately by the producer and any wholesale and retail margins that may be applicable.

2.153 The basic price measures the amount retained by the producer and is, therefore, the price most relevant for the producer's decision making.

2.154 The producers' price is the amount receivable by the producer from the purchaser for a unit of a good or service produced as output minus any VAT, or similar deductible tax invoiced to the purchaser. The producers' price excludes any transport charges invoiced separately by the producer.

2.155 The purchasers' price is the amount paid by the purchaser, excluding any VAT or similar tax deductible by the purchaser, in order to take delivery of a unit of a good or service at the time and place required by the purchaser. The purchasers' price of a good includes any transport charges paid separately by the purchaser to take delivery at the required time and place. This is the price most relevant for the purchaser.

2.156 The differences between the three sets of prices are most important in the compilation of monetary supply and use tables. When compiling monetary supply and use tables in basic prices the transport charges and wholesale and retail margins are allocated to the relevant services (transport, wholesale and retail services) rather than being deducted from the table as a whole. Full details on the appropriate valuation approaches in the compilation of monetary supply and use tables are contained in the 2008 SNA Chapter 14.

2.7.4 Volume measures

2.157 For estimates compiled in monetary terms, the changes over time in the values of goods and services can be decomposed into two components: changes in prices and changes in volumes. These volumes are not equivalent to measures of the physical volume of solids, liquids or gases but instead relate to an economic notion of volume which encompasses both the changes in quantity and quality of goods, services and assets. Thus for example, the economic notion of volume would include increases in the number of cars produced (or their mass) as well as improvements in the quality of the cars. Thus even if the number of cars produced remained the same over time there may be an increase in volume if the quality of cars improved.

2.158 The measurement of economic activity in terms of volumes rather than values is commonly referred to as measurement in “constant prices”. Volume measures are particularly important for the measurement of economic growth which is generally understood as the volume increase in key aggregates, such as gross domestic product.

2.159 The compilation of volume measures is undertaken by removing the effect of price change from a time series of transactions in products, income flows or asset values. Ideally, detailed information on the price changes of individual products or assets is weighted together to provide price indices that reflect changes in the prices of the specific products or assets of interest. Where such detail is not available, it is necessary to use general measures of price change, i.e. measures of inflation, rather than specific price indices. Volume measures derived using general price indices are commonly referred to as “real” measures. Real measures are often derived in cases where it is necessary to remove the effects of changes in purchasing power from measures of income.

2.160 Volume measures, particularly those for production and consumption, are essential in the assessment of environmental-economic trends. They may help illustrate the extent to which the economy becomes more or less efficient in terms of resource inputs or residual outputs. More generally, such assessments may indicate to what extent economic growth is coupled to, or can be decoupled from, environmental pressures such as the use of natural resources as inputs to economic production or emissions from production.

2.161 An important application of volume measures is in the derivation of volume measures of the value of stocks of environmental and other assets. The analysis of changes in total economic wealth is enhanced when the impact of price changes on the changing values of assets is removed.

2.162 A general description of methods for deriving measures of assets in volume terms is provided in Chapters 5 and 6. Details regarding their theoretical basis and their compilation are presented in the 2008 SNA Chapter 15 and in international manuals on the compilation of consumer and producer price indices.[8]

[8] See *Consumer Price Index Manual: Theory and Practice* (2004), ILO/IMF/OECD/UNECE/Eurostat/World Bank and *Producer Price Index Manual: Theory and Practice* (2004), ILO/IMF/OECD/UNECE/World Bank

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Chapter 3: Physical flow accounts

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3.1 Introduction

3.1 An economy cannot function without drawing in natural resources and other inputs from the environment and using the environment to absorb the unwanted by-products of economic production. Measuring the flows of particular natural inputs into the economy and releases of residuals from the economy can therefore provide instructive information. This measurement is generally carried out using physical units of measure.

3.2 The usefulness of this information is considerably strengthened when it is organised using the same framework as used to assess economic flows in monetary terms. The use of the same framework, as outlined in this chapter, allows consistent analysis of the relationships between the flows of natural inputs and economic activity, the relationships between economic activity and the releases from the economy, and significantly, the relationships between the flows in physical and monetary terms. The organisation and combined presentation of both physical and monetary flows on specific topics is discussed in Chapter 6.

3.3 The framework for measuring physical and monetary flows is also aligned with the framework for the measurement of environmental assets as presented in Chapter 5. This is a particularly important connection for natural resource flows and for the assessment of production processes in extracting industries. Relevant flows are recorded both in the asset accounts and in physical supply and use tables.

3.4 The use of the SEEA framework allows robust indicators to be established concerning the consumption of resources relative to economic indicators such as output and value added, since there is a parallel in the underlying accounting principles. Indicators on energy use, water consumption and air emissions by industry are further examples of the potential uses of data organised in a coherent and consistent manner.

3.5 The compilation of data on physical flows requires the use of a range of data sources and classifications. While this chapter provides an overall framework for this compilation work, more detailed guidance on specific topics, for example energy, air emissions and water, can be found in other handbooks, manuals and guidelines. References to relevant publications are presented at the end of this book.

3.1.1 The physical flow accounting framework and sub-systems

3.6 The physical flow accounting framework presented in this chapter is intended to provide a set of accounting principles and boundaries within which a consistent recording of all types of physical flows relating to economic activity can be made. Most commonly, the recording of physical flows will focus on particular areas of interest, in part due to the fact that physical flows may be measured in a variety of units that cannot necessarily be compared, and in part due to the breadth and complexity of recording all relevant physical flows in a single account. Therefore, while the chapter presents a complete accounting framework for all physical flows it is expected that compilers will focus on the application of the general principles in specific areas, such as the measurement of physical flows of energy, water, air emissions and solid waste.

3.7 The framework for the measurement of physical flows is based on the structure of the monetary supply and use tables used to measure economic activity. In broad terms these tables show monetary transactions in products between industries, households, government and the rest of the world. These tables are based on the principles outlined in the 2008 SNA and are introduced in Chapter 2.

3.8 The same structure can be used to record the underlying physical flows relating to the monetary transactions between the different economic units. Further, flows to and from the environment can be linked in by adding relevant columns and rows to the monetary supply and use table. These additions yield a physical supply and use table (PSUT) that can record all physical flows: (i) from the environment, (ii) within the economy and (iii) back to the environment.

3.9 However, unlike monetary transactions, it is not immediately obvious that all physical flows can simply be aggregated or that all physical flows should be recorded in a similar way. Consequently, three different sub-systems have developed within the broad supply and use framework – material flow accounting[9], water accounts and energy accounts.

3.10 Key features of the three sub-systems are:

- In all three sub-systems physical flow accounting involves recording flows from the environment to the economy, flows within the economy, and flows back to the environment.
- In material flow accounting flows are measured in terms of mass (e.g. tonnes). In water accounts the unit of measurement is volume (e.g. cubic metres) and in energy accounts the unit of measurement is energy content (e.g. joules)[10].
- In energy accounts there is consideration of flows of energy such as from geothermal sources, solar radiation, etc and these flows are not considered flows of materials in a material flow accounting context. At the same time a significant part of energy input is carried by physical substances, referred to as fuels, and these items are within scope of both energy accounts and material flow accounts – noting that they are measured in different units in the different accounts.

3.11 Within each of these sub-systems of physical flow accounting finer levels of focus can be undertaken consistent with the general principles of PSUTs. This is especially the case with regard to material flow accounts. At an aggregate national level, i.e. summing all industries, Economy Wide Material Flow Accounts (EW-MFA) can be compiled. Another perspective is to focus on the

[9] Material flow accounting includes the recording of physical flows of products, air emissions, solid waste and other residual flows.

[10] Energy content is measured on a net calorific value basis. Energy accounts may also be measured in terms of the mass of particular energy products but such accounts exclude the energy supplied from renewable sources such as solar and wind energy and are not discussed in this chapter.

construction of detailed accounts relating to individual products, or on the flows of different types of residuals such as emissions to air or solid waste.

3.12 There may also be interest in looking at only one part of the physical flows, for example energy use by industries and households, rather than considering these flows in conjunction with energy supply. Nonetheless, even in this narrower case, the same concepts, definitions and standards are applied such that the organisation of data and the development of broader information systems can be supported.

3.13 Measuring physical flows requires large amounts of basic data, consistent classifications and units of measurement 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 and accounts can be applied.

3.14 Therefore, while this chapter aims to provide a comprehensive overview of the systems of physical flows in common use, it should be recognized that a complete implementation of the accounts presented here is very ambitious and by no means always necessary since useful analysis can be done with any of the individual components of a full set of physical flow accounts.

3.1.2 Chapter structure

3.15 This chapter explains the physical supply and use approach in section 3.2 including definition of natural inputs, products and residuals. These definitions are fundamental in defining the boundaries between the environment and the economy and hence in constructing meaningful supply and use tables.

3.16 In section 3.3 a range of general accounting matters are discussed including gross and net recording of flows and the treatment of flows between countries.

3.17 The final three sections of the chapter discuss the measurement of individual physical flow accounts. Energy accounts are discussed in Section 3.4, Water accounts are discussed in Section 3.5 and a number of material flow accounts, including air emission, water emission and solid waste accounts, are discussed in Section 3.6.

3.2 The physical flow accounting framework

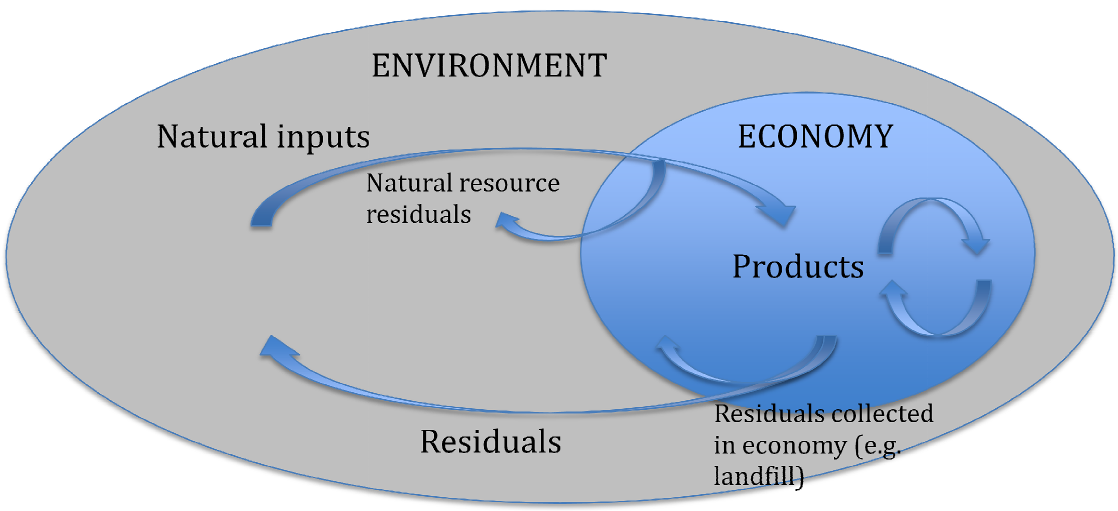
3.18 This section introduces the physical supply and use approach to physical flow accounting through the introduction of the broad framework and its underlying accounting principles and then the definitions of the three key flows – natural inputs, products and residuals.

3.2.1 The physical supply and use table approach

3.19 As explained in Chapter 2, in the context of measuring physical flows related to supply and use, the economy is defined by the production boundary of the SNA. The production boundary comprises a specific set of economic activities carried out under the control and responsibility of an institutional unit in which inputs of labour, capital, and goods and services are used to produce outputs of goods and services (products).[11] The SEEA recognises that some of the inputs (natural inputs of materials and energy) come from the environment and that, as a result of the production, consumption and accumulation of products, a range of other physical flows occur that usually result in materials and energy returning to the environment.

3.20 Flows from the environment into the economy are referred to as natural inputs, flows within the economy consist of either products or residuals, and flows from the economy to the environment are residuals. This series of flows is represented in Figure 3.2.1. Some natural inputs, after entering the economy, are recorded as immediately returning to the environment as they are no longer required by the economy. Examples of these natural resources residuals include mining overburden and discarded catch in fishing. Also, some residuals remain in the economy rather than returning directly to the environment, for example solid waste collected and stored in controlled landfills.

Figure 3.2.1 Physical flows in relation to the production boundary of the economy



[11] The SNA production boundary is described in detail in 2008 SNA paragraphs 6.23 – 6.48.

3.21 The underlying framework for the recording of physical flows follows the monetary supply and use tables for products as defined in the SNA and summarised in SEEA Chapter 2. The monetary supply and use table covers all flows of goods and services within the production boundary of the SNA.

3.22 The intent in physical flow accounting is to record the physical flows underpinning the transactions recorded in the monetary supply and use tables, primarily with respect to goods, and then to extend the monetary supply and use table to record physical flows from the environment to the economy (such as flows of natural resources) and physical flows from the economy to the environment (such as emissions to air and water).

3.23 Conceptually, flows solely within the environment are out of scope of physical supply and use tables although there may be instances where the recording of such flows is useful for analytical purposes. It is also noted that the asset accounts presented in Chapter 5 include flows within the environment to the extent that the flows reflect changes in the stock of environmental assets.

3.24 This general framework of flows may be applied in the case of individual commodities or groups of commodities. For example, flows of the hazardous element mercury might be tracked from the point it is extracted from the environment, circulated within the economy and released to the environment. Alternatively, there may be interest in only analysing physical flows into the economy or out of the economy without necessarily linking the two. For example the analysis of waste will focus on flows within the economy (for examples flows to waste treatment plants) and from the economy to the environment.

3.25 A full articulation of all flows is generally most relevant for energy and water where all flows can be meaningfully expressed in a single unit – e.g. joules or cubic metres. The general framework for the full articulation of physical flows is shown in Table 3.2.1 in the form of a physical supply table and a physical use table.

3.26 The rows of the table show the types of natural inputs, products and residuals. The rows for natural inputs and residuals are an extension in the PSUT compared to the monetary supply and use table in the SNA. The top half of the table, the supply table, shows the flows relating to the production and supply of natural inputs, products or residuals by different economic units or the environment. The bottom half of the table, the use table, shows the flows relating to the consumption and use of natural inputs, products and residuals by different economic units or the environment. Each of these flows is defined and discussed in detail later in this section.

3.27 The columns of the PSUT are structured to indicate the activity underlying the flow, e.g. whether it is related to production, consumption or accumulation, and the economic units involved. The first column covers the use of natural inputs, the production and intermediate consumption of products, and the generation and receipt of residuals by all firms in the economy. It is classified by industry using ISIC.

3.28 The second column covers the consumption of products by households and the generation of residuals from this consumption. The activity of households in extracting natural inputs from the environment for their own consumption is considered a productive activity and hence this activity should be recorded in the first column against the relevant industry class.

3.29 Unlike the monetary supply and use table, no entries are made in relation to government final consumption. Government final consumption represents the purchase and consumption by governments of their own output and does not have an associated physical flow. All of the physical flows related to the intermediate consumption of governments, e.g. paper, electricity, desks, etc, are recorded in the first column under the relevant industry class (commonly public administration). In addition, the generation of residuals by governments in the production of their output is recorded in the first column.

3.30 The third column, labelled accumulation, concerns changes in the stock of materials in the economy. From a supply perspective, this column records reductions in the physical stock of produced assets through, for example, demolition or scrapping. It also shows emissions from controlled landfill sites which are accumulations of residuals from previous accounting periods. From a use perspective, the accumulation column records additions to the physical stock of produced assets (gross capital formation) and the accumulation over an accounting period of materials in controlled landfill sites. Also, amounts of water, energy and materials that are incorporated into other products are recorded in the accumulation column in the use table.

3.31 These accumulation flows may be classified by industry using ISIC and, if so, can be combined with industry level information from the first column to provide an overall assessment of flows of residuals by industry. It is noted that retaining the distinction between residuals from current production activity (from the first column) and residuals from past production activity (from the third column) may be important for some analyses. Alternatively, the accumulation flows may be classified by product, for example by type of scrapped produced asset. Further discussion on the recording of scrapped and demolished produced assets is included later in this section.

3.32 The fourth column recognises the exchanges between national economies in terms of imports and exports of products and flows of residuals. Residuals received from the rest of the world and sent to the rest of the world primarily concern the movement of solid waste between different economies. Excluded from these flows are so-called transboundary flows, for example polluted water flowing downstream into a neighbouring country or air emissions transferred into other countries' environments. Transboundary flows are considered flows within the environment and hence are out of scope of the PSUT framework. Where relevant these flows may be recorded as supplementary items and may also be relevant in a broader assessment of the state of the environment, for example in assessments of the quality of water resources over time.

Table 3.2.1 General physical supply and use table

SUPPLY						
	Production; Generation of residuals		**Accumulation**	**Flows from the Rest of the World**	**Flows from the Environment**	**Total**
	Production; Generation of residuals by industries (incl. household production on own account) - classified by ISIC	**Generation of residuals by households**	Industries - classified by ISIC			
Natural inputs					A. Flows from environment (incl. natural resource residuals)	Total Supply of Natural Inputs (TSNI)
Products	C. Domestic production (incl sale of recycled and reused products)			D. Imports of products		Total Supply of Products (TSP)
Residuals	I1. Residuals generated by industry (incl. natural resource residuals) I2. Residuals generated following treatment	J. Residuals generated by household final consumption	K1. Residuals from scrapping and demolition of produced assets K2. Emissions from controlled landfill sites	L. Residuals received from rest of the world	M. Residuals recovered from the environment	Total Supply of Residuals (TSR)
TOTAL SUPPLY						
USE						
	Intermediate consumption of products; Use of natural inputs; Collection of residuals	**Final consumption***	**Accumulation**	**Flows to the Rest of the World**	**Flows to the Environment**	**Total**
	Industries - classified by ISIC	**Households**	Industries - classified by ISIC			
Natural inputs	B. Extraction of natural inputs					Total Use of Natural Inputs (TUNI)
	B1. Extraction used in production B2. Natural resource residuals					
Products	E. Intermediate consumption (incl purchase of recycled and reused products)	F. Household final consumption (incl purchase of recycled and reused products)	G. Gross Capital Formation (incl. fixed assets and inventories)	H. Exports of products		Total Use of Products (TUP)
Residuals	N. Residuals received by waste mgt and other industries (excl accumulation in controlled landfill sites)		O. Accumulation in controlled landfill sites	P. Residuals sent to the rest of the world	Q. Residual flows to the environment Q1. Direct from industry and households (incl. natural resource residuals & landfill emissions) Q2.Following treatment	Total Use of Residuals (TUR)
TOTAL USE						

*No entries for government final consumption are recorded in physical terms. All government intermediate consumption, production and generation of residuals is recorded against the relevant industry in the first column of the PSUT.

3.33 The fifth column is the significant addition to the monetary supply and use table structure in the SNA. In this column flows to and from the environment are recorded. Within the PSUT the environment is a "passive" entity that does not undertake production, consumption or accumulation in the way as units inside the economy. Nonetheless, the incorporation of the environmental column allows a full accounting for flows of natural inputs and residuals that would otherwise not be possible.

Accounting and balancing identities

3.34 The PSUT contains a range of important accounting and balancing identities. The starting point for the balancing of the PSUT is the supply-use identity, which recognises that, within the economy, the amount of a product supplied must also used within the economy, most likely by a range of different economic units, or exported. Thus (using references to the cells in Table 3.2.1)

Total Supply of Products (TSP) = Domestic production (C) + Imports (D)

is identical to

Total Use of Products (TUP) = Intermediate consumption (E) + Household Final Consumption (F) + Gross capital formation (G) + Exports (H)

3.35 This supply-use identity for products also applies in the monetary supply and use table. In the PSUT the supply-use identity is extended such that the total supply of natural inputs must equal the total use of natural inputs (TSNI = TUNI) and the total supply of residuals must equal the total use of residuals (TSR = TUR).

3.36 When applied to all three types of physical flows these equalities also relate to the fundamental physical identities underpinning the physical supply and use tables concerning the conservation of mass and the conservation of energy. These physical identities imply the existence of material and energy balances for all individual materials within the system.

3.37 It can be shown that, over an accounting period, flows of materials into an economy must equal the flows of materials out of an economy plus any net additions to stock in the economy. The net additions to the stock comprise additions and deductions over an accounting period in (i) gross capital formation in investment goods and inventories of products; (ii) physical flows of residuals to and from the rest of the world; (iii) residuals recovered from the environment (e.g. oil collected following an oil spill) and (iv) the accumulation of solid waste in controlled landfill sites (net of emissions from these sites).

3.38 Thus the input-output identity describing the physical flows between an economy and the environment is as follows (using references to the cells in Table 3.2.1)

Materials into the economy = Natural inputs (A) + Imports (D) + Residuals received from the rest of the world (L) + Residuals recovered from the environment (M)

is equal to

Materials out of the economy = Residual flows to the environment (Q) + Exports (H) + Residuals sent to the rest of the world (P)

plus

Net additions to stock in the economy = Gross capital formation (G) + Accumulation in controlled landfill sites (O) - Residuals from produced assets and controlled landfill sites (K)

3.39 This identity may be applied both at the level of an entire economy (as described) and also at the level of an individual industry or household where notions of imports and exports relate to flows to and from the rest of the economy as well as to the rest of the world. At the same time, since natural inputs are transformed and combined in a wide variety of ways and multiple times, recording a full balance is difficult to achieve in practice.

3.40 Particular note is made regarding the flows of residuals. For these flows a number of stages need to be recognised. In the first stage, residuals are generated or come into the economy as reflected in cells (I1 and J to M) in Table 3.2.1. These residuals are received by other units in the economy (N & O), sent to other countries (P) or returned to the environment (Q1). The residuals received by other units (N) may be treated or processed and then either sold as recycled or reused products (for example reused water) or returned to the environment. If sold as recycled or reused products the production is recorded in (C) and the purchase in (E) or (F). The supply of the treated residual is recorded in (I2) and the use in (Q2).

3.41 In practice, a complete PSUT is rarely compiled other than for energy and water. Nonetheless, these accounting identities and a common set of accounting principles can be applied even where only individual commodities or small groups of similar commodities are being recorded. In particular, clear boundaries about the point of transition between the environment and the economy and back to the environment must be defined.

3.42 The following parts explain the general definitions and boundary issues relating to natural inputs, products and residuals.

3.2.2 Definition and classification of natural inputs

3.43 ***Natural inputs are all physical inputs that are moved from their location in the environment as a part of economic production processes or are directly incorporated into economic production processes.***

3.44 The three broad classes of natural inputs are natural resource inputs, inputs from renewable energy sources and other natural inputs as presented in Table 3.2.2. This section discusses each of these classes and notes some specific measurement issues for natural resource inputs concerning the flows of resources affected by extraction processes but not used by the economy (i.e. natural resource residuals) and the treatment of cultivated biological resources.

Natural resource inputs

3.45 ***Natural resource inputs comprise physical inputs to the economy from environmental assets defined as natural resources.*** Thus natural resource inputs comprise inputs from mineral and energy resources[12], soil resources, natural timber resources, natural fish resources, other natural biological resources and water resources. Natural resource inputs exclude the flows from cultivated biological resources. Cultivated biological resources are produced within the economy and hence are not flows from the environment.

3.46 For natural resources, the point at which they are recognised as entering the economy needs to be defined for each type of resource. It is recognised that some amount of economic production must be undertaken before the natural resource can be considered extracted and hence it is a matter of determining the point at which the natural resource is best meaningfully described as extracted, and hence "enters the economy" as part of a longer production process.

3.47 All natural resource inputs are recorded as entering the economy from the environment. However, some natural resource inputs do not subsequently become used in production and instead immediately return to the environment. These flows are termed natural resource residuals and may be of particular interest in the assessment of sustainable resource management.

3.48 There are three types of natural resource residuals

i. Losses during extraction which cover resources that the extractor would prefer to retain (for example losses of gas through flaring and venting),

[12] In physical flow accounts for energy (Section 3.4) the term "energy resources" is used to cover all sources of energy from the environment. This includes the relevant mineral and energy resources referred to in Table 3.2.2 (i.e. oil, natural gas, coal & peat, etc) and also timber resources used for energy purposes, and inputs from renewable energy sources.

ii. Unused extraction which covers resources in which the extractor has no ongoing interest (for example mining overburden, mine de-watering and discarded catch)[13] and

iii. Return flows of water. These flows are separately identified as often they represent a large proportion of the total amount of abstraction.

Table 3.2.2 Classes of Natural Inputs

Natural resource inputs			
	Extraction used in production		
		Mineral and energy resources	
			Oil resources
			Natural gas resources
			Coal and peat resources
			Non-metallic minerals (excl. coal & peat)
			Metallic minerals
		Soil resources	
		Natural timber resources	
		Natural aquatic resources	
		Other natural biological resources (excluding timber and aquatic resources)	
		Water resources	
			Surface water
			Groundwater
			Soil water
	Natural resource residuals		
Inputs from renewable energy sources			
	Solar energy		
	Hydro energy		
	Wind energy		
	Wave and tidal energy		
	Geothermal energy		
	Other electricity and heat energy		
Other natural inputs			
	Inputs from soil		
		Soil nutrients	
		Soil carbon	
		Other inputs from soil	
	Inputs from air		
		Nitrogen	
		Oxygen	
		Carbon dioxide	
		Other inputs from air	
	Other natural inputs n.e.c.		

[13] In some cases, natural resource residuals can be collected and used for other purposes than the primary output of the extractor or by other economic units. Examples include the harvest of timber felling residues by households for fuelwood, or the use of mining overburden to provide materials for road construction. In these cases, the quantities collected should be recorded as extraction incorporated into products rather than under natural resource residuals flowing to the environment.

3.49 In some cases there is a clear link between the class of natural resource that is extracted and the associated natural resource residual. For example, the returns of abstracted of surface water are within the same class of natural input. However, in some cases the classes are different. For example, for soil and rock moved in the extraction of minerals, the total natural resource input will be a combination of the minerals extracted and the soil and rock moved (mining overburden).

3.50 Table 3.2.3 presents examples of different natural resource inputs. It separates the quantities of resource extracted into those amounts that are intended and available for use in the economy(i.e. extraction used in production) and those amounts that return to the environment (i.e. natural resource residuals). In general terms the point of entry to the economy is the point at which the resource is available for further processing. The notion of processing includes the transportation of the resource, i.e. the extraction point should be as close to the physical location of the resource as possible.

3.51 In situations where a natural resource residual is subsequently sold, for example sales of felling residues for fuelwood, the flows are recorded as extraction used in production. The recording of extractions used in production and natural resource residuals is consistent with the recording of extraction in the asset accounts described in Chapter 5.

Table 3.2.3 Examples of natural resource inputs

Natural resource	**Extraction used in production**	**Natural Resource Residual**
Mineral and energy resources	Gross ore Crude oil Natural gas	Mining overburden Flaring, venting at well head Reinjection of natural gas
Soil resources	Excavated soil used for agricultural, construction and land reclamation purposes	Dredgings Unused excavated soil
Natural timber resources	Removals of timber	Felling residues
Natural fish resources	Gross catch less discarded catch	Discarded catch
Other natural biological resources	Harvest/capture	Harvest/capture residues
Water resources	Abstracted water	Mine dewatering

Biological resources

3.52 Biological resources require special consideration in the determination of the boundary between the environment and the economy. To ensure consistency with the production boundary of the SNA, a distinction must be made between those resources that are considered to be cultivated as part of a process of production (cultivated biological resources) and those biological resources that are not produced (natural biological resources).

3.53 The criteria used to make the distinction include the extent of direct control, responsibility and management over the growth and regeneration of the biological resource. They are discussed in greater detail in Chapter 5 with regard to timber resources

(Section 5.8) and aquatic resources (Section 5.9). A consistent application of the criteria should be maintained for the purposes of both asset accounts and physical flow accounts.

3.54 Applying the distinction is important because the accounting treatment varies depending on whether the resource is natural or cultivated. For natural biological resources the resources are considered inputs to the economy at the time they are extracted – following the logic presented in Table 3.2.3. However, cultivated biological resources are not considered natural resource inputs and are instead treated as growing within the economy.

3.55 This difference in treatment has implications for the recording of other physical flows. For natural biological resources, the use of oxygen and nitrogen, etc and the uptake of soil nutrients and water are treated as flows within the environment and only the actual harvest of resources is considered to flow into the economy.

3.56 For cultivated biological resources, a complete accounting of related flows would require the recording of the nutrients and other substances (e.g. oxygen, carbon dioxide) absorbed from the environment as part of natural inputs, since the resources themselves are already “in” the economy. The physical flows resulting from metabolism, photosynthesis and transpiration are either embodied in products or return to the environment as residuals.

Inputs from renewable energy sources

3.57 ***Inputs from renewable energy sources are the non-fuel sources of energy provided by the environment.*** These are increasingly important sources of energy for economies in many countries. Inclusion of these inputs provides a basis for a complete balance of the flows of energy between the environment and the economy when measured in terms of energy content (joules). Inputs from renewable energy sources classified by different sources such as, but not limited to, solar energy, hydropower, wind energy, wave energy and geothermal energy. Inputs of energy sourced from natural resources, such as timber resources, are not included under this heading.

3.58 Estimates of inputs from renewable energy sources should reflect the amount of energy incident on the technology put in place to collect the energy – e.g. solar panel, wind turbine, etc. Estimates should not be based on the total potential energy that might be harnessed in places where there is no equipment to capture the energy. In practice, estimates of inputs from renewable energy sources will generally reflect the amount of energy actually produced, commonly but not exclusively, in the form of electricity.

3.59 Special consideration is required with regard to hydropower since, depending on the physical flow accounting involved, the relevant natural inputs may be recorded as inputs from renewable energy sources or natural water resource inputs. For the purposes of compiling energy accounts, the entries concerning the flows from the environment should be considered inputs from renewable energy sources equal to the electricity produced by the hydro power plant, measured in joules. For water accounts, the flows from the environment should be recorded as natural resource inputs of water resources equal to the volume of water that passes through a hydropower plant. No double counting is implied since each of these accounts is compiled separately in different units for different purposes.

Other natural inputs

Inputs from soil

3.60 ***Inputs from soil comprise nutrients and other elements present in the soil that are absorbed by the economy during production processes or released to the environment as a result of production processes.*** Inputs from soil include nutrients (e.g. nitrogen, phosphorous and potassium) absorbed by cultivated plants as they grow and the carbon bound in soil that may be released as the result of cultivation. Only the amounts actually absorbed or released are considered natural inputs. Note that these inputs are distinct from the bulk extraction of soil that is covered under natural resource inputs.

Inputs from air

3.61 ***Inputs from air comprise substances taken in by the economy from the air for purposes of production and consumption.*** They include the compounds and elements (including nitrogen, oxygen and carbon dioxide) used by cultivated biological resources and the substances absorbed during combustion and other industrial processes. They are part of the structure of PSUT as they enable a balance of materials to be recorded in the system.

3.2.3 Definition and classification of products

3.62 Following the SNA, ***products are goods and services that result from a process of production in the economy***. The scope of products included in physical flow accounts is limited to those with positive monetary value.

3.63 For an individual enterprise, different types of production may be recorded. Products that are sold to other economic units are considered to result from either the primary or secondary production of the enterprise depending the relative significance of the product. In principle, the enterprises that produce the same primary products are grouped to the same industry class.

3.64 In some cases, products are produced on own-account. This occurs when they are not sold to other economic units but they are used either directly for the final consumption of the producer (e.g. production of agricultural output consumed by farmers) or they are a form of capital formation (e.g. own-account construction of a house). In both cases the physical flows should be recorded to ensure consistency with the output and production boundaries of the monetary supply and use tables.

3.65 An enterprise may also undertake ancillary production. This generally involves the production of supporting services (such as accounting, employment, cleaning, transport services) that might be purchased from other enterprises but are produced in-house to support the production of primary and secondary products. The SNA recommends that only in cases where ancillary production is significant should distinct measures of output for the production of these different services be recorded. In these cases, separate establishments should be created that are treated as undertaking the ancillary production. However, in most cases, the production of these services is not recorded as a separate set of outputs and rather the inputs are recorded as comprising part of the overall inputs to the production of the firm's primary and secondary outputs.

3.66 There are also some products that are used as part of production processes within an enterprise (intra-enterprise flows) that are not recognized by monetary transactions in the SNA. For example, flows of water abstracted by a farmer for irrigation purposes would not be recorded in monetary terms in the SNA. For physical flow accounting, these intra-enterprise flows should be recorded where possible since there are physical flows that take place. However, the extent of recording should be consistent with the analytical purpose at hand.

3.67 There are many situations in which households undertake production involving the extraction or collection of natural resource inputs and then consume this production on own-account. Examples include the collection of fuelwood, the abstraction of water, the generation of energy using solar panels, and fish caught in recreational fishing. In these cases, the production is recorded as part of the production of the relevant economic activity in the industry column of the PSUT. Consistently, the use of natural inputs by households is also recorded in the industry column. Depending on the significance of the activity it may be useful to separate this production from that of other units undertaking the same activity. The corresponding household final consumption of own-account production is shown in the second column of the PSUT.

3.68 An important product flow in the PSUT framework is the flow of fertilisers. The spreading of fertilisers on to soil results in two flows. First, there are nutrients that are absorbed by the crops and this amount is considered a product flow – that is, it remains within the economy. Second, there are nutrients that are not absorbed and hence remain in the soil. These are recorded as flows of residuals from the dissipative use of products. Fertilisers include those fertilisers produced on own-account such as manure. Flows of fertilisers are important components in the compilation of nutrient balances.

3.69 Products may be either goods or services. In general, the product component of physical flow accounts will focus on goods that are transacted between economic units but in some cases, for example, the provision of wastewater treatment services, there will be an interest in comparing the flow of wastewater into and out of a treatment plant with the associated payment for the services.

Classification of products

3.70 Generally, physical flows of products are classified using the Central Product Classification (CPC). For some specific accounts, for example energy and solid waste accounts, specialised product classifications may be appropriate. These are discussed in relevant sections.

3.2.4 Definition and classification of residuals

3.71 ***Residuals are flows of solid, liquid and gaseous materials and energy that are discarded, discharged or emitted by establishments and households through processes of production, consumption or accumulation.***

3.72 Residuals may be discarded, discharged or emitted directly to the environment or be captured, collected, treated, recycled or reused by economic units. These various transformation processes may lead to the generation of new products that are of economic value to the unit undertaking the transformation even if the residual, when first discarded or emitted has no economic value to the household or establishment discarding or emitting the residual.

3.73 In situations where the intent is to discard a product but the discarder receives money or other benefits in exchange for the discarded product, this is treated as a transaction in a product and not as a residual. These flows may be of particular interest in the compilation of solid waste accounts.

3.74 A distinction must be made between payments made by a generator of residuals to establishments that collect, treat or otherwise transform residuals and the flows of the residuals themselves. The payments made are treated as payments for services and are treated as transactions in products while the flows of residuals are recorded separately. A specific case of this distinction is in the case of flows of solid waste between countries. The payments for the services provided for the transport and treatment of waste by other countries are recorded as imports and exports of services while the physical flows of waste are separately recorded as flows of residuals.

3.75 Residuals should be recorded at the time the emission or discard event takes place. The timing of the emission or discard event may be quite distinct from the time of the acquisition of a product which is the appropriate time to record the flow from the perspective of the monetary accounts.

3.76 Controlled and managed landfill sites, emission capture and storage facilities, treatment plants and other waste disposal sites are considered to be within the economy. Therefore, flows of residuals into these facilities are regarded as flows within the economy rather than flows to the environment. Subsequent flows from these facilities may either be directly to the environment as residuals or lead to the creation of other products or residuals.

3.77 Household or industrial waste may be dumped (possibly illegally) in open country or by the roadside. As well, tankers at sea may wash their tanks (also possibly illegally) or lose their cargo through being wrecked. These flows should be recorded as residuals flowing from the economy to the environment.

3.78 Efforts might be made to recover residuals, including natural resource residuals, from the environment and bring them back into the economy either for treatment or for disposal 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 particular locations, may arouse a sufficient degree of concern to merit identifying these flows explicitly.

3.79 The attribution of residuals to individual economies is consistent with the principles applied in the determination of the residence of economic units as outlined in Chapter 2. Residuals are attributed to the country in which the emitting or discarding household or enterprise is resident (for details see Section 3.3). The question of whether the residual has been emitted or discarded into a national environment or into another countries' environment is not directly addressed in this recording although this may be of interest in determining the change in the state of a national environment over time.

3.80 In principle, flows of residuals between the national environment and another environment are not recorded in PSUT as there are no flows out of or into an economy. Nonetheless, depending on the nature of the relationship between the different national environments there may be interest in recording these flows. For example, countries at the downstream end of a river system may be interested in the flows of residuals generated by other countries transported by a river or the deposition of acidification ("acid rain") originating from acidifying emissions in other countries.

Groups of residuals

3.81 There are a wide variety of different types of residuals and they are not usually accounted for as a single type of flow using mutually exclusive classes. Rather, different groups of residuals are analysed depending on the physical nature of the flow, the purpose behind the flow or simply to reflect the balance of physical flows leaving the economy. The following are the most widely accepted groupings of residuals and their definitions.

Solid waste

3.82 ***Solid waste covers discarded materials that are no longer required by the owner or user.*** Solid waste includes materials that are in a solid or liquid state but excludes wastewater and small particulate matter released into the atmosphere.

3.83 Solid waste includes all materials sent to or collected by waste collection or treatment schemes including landfill establishments. Solid waste also includes those same materials if they are discarded directly to the environment – whether legally or illegally. In addition, solid waste may include some discarded materials exchanged between economic units, for example scrap metal, for which the discarder receives payment. In these circumstances, the solid waste is considered a product (since the solid waste has a positive value) rather than a residual. Further discussion on the delineation between solid waste residuals and products is in Section 3.6 in the description of physical flow accounts for solid waste.

Wastewater

3.84 ***Wastewater is discarded water that is no longer required by the owner or user.*** Water discharged into drains or sewers, water received by water treatment plants and water discharged direct to the environment is all considered wastewater. Wastewater includes return flows of water which are flows of water direct to the environment, with or without treatment. All water is included regardless of the quality of the water, including returns from hydro-electric power generators.

3.85 Wastewater also includes reused water which is wastewater supplied to a user for further use with or without treatment. Wastewater that is recycled within the same firm is not recorded in SEEA accounts.

Emissions

3.86 ***Emissions are releases of substances to the environment by establishments and households as a result of production, consumption and accumulation processes.*** Generally, emissions are analysed by type of receiving environment, i.e. emissions to air, emissions to water, emissions to soil, and by type of substance.

3.87 Most focus in the accounting for emissions is on the impact on the environment. However, in some cases releases of substances by establishments and households may be collected and contained by economic units or transferred between economic units thus lessening the potential impact on the environment. For example, the removal of substances in wastewater by wastewater treatment facilities before the return of water to the inland water system. The total quantity of releases of substances from establishments and households is referred to as gross releases. Gross releases comprise emissions to the environment and releases to economic units.

3.88 ***Emissions to air are gaseous and particulate substances released to the atmosphere by an establishment or household as a result of production, consumption and accumulation processes.*** By convention, emissions to air exclude the release of steam or water via evaporation. Further details on accounting for emissions to air are presented in Section 3.6.

3.89 ***Emissions to water are substances released to water resources by an establishment or household as a result of production, consumption and accumulation processes.*** For any individual establishment or household, emissions to water are measured in terms of the additional substances that the establishment or household has added to water rather than the total quantity of substances in the water discharged by the establishment or household. In this way, substances that were already in the water received by the establishment or household are not attributed to that unit.

3.90 Emissions to water exclude those materials that cannot be carried by normal flows of water (i.e. excluding materials carried in floods) such as large items of solid waste. These materials are included in measures of solid waste.

3.91 Since a large proportion of gross releases of substances to water by establishments and households occurs via sewerage systems, accounting for these releases generally covers both emissions to the environment and releases to economic units (largely, wastewater treatment facilities). Further details on accounting for emissions to water and associated releases to economic units are presented in Section 3.6.

3.92 ***Emissions to soil are substances released to the soil by an establishment or household as a result of production, consumption and accumulation processes.*** Some emissions to soil may continue to flow through the environment and enter the water system. In principle, flows of substances having been recorded as emissions once, should not be recorded a second time as being attributable to an individual establishment.

Dissipative uses of products

3.93 ***Dissipative uses of products covers products that are deliberately released to the environment as part of production processes.*** For example, fertilisers and pesticides are deliberately spread on soil and plants as part of agricultural and forestry practice, and in certain countries salt is spread on roads to improve road conditions for drivers. In these cases, a proportion of the amount of product released may be used or absorbed as part of the production process and hence becomes incorporated into new products. The remaining proportion will remain in the environment and this proportion should be recorded as a residual flow to the environment.

Dissipative losses

3.94 ***Dissipative losses are material residues that are an indirect result of production and consumption activity.*** Examples include particulate abrasion from road surfaces, abrasion residues from car brakes and tyres and zinc from rain collection systems. These residues should be accounted for as dissipative losses as part of ensuring an overall balance of flows from the economy to the environment.

Residual heat

3.95 Residual heat results from the transformation of energy. ***Residual heat is that part of energy that is no longer available for economic purposes after a transformation process.*** Residual heat may originate from two principal energy transformation processes. First, residual heat is generated during the transformation of primary energy products into secondary energy products (e.g. the heat lost during the transformation from coal to electricity). In this case the flow of residual heat is equal to the difference between energy input and energy output. Second, residual heat is generated from the end use of energy products (e.g. fuel use for vehicles, electricity use for heating). In this case the flow of residual heat is equal to the energy input.

3.96 Residual heat losses need to be recorded to ensure the maintenance of the energy balance principle in the physical flow accounts. These flows are most relevant in the construction of energy accounts.

Natural resource residuals

3.97 ***Natural resource residuals are natural resource inputs that do not subsequently become incorporated into production processes and instead immediately return to the environment.*** Natural resource residuals are recorded as a generation of residuals by natural resource extracting industries and as a flow of residuals directly to the environment.

3.98 Examples of natural resource residuals include the flaring and venting of natural gas, discarded catch in fishing and felling residues from the harvesting of natural timber resources. Excluded from natural resource residuals are residuals associated with the harvesting of cultivated biological resources such as crop residues, felling residues from cultivated timber resources and manure from the farming of livestock. These residuals are recorded as solid waste. A more detailed discussion of natural resource residuals is presented earlier in this section (see paragraphs 3.47-3.51).

Losses

3.99 Another way in which residuals are considered is in terms of losses. This is of particular interest in the analysis of physical flows of energy and water. Four types of losses are identified according to the stage at which they occur through the production process. It is noted that some types of losses may be necessary for maintaining safe operating conditions as is the case of flaring and venting in the extraction of natural gas, while others may be unwanted losses as is the case for water evaporation from distribution channels.

3.100 The four types of losses are:

i. Losses during extraction are losses that occur during extraction of a natural resource before there is any further processing, treatment or transportation of the extracted natural resource. During the extraction process, some of the natural resource may be reinjected into the deposit from which it was extracted. This may be the case for example for natural gas re-injected into the reservoir or water abstracted from groundwater and re-injected into an aquifer. These flows are also considered as losses during extraction. In the case of water they are also considered return flows. Some losses during extraction may also be recorded as natural resource residuals.

ii. Losses during distribution are losses that occur between a point of abstraction, extraction or supply and a point of use.

iii. Losses during storage are losses of energy products and materials held in inventories. They include evaporation, leakages of fuels (measured in mass or volume units), wastage and accidental damage. Excluded from the scope of inventories are non-produced assets, even though they might be considered as being stored. Thus, for example, the evaporation of water from artificial reservoirs is excluded from losses during storage. These reductions in the volume of water are shown in asset accounts (Chapter 5).

iv. Losses during transformation refer to the energy lost, for example residual heat, during the transformation of one energy product into another energy product. It is essentially an energy balance concept reflecting the difference in calorific value between the input and output commodities. Losses during transformation only apply to energy flows.

3.101 Losses should be recorded if there is a preference on the part of the economic unit to retain the physical quantities that return to the environment. Particularly in situations where resources are being extracted, some physical quantities of resources may be “lost” as part of the extraction process but if these quantities are of no interest to the extractor then they should not be considered losses.

3.102 From the perspective of suppliers of products, the amounts of water, electricity, other energy products and other materials that are illegally diverted from distribution networks or from storage may be considered losses due to theft. However, since in physical terms the water, energy or other material is not lost to the economy they are not considered losses in the SEEA. Nonetheless there may be interest in compiling data concerning theft as a subset of overall use of water, energy and other materials. It should be noted that losses due to theft may be difficult to measure in practice and may often be included in losses in distribution.

Classification of groups of residuals

3.103 There is no single classification of all residuals. The complication is that the various groups of residuals overlap each other. In order to suitably organise information to answer different policy and research questions, there is no clear approach that might be taken to resolve issues of double counting. Such double counting would arise if a complete classification was constructed following the structure of the various groups of residuals just defined.

3.104 An example of the potential overlap is the treatment of flaring and venting of natural gas at the wellhead. These flows of gas are considered natural resource residuals, losses during extraction and a component of air emissions.

3.105 Table 3.2.5 gives an indication of the types of materials that are commonly included in the different groupings of residuals to support analysis of residuals whether the focus is on the purpose behind the discard (e.g. waste), the destination of the substance (e.g. emissions to air), or the processes leading to the emission (e.g. dissipative losses).

Table 3.2.5 Typical components for groups of residuals

Group	Typical components
Solid waste (includes recovered materials) (a)	Chemical and healthcare waste, Radioactive waste, Metallic waste, Other recyclables, Discarded equipment and vehicles, Animal and vegetal wastes, Mixed residential and commercial waste, Mineral wastes and soil, Combustion wastes, Other wastes
Wastewater (a)	Water for treatment and disposal, Return flows, Reused water
Emissions to air	Carbon Dioxide, Methane, Dinotrogen oxide, Nitrous oxides, Hydrofluorocarbons, Perfluorocarbons, Sulphur Hexaflouride, Carbon monoxide, Non-methane volatile organic compounds, Sulphur dioxide, Ammonia, Heavy metals, Persistent organic pollutants, Particulates (e.g. PM10, dust)
Emissions to water	Nitrogen compounds, Phosphorous compounds, Heavy metals, Other substances and (organic) compounds
Emissions to soil	Leaks from pipelines, chemical spills
Residuals from dissipative use of products	Unabsorbed nutrients from fertilisers, salt spread on roads.
Dissipative losses	Abrasion (tyres/brakes), Erosion/corrosion of infrastructure (roads, etc)
Residual heat	Heat released to water bodies in cooling water from electricity power plants, heat released from burning of fuel in vehicles
Natural resource residuals	Mining overburden, felling residues, discarded catch.

(a) This listing will include some flows defined as products as well as flows defined as residuals.

Accumulation of residual flows

3.106 The environmental impacts caused by residuals relate to residual flows from the current period and also flows in the past periods because of the ability of residuals to accumulate. The effect of continuing the existing flow of residuals may be quite different depending on the level already accumulated at the beginning of the period. The measurement of how flows of residuals affect the state and quality of the ecosystems that receive residuals is addressed in SEEA Experimental Ecosystem Accounts.

3.107 It is noted here that the damage inflicted by the ambient concentrations of a residual often increases non-linearly with the amount of residual generated. However, the supply and use tables described in this section 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. It is also noted in this regard that the impact on the environment will vary depending on the type of residual and type of environment.

The recording of scrapped and demolished produced assets

3.108 The general physical supply and use table shown in Table 3.2.1 includes an entry for residuals from scrapping and demolition of produced assets (Cell K). The recording of these residuals under the column for accumulation highlights that they relate to production activity that took place in previous periods as opposed to residuals that are the result of current period production activity.

3.109 Many of these residuals will be collected and treated (and possibly recycled) by waste treatment and similar enterprises. In the use table these residuals are shown as received by waste treatment enterprises (Cell N), accumulated in controlled landfill (Cell O), sent to the rest of the world (Cell P) or flowing directly to the environment (Cell R).

3.110 A particular interest in recording these residuals is attributing the residuals to the former owner and user of the scrapped and demolished produced assets. Ideally, this recording would be possible by classifying the accumulation column by industry and appropriately attributing the residual flows to the industry responsible for the scrapped asset. However, if classifying the accumulation column in this way is not possible, then two additional entries may be recorded in the first column. One entry is in Cell N reflecting the implicit use of the scrapped asset by the scrapping enterprise and the second entry is in Cell I reflecting the generation of residuals by the scrapping industry that are subsequently collected by the waste treatment industry. Two entries are required to maintain a balance of flows for the industry that is scrapping the produced asset.

3.111 In practice, there may be difficulties in attributing the scrapping and demolition of produced assets to the former user because assets, particularly buildings, may be sold just prior to scrapping or demolition. Hence at the time the event generating the residual occurs, a different industry may be the owner and "user" of the produced asset. Where possible, the residual should be attributed to the industry that has most recently used the produced asset as a capital input to a production process.

3.3 Principles of physical flow accounting

3.3.1 Introduction

3.112 The application of the broad framework for physical flow accounting outlined in section 3.2 requires the adoption of a range of accounting principles and conventions. A number of these are explained in Chapter 2 including the principle of double entry accounting, the units of measurement, and the definitions of economic units and industries.

3.113 This section describes in detail some specific recording principles relevant to physical flow accounting namely, gross and net recording of physical flows, the treatment of international flows of goods, the treatment of goods for processing and the treatment of losses.

3.3.2 Gross and net recording of physical flows

3.114 The PSUT framework presented in section 3.2 records all flows between the environment and the economy, between different economic units and, where applicable, records flows within economic units where own-account production and consumption of products is significant. This recording of flows is referred to in the SEEA as gross recording. The key advantage of a gross recording approach is that a full reconciliation of all flows at all levels of the supply and use table, for example by industry and product, can be made.

3.115 However, recording all of these flows may hide some key relationships and hence for analytical purposes, alternative consolidations and aggregations of flows have been developed. These alternative views are often referred to as net although the nature of the consolidations and aggregations varies and hence there is no single application of net recording. This section mentions some of the main types of net recording of relevance in the SEEA.

3.116 It is noted that the terms gross and net are used in a wide range of accounting situations. In the SNA the term net is used to indicate whether an accounting aggregate has been adjusted for consumption of fixed capital (depreciation). In other situations, the term net is used simply as the difference between two accounting items. The terms gross and net are also used to describe different aggregates that have different measurement scopes.

3.117 One of the common areas in which gross and net recording is applied is in energy accounts. Energy accounts compiled on a gross basis show all flows of energy between economic units. Some of these flows represent flows of energy products to energy producers, e.g. flows of coal to electricity producers, and other flows are to an end user, e.g. flows of electricity to households. Net energy accounts exclude non-consumptive energy uses that represent the transformation of one energy product to another energy product and hence allow a focus on the end use of energy.

3.118 Generally, care should be taken in the use and interpretation of the terms gross and net and clear definitions of inclusions and exclusions should be provided and sought wherever possible.

3.3.3 Treatment of international flows

3.119 The treatment of physical flows to and from the rest of the world needs careful articulation. The underlying principle to be applied is one of residence whereby relevant flows are attributed to the country of residence of the producing or consuming unit. This differs from the territory principle of recording that is applied in a number of statistical frameworks. The concept of territory attributes the relevant flows to the country in which the producing or consuming unit is operating at the time of the flow.

3.120 Following both the SNA and the Balance of Payments Manual (BPM6), ***the residence of an institutional unit is defined by the economic territory with which it has the strongest connection***.[14] In the vast majority of situations the concepts of territory and residence are closely aligned but there are important activities, in particular international transport, that need to be considered directly so as the appropriate treatment can be defined. This part examines the key areas of international transport, tourist activity and natural resource inputs, in turn.

International transport

3.121 The appropriate recording of international transport activity is important particularly for information concerning the use of energy and the associated release of emissions. The appropriate and consistent attribution of physical flows relating to international transport to individual countries is an important component of the SEEA.

3.122 To ensure consistency with other parts of the accounts, the treatment is centred on the residence of the operator of the transport equipment. Usually this will be the location of the headquarters of the transport operator. Therefore, regardless of the distances travelled, the number of places of operation, whether the transport service is supplied to non-residents or whether the transport service is between two locations not within the resident country; all revenues, inputs (including fuel wherever purchased) and emissions are attributed to the country of residence of the operator.

3.123 Once the determination of the residence of the operator of international transport equipment using standard SNA and BPM principles has taken place, the appropriate accounting is illustrated in the following examples:

i. A ship, whose operator is a resident in Country A, transports goods from Country B to Country C, and refuels in Country C before returning home. In this case purchases of fuel are attributed to Country A (being exports of fuel from Country C and imports of

[14] See 2008 SNA, paragraph 4.10 – 4.15.

fuel of Country A). Payments for transport service by Country C are exports of services by Country A. All emissions by the ship are attributed to Country A.

ii. A passenger aircraft, whose operator is a resident in Country X, transports people from Country X to Country Y and returns to Country X. The passengers are from various countries, X, Y and Z. In this case any purchases of fuel are attributed to Country X and are recorded as imports if purchased in Country Y. Payments by the passengers are recorded as exports of services by Country X if the passengers are resident in Country Y or Z. All emissions by the aircraft are attributed to Country X.

3.124 Special note is required in relation to the bunkering of fuel, primarily for ships and aircraft. Special arrangements may be entered into such that a unit resident in a country stores fuel in another country while still retaining ownership of the fuel itself. Following the principles of the SNA and the BPM, the location of the fuel is not the primary consideration. Rather focus must be on the ownership of the fuel. Thus if Country A established a bunker in Country B and transports fuel to Country B in order to refuel a ship that it operates then the fuel it considered to have remained in the ownership of country A and no export of fuel to Country B is recorded. Thus the fuel stored in Country B is not necessarily all attributable to Country B. This treatment is likely to differ from the recording in international trade statistics and adjustments may be needed to source data to align to this treatment.

Tourist activity

3.125 The recording of tourist activity is consistent with the recording of international transport activity in that the concept of residence is central. Tourists include all those travelling outside their country of residence including short term students (i.e. less than 12 months), people travelling for medical reasons and those travelling for business or pleasure. The consumption activity of a tourist travelling abroad is attributed to the tourist's country of residence and not to the location of the tourist when the consumption is undertaken. Thus purchases by the tourist in other countries are recorded as an export by the country visited and as an import of the country of residence of the tourist.

3.126 Solid waste generated by tourists will generally be attributed to local enterprises (e.g. hotel, restaurant). Emissions from local transport used by tourists in a foreign country are attributed to the local transport company and, as noted in regard to international transport, emissions from aircraft and other long distance transport equipment are attributed to the country of residence of the operator. In neither case is the emission attributed to the tourist.

3.127 Emissions from cars are also attributed to the country of residence of the operator (in this case the driver of the car), whether the car is owned by the driver or the car is being hired from a rental car company. Emissions from taxis, local minibuses and the like are also attributed to the driver or relevant business rather than the passenger.

Natural resource inputs

3.128 Natural resource inputs denote physical flows from the environment to the economy. They derive from stocks of natural resources comprising mineral and energy resources, soil resources, natural timber resources, natural aquatic resources, other natural biological resources and water resources. All of these resources are considered to be owned by residents of the country in which the resources are located. By convention, natural resources that are legally owned by non-residents are considered to be owned by a notional resident unit and the non-resident legal owner is shown as the financial owner of the notional resident unit. Consequently, in general, the extraction of natural resource inputs must take place within a country's economic territory by economic units that are resident in the country.

3.129 Where illegal extraction takes place, for example when non-residents illegally log timber resources, the reduction in the country's resources should be recorded in the asset account (see Chapter 5) as part of extractions of natural resources. However, the associated natural resource input in the PSUT should only be shown in the accounts of the country in which the illegal extractor is resident. No exports should be recorded.

3.130 The major exception to this treatment concerns natural aquatic resources. Following accounting conventions, the harvest of aquatic resources is allocated to the residence of the operator of the vessel undertaking the harvesting rather than to the location of the resources. Thus the amount of natural resource input that should be recorded for a country is equal to the quantity of aquatic resources caught by vessels resident of the country regardless of where the resources are caught. Natural resource inputs are not recorded for the harvest of aquatic resources by vessels operated by non-residents in national waters and neither are exports recorded in this situation. In the accounts of the country to which the non-resident operator belongs, there should be entries for natural resource inputs for aquatic resources caught in non-national waters but there should be no reduction in national aquatic resources in the asset accounts of the harvesting country for this harvest.

3.3.4 Treatment of goods for processing

3.131 It is increasingly common for goods from one country to be sent to another country for further processing before being returned to the original country, sold in the processing country or sent to other countries. In situations where the un-processed goods are sold to a processor in a second country there are no particular recording issues. However, in situations where the processing is undertaken on a fee for service basis and there is no change of ownership of the goods (i.e. the ownership remains with the original country) the financial flows are unlikely to relate directly to the physical flows of goods being processed.

3.132 From a monetary accounts perspective, the firm processing the goods assumes no risk associated with the eventual marketing of the products and the value of the output of the processor is the fee agreed for the processing which is recorded as an export of a service to the first country. A consequence of this treatment is that the recorded pattern of inputs for the establishment that is processing goods on behalf of another unit is quite different from the pattern of inputs when the establishment is manufacturing similar goods on their own account.

3.133 A simple illustration may be given by referring to the production of petroleum products. A firm that refines crude oil on own account has intermediate consumption of crude oil and output of refined petroleum products. A firm that is processing crude oil on behalf of another unit has all the other similar inputs and uses the same produced assets but, in their accounts, shows neither the intermediate consumption of crude oil nor the output of refined petroleum products. Instead only an output equal to the processing fee is recorded.

3.134 For similar amounts of crude oil processed, the estimates of value added and other inputs (i.e. labour and produced assets) are likely to be comparable. However, the result of recording only the processing fee rather than the full value of the goods processed does change the measured supply and use relationship.

3.135 Although this treatment accords with the SNA and provides the most appropriate recording of the monetary flows, it does not correspond to the physical flows of goods. Consequently, a different treatment of goods for processing is recommended for physical supply and use tables. The treatment is to record the physical flows of goods, both as they enter into the country of the processing unit and as they leave that country. Tracking the physical flows in this way enables a clearer reconciliation of all physical flows in the economy and also provides a physical link to the recording of the environmental impact of the processing activity in the country in which the processing in being undertaken, including for example, emissions to air.

3.136 Generally, information on the physical flow of goods between countries is available in international trade statistics. However, it is necessary to identify those flows of goods where the ownership has not changed and to apply a different treatment in monetary terms compared to the international trade data.

3.137 Depending on the products and industries that are of interest reconciliation entries may be required if accounts combining physical and monetary data are to be compiled.

3.4 Physical flow accounts for energy

3.4.1 Introduction

3.138 Energy flow accounts describe energy flows, in physical units, from the initial extraction or capture of energy resources from the environment into the economy (natural inputs), to the flows within the economy in the form of supply and use by industries and households and finally, the flows of energy back to the environment (energy losses).

3.139 The compilation of energy flow accounts allows for a consistent monitoring of the supply and use of energy by energy type and, in combination with monetary information, indicators of energy intensity, efficiency and productivity can be derived.

3.140 Energy flow accounts are a sub-system within the general physical flow framework. Energy accounts data are compiled by converting physical measures of mass and volume such as tonnes, litres and cubic metres into a common unit representing energy content in net calorific terms. The use of the joule as a common unit is recommended by the International Recommendations for Energy Statistics (IRES).[15]

3.4.2 Scope and definitions of energy flows

3.141 Energy flows consist of flows of (i) energy resources, (ii) flows of energy products, (iii) energy residuals, and (iv) energy incorporated into non-energy products. Flows of air emissions and solid waste generated by energy production and use are not included although all types of waste used as inputs for the production of energy are included.

3.142 Flows of energy resources involve the removal and capture of energy from the environment by economic units in the national territory. Energy resources[16] may come in the form of mineral and energy resources, natural timber resources or as inputs from renewable energy sources such as solar, wind and hydropower.

3.143 Energy products are products that are used (or might be used) as a source of energy. They comprise fuels that are produced/generated by an economic unit (including households) and are used (or might be used) as sources of energy; electricity that is generated by an economic unit (including households); and heat that is generated and sold to third parties by an economic unit.[17] Energy products include biomass and solid waste that are combusted for the production of electricity and/or heat[18]. Some energy products may be used for non-energy purposes.

3.144 A distinction can be made between primary and secondary energy products. Primary energy products are produced direct from the extraction or capture of energy resources

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[15] International Recommendations on Energy Statistics (IRES) 2011, 4.29

[16] The use of the term energy resources in this context is broader than its use in the SEEA category of environmental assets "Mineral and energy resources". For the energy accounts, energy resources also covers natural timber resources and inputs from renewable energy sources.

[17] International Recommendations on Energy Statistics (IRES) 2011, 3.7

[18] International Recommendations on Energy Statistics (IRES) 2011, 2.B

from the environment. Secondary energy products are the result of transformation of primary, or other secondary, energy products into other types of energy products. Examples include petroleum products from crude oil, charcoal from fuelwood and electricity from fuel oil.

3.145 Heat and electricity may be either primary or secondary products depending on their production process. For example, if heat is captured directly from the environment through solar panels it is a primary energy product. It is a secondary energy product if produced from other energy products such as coal or oil.

3.146 Generally, physical and monetary flows of energy products should be classified using the Standard International Energy Product Classification (SIEC) presented in the IRES. Often, monetary flows will be classified using the CPC. Since there is not a one-to-one relationship between SIEC and CPC categories a correspondence between these classifications will be needed for detailed analysis of combined physical and monetary datasets.

3.147 Energy residuals in physical terms comprises a number of components. Most focus is on energy losses which are defined consistently with the general definition of losses outlined in Section 3.2. Particular examples of energy losses during extraction include flaring and venting of natural gas (also recorded as part of natural resource residuals) and losses during transformation in the production of primary energy products from energy resources and in the production of secondary energy products. Losses during distribution may arise from the evaporation and leakages of liquid fuels, loss of heat during transport of steam, and losses during gas distribution, electricity transmission and pipeline transport.

3.148 Energy residuals include residual heat which is that part of energy that is no longer available for economic purposes after the transformation process. Residual heat is generated through transformation processes. These amounts of residual heat are recorded as losses during transformation. Residual heat is also generated when end users (either households or enterprises) use energy products (e.g. electricity). These amounts of residual heat are recorded as Residual heat n.e.c. (See also paragraphs 3.95 & 3.96.)

3.149 Energy incorporated into non-energy products represents the use of energy from energy products to manufacture non-energy products. For example, the energy in naphtha (an energy product) is used in the manufacture of plastics.

3.4.3 Physical supply and use tables for energy

3.150 Physical supply and use tables for energy record the flows of energy resources, energy products, energy residuals and energy incorporated into non-energy products in physical units of measure. They are based on the principle that the total supply of each flow is equal to the total use of the same flow (i.e. total supply of energy products equals total use of energy products).

3.151 Table 3.4.1 shows the SEEA physical supply and use tables for energy. The table includes flows of all energy resources and products including those energy products that are transformed into other energy products. Therefore, the energy content of some products is counted more than once. Coal, for example, is used as input into a transformation process to obtain electricity and heat, and the accounts record the energy content of the coal as well as the energy content of the resulting electricity and heat.

3.152 The columns of the energy supply and use table follow the structure of the general PSUT presented in Table 3.2.1. The level of industry detail shown is to highlight those industry groups that most commonly play a significant role in energy production or use, but there is no restriction in the amount of industry detail that may be incorporated. The accumulation column records changes in the inventories of energy products that can be stored, for example coal, oil and natural gas.

Table 3.4.1 Physical supply and use table for energy		**(Joules - net calorific value)**										
Physical supply table for energy												
		Production (including household production on own-account); Generation of residuals							**Accumulation**	**Flows from the Rest of the world**	**Flows from the environment**	**TOTAL SUPPLY**
		Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Transportation and storage	Other industries	Households		Imports		
		ISIC 01	ISIC 02	ISIC 03	ISIC 04	ISIC 08						
Energy resources												
	Natural resource inputs											
	Mineral and energy reosources											
	Timber resources											
	Inputs from renewable energy sources											
	Solar energy											
	Hydro energy											
	Wind energy											
	Wave and tidal energy											
	Geothermal energy											
	Other heat and electrical energy											
Energy products												
Production of energy products by SIEC class												
	Coal											
	Peat and peat products											
	Oil shale/ oil sands											
	Natural gas											
	Oil											
	Biofuels											
	Waste											
	Electricity											
	Heat											
	Nuclear fuels and other fuels nec											
	Total											
Energy residuals												
	Losses during extraction											
	of which Reinjection of natural gas											
	of which Flaring and venting at well head											
	Losses during distribution											
	Losses during storage											
	Losses during transformation											
	Residual heat n.e.c.											
Energy incorporated into non-energy products												
TOTAL SUPPLY												

Physical use table for energy												
		Intermediate consumption; Use of energy resources; Receipt of energy losses						**Final consumption**	**Accumulation**	**Flows to the Rest of the world**	**Flows to the environment**	**TOTAL USE**
		Agriculture, forestry and fishing	Mining and quarrying	Manufacturing	Electricity, gas, steam and air conditioning supply	Transportation and storage	Other industries	Households		Exports		
Energy resources												
	Natural resource inputs											
	Mineral and energy reosources											
	Timber resources											
	Non-fuel energy inputs											
	Solar energy											
	Hydro energy											
	Wind energy											
	Wave and tidal energy											
	Geothermal energy											
	Other heat and electrical energy											
Energy products												
Transformation of energy products by SIEC class												
	Coal											
	Peat and peat products											
	Oil shale/ oil sands											
	Natural gas											
	Oil											
	Biofuels											
	Waste											
	Electricity											
	Heat											
	Nuclear fuels and other fuels nec											
	Total											
End-use of energy products by SIEC class												
	Coal											
	Peat and peat products											
	Oil shale/ oil sands											
	Natural gas											
	Oil											
	Biofuels											
	Waste											
	Electricity											
	Heat											
	Nuclear fuels and other fuels nec											
	Total											
Energy residuals												
	Losses during extraction											
	Losses during distribution											
	Losses during storage											
	Losses during transformation											
	Residual heat n.e.c.											
Energy incorporated into non-energy products												
TOTAL USE												

Key components of the PSUT for energy

3.153 The key components of the PSUT for energy concern (i) the supply and use of energy resources, (ii) the supply of energy products, including energy products produced on own account; (iii) imports and exports of energy products; (iv) the transformation and end-use of energy products; and (v) the supply and use of energy residuals and energy incorporated into non-energy products. These five areas are discussed in the following paragraphs.

Supply and use of energy resources

3.154 The first part of the energy supply table and the first part of the energy use table relate to the flows of energy resources. The structure of these parts is analogous to the sections on natural inputs in the general PSUT described in Table 3.2.1. In the supply table the various energy resources are shown as being supplied by the environment. In the use table the energy resources are shown as being used by the extracting industries. The total supply of each energy resource must equal to the total use of each energy resource.

3.155 Energy resources may be presented at varying levels of detail depending on those resources of most relevant and analytical interest in a country. For those energy resources that are types of mineral and energy resource (e.g. oil and natural gas), all of the extracted resource is recorded as an energy resource regardless of the ultimate purpose for the use of the extracted natural resource. On the other hand, for natural timber resources only that amount of wood extracted for fuelwood is recorded as an energy resource.

3.156 In principle, the inputs from renewable energy sources (solar, hydro, wind, wave and tidal, geothermal) should reflect the amount of energy incident on the technology put in place to collect the energy. In practice, inputs from renewable energy sources are recorded in terms of the amounts of heat and electricity produced via the relevant technology. Consequently, in practice, losses of energy in the capture of renewable energy are not included in the PSUT. Energy from hydro-electric schemes is recorded here in terms of energy produced rather than as water resources.

3.157 For those energy resources that are types of mineral and energy resource, losses of energy during extraction are included in the total amount of resource extracted from the environment, in line with the general treatment of natural resource residuals and losses. Entries for losses during extraction should also be made in the bottom parts of the supply and use tables concerning energy residuals.

Supply of energy products

3.158 All energy products supplied from one unit to another, including between units within a single enterprise, are included in the flow accounts no matter if the energy product is sold or exchanged as part of a barter or provided free of charge.

3.159 Energy products are primarily produced by establishments classified to ISIC section B, *Mining and quarrying*, ISIC Section C, *Manufacturing* and ISIC section D, *Electricity, gas, steam and air conditioning supply.* For many countries, the main source of supply may be imported energy products. Energy products are classified following the Standard International Energy product Classification (SIEC).

3.160 Energy products are produced as secondary production by many industries including for use within an establishment (i.e. for own account production and use). Where it is possible to quantify the own account production and use of energy products, these flows should be recorded separately in the accounts as flows of energy for own use.[19]

3.161 A special case in the supply of energy products concerns the energy production of households. Households may purchase and install equipment for the generation of energy products (for example, solar panels) and also may collect and use energy resources such as fuelwood to generate energy products. The energy produced is either consumed on own account or sold on the market, for example by selling electricity produced to an electricity grid.

3.162 Following the general principles of recording production, all activity should be allocated to the relevant industry whether for own-account consumption or for sale. A distinction between those amounts of energy produced by households for sale as compared to own-use may also be compiled. Energy produced for own-account consumption should be recorded as household final consumption in the use table.

Imports and exports of energy products

3.163 Imports and exports of energy products should be recorded when change of ownership between a resident and a non-resident unit occur. In the absence of sources specifying the date on which ownership changes, there is a strong presumption that the goods will cross the frontiers of the countries concerned either shortly before or soon after the change of ownership takes place.

3.164 Energy products in transit through the economic territory should generally not be included in imports and exports. However, for electricity and heat it may be difficult to distinguish between transit flows and other flows, and all flows of electricity and heat into a country may therefore in practice be recorded as imports, and all outgoing flows may be recorded as exports. Energy products sent abroad for processing should be treated following the treatment of goods for processing described in Section 3.3.

3.165 Energy use by resident units abroad, essentially covering tourists driving abroad and companies engaged in international transport activities, should be recorded in the accounts

[19] Generally these flows are not recorded in monetary supply and use tables.

either as the use of the industries earning the value added from these activities or as a use of the households operating the transport equipment. Conversely, all energy use by non-resident entities within the national boundary (ships, planes, trucks and tourists) should be excluded.

Transformation and end-use of energy products

3.166 The use of energy products is split into two sections in the use table. The first section, “Transformation of energy products”, records the transformation of energy products to other energy products. For example, the mining and quarrying industry may produce coal as an energy product in the supply table and its use to produce electricity would be shown in the transformation of energy products as the use of coal by the electricity supply industry.

3.167 The second section, “End-use of energy products”, records the use of energy products to produce goods and services that are not energy products. These goods and services may be used for intermediate consumption, for household final consumption, as a change in inventories of energy products, or for export. Some end-use will relate to non-energy uses of energy products, for example the use of oil based products as lubricants or in the production of plastics.

3.168 In total, intermediate consumption includes the use of all energy products by industries as inputs in a production process, regardless of the nature of the production process, i.e. whether it is a process converting an energy product into another energy product for further use in the economy (transformation), or whether it is a process which ultimately uses the energy content of the energy product so that no further use of the energy is possible (end-use), in some cases by incorporating the energy in a non-energy product.

3.169 Some energy products may be stored by industries for later transformation or end-use. The net changes in the quantities stored are recorded as changes in inventories and are recorded in the accumulation column for each relevant energy product.

3.170 Final consumption refers to the consumption by households of energy products purchased or otherwise obtained from energy suppliers. All final consumption reflects the end use of energy. Final consumption includes the energy products produced by the households themselves, e.g. energy produced from fuelwood gathered by households and electricity generated by windmills for own-use by households.

3.171 The concept of final consumption of energy in the SEEA differs from concept of final consumption defined in IRES. In IRES final consumption relates to the total end-use of energy by industries and households (excluding change in inventories and exports). It is therefore a broader measure than final consumption in the SEEA which relates only to end-use by households.

Energy residuals and energy incorporated into non-energy products

3.172 The bottom parts of the supply and use tables record entries associated with energy residuals and energy incorporated into non-energy products. Different types of energy residuals are recorded – losses during extraction, losses during distribution, losses during transformation, losses during storage and residual heat n.e.c. (excluding any losses as heat in other loss categories). The different energy residuals are recorded as being supplied by various industries and households in the supply table and received by the environment in the use table. Energy incorporated into non-energy products is separately recorded below energy residuals.

3.173 Losses of energy products are recorded as part of the intermediate consumption of the producer when the losses concern energy products before a change of ownership from the producer to the user has taken place. However, if there are losses of energy products after they have been delivered from the producer to the user of the product (for example from storage) are recorded as part of intermediate or final consumption of the user.

3.174 Energy residuals relating to residual heat are recorded as being generated by the relevant industry or household in the supply table and as being received by the environment in the use table. In concept, measures of residual heat can encompass heat related losses in any other loss categories. Since losses during transformation, distribution and storage are distinct types of losses, they are of particular analytical interest and they should be recorded separately from amounts of other residual heat. Residual heat n.e.c. is thus restricted to heat generated by end uses of energy products.

3.175 By convention, energy incorporated into non-energy products is recorded as supplied by those industries incorporating the energy into non-energy products (generally manufacturing industries) and, in the use table it should be recorded as a flow to accumulation as it is considered to have left the energy product system but remains within the economy. The recording of these flows ensures that the input-output identity described in Section 3.2 holds for all industries and households.

3.4.4 Energy statistics, energy accounts and energy balances

3.176 Energy statistics, energy accounts and energy balances all provide information on energy supply and energy use. Energy statistics result from the collection and compilation of information on production, imports, exports and domestic use of energy products on the basis of specific surveys and by using e.g. business statistics and international trade statistics. Energy balances re-organise these basic statistics by confronting and consolidating the supply and use sides, and by highlighting the transformation of energy within the economy. Similarly, energy accounts, which consistently use national accounts classifications and definitions, can be seen as a re-organization and broadening of scope of energy statistics. Both energy balances and energy accounts apply the principle that supply equals use, but the supply and use are defined in different ways in these two systems.

3.177 One main difference between the energy balances and the energy accounts concerns how activities are classified and the treatment of various activities within the national boundary. The energy accounts use the concept of residence to determine whether a specific energy flow should be included, for instance, as imports and whether it is included as part of the energy use or not. The boundary of the energy balances follows the national territory.

3.178 In contrast to the energy accounts, energy balances normally include only physical data on energy. Since one of main purposes of energy accounts is to link physical and monetary data in a comparable way, this leads to different definitions and a different organisation of energy data in physical terms so that it can be aligned with the data in monetary terms in the national accounts.

3.179 One method of reconciling aggregates that are derived from energy accounts and energy balances is the compilation of bridge tables. These tables show the adjustments required to either energy accounts or energy balances to account for the conceptual differences between the approaches. A full description of the relationship between energy accounts and energy balances and associated bridge tables is included in SEEA Energy.

3.4.5 Energy aggregates

3.180 Accounting for energy flows provides a framework for the assessment of energy production and consumption and related issues of resource use and air emissions. Many aggregates and indicators can be derived from PSUT and, using the structured framework, these data can be linked to data from the economic accounts in physical and monetary terms, to derive measures of intensity and productivity in energy use.

3.181 An aggregate that can be derived from the PSUT framework is the economic use of energy. Economic use of energy is the total amount of energy that has been used within the economy for production, consumption, or accumulation activities during an accounting period and that after its use can no longer be used for any other economic activity. In terms of the variables contained in the PSUT (Table 3.4.1), economic use of energy is equal to total losses plus other residual heat plus energy incorporated into non-energy products.

3.5 Physical flow accounts for water

3.5.1 Introduction

3.182 Water flow accounts describe water flows, in physical units, from the initial abstraction of water resources from the environment into the economy, to the water flows within the economy in the form of supply and use by industries and households and finally flows of water back to the environment. This section focuses on description of a PSUT for water noting that individual components of the PSUT could be compiled separately. Related accounting for emissions to water (Section 3.6) and asset accounts for water (Section 5.11) are also relevant.

3.183 For the purposes of water resource management the compilation of data for a river basin or other hydrologically relevant area may be appropriate. It is noted however, that while physical data may be available for such geographic areas, corresponding economic data will generally only be available for administrative regions and these two geographic boundaries may not align.

3.5.2 Scope of water flows

3.184 Water is in continuous movement. Solar radiation and gravity keep water moving from land and oceans to the atmosphere in the form of water vapour (evaporation and transpiration) and falling back through precipitation. The focus of the SEEA is the inland water resource system with provision for the inclusion of sea or ocean water abstracted for production and consumption (e.g. saline water for desalinization or cooling).

3.185 The inland water resource system comprises surface water (rivers, lakes, artificial reservoirs, snow, ice, glaciers), groundwater and soil water within the territory of reference. All flows associated with the inland water system are recorded in the asset accounts for water resources, including flows to and from accessible seas and oceans. The PSUT records the abstraction of water from the inland water system by economic units, the distribution and use of this water by various economic units and the returns of water to the inland water system. Flows such as the evaporation of water from lakes and artificial reservoirs and flows between water bodies are considered flows within the environment and are recorded in the asset accounts as described in Chapter 5.

3.186 Emissions to water (e.g. pollution) are recorded in a separate PSUT that is discussed in Section 3.6. The broader issue of the impact of economic activity on the quality of water requires an assessment of the quality of the stock of water resources. Water quality accounts are discussed in more detail in SEEA-Water.

3.5.3 Physical supply and use table for water

3.187 Physical supply and use tables can be compiled at various levels of detail, depending on the required policy and analytical focus and data availability. A basic PSUT for water contains information on the supply and use of water and provides an overview of water flows. The PSUT is divided into five sections that organize information on (i) the abstraction of water from the environment; (ii) the distribution and use of abstracted water across industries and households; (iii) flows of wastewater and reused water (between households and enterprises); (iv) return flows of water to the environment; and (v) evapotranspiration and water incorporated into products.

3.188 Table 3.5.1 shows the SEEA physical supply and use table for water. The columns of the PSUT are structured in the same way as for the general PSUT described in Table 3.2.1.

3.189 The breakdown of the economic activities, classified according to ISIC distinguishes the following groups:

- ISIC 01-03 which includes *Agriculture*, *Forestry* and *Fishing*;[20]
- ISIC 05-33, 41-43 which includes: *Mining and quarrying*, *Manufacturing and Construction*;
- ISIC 35 - *Electricity, gas, steam and air conditioning supply*;
- ISIC 36 - *Water collection, treatment and supply*;
- ISIC 37 - *Sewerage*;
- ISIC 38, 39, 45-99, *Other industries*.

3.190 Industry classes ISIC 35, 36 and 37 are specifically identified because of their importance in the supply and use of water and provision of water-related services. ISIC 35 is a major user of water for hydroelectric power generation and cooling purposes: it abstracts and returns into the environment enormous quantities of water. ISIC 36 and 37 are the key industries for the distribution and treatment of water and wastewater.

3.191 The following paragraphs describe the key components of the physical supply and use table for water.

Abstraction of water

3.192 The abstraction of water is recorded in the first part of the supply table, "Sources of water", as being supplied by the environment and the same volume of water is recorded in the first part of the use table, "Sources of water by industry", by the industry that undertakes the abstraction. Water may be abstracted from artificial reservoirs, rivers, lakes, groundwater and soil water. The capture of precipitation via, for example, the capture of water from the roofs of houses in water tanks, is recorded as abstraction via precipitation. Precipitation direct to inland water resources is not recorded in the PSUT but is recorded in the asset account.

3.193 Abstraction is defined as the amount of water that is removed from any source, either

[20] For certain analytical purposes it may be relevant to distinguish between the uses of water by these different industries.

permanently or temporarily, in a given period of time for consumption and production activities. Water used for hydroelectric power generation, is considered as abstraction and is recorded as a use of water by the abstractor. Water abstraction is disaggregated by source and by industry. All flows of abstracted water are treated as flows of products.

3.194 Following the general treatment of household activity, the abstraction of water by households for own-consumption should be recorded as part of the water collection, treatment and supply industry (ISIC 36). This activity is shown as a separate column in Table 3.5.1.

3.195 Consistent with the treatment for the asset accounts for water resources, the water in artificial reservoirs is not considered to be produced, i.e. it did not come into existence via a process of production. Consequently, abstraction from artificial reservoirs is recorded as abstraction from the environment and flows of precipitation into the artificial reservoirs and flows of evaporation from the reservoirs are not recorded in the PSUT for water. These flows are recorded in the asset accounts for water resources as part of the overall accounting for the change in the stock of water resources over an accounting period.

3.196 Abstraction of soil water refers to the uptake of water by plants that is either embodied in the harvested product or is transpired as the crop grows. It is limited to soil water used in agricultural production and cultivated timber resources. The abstraction of soil water is equal to the amount of transpiration by the crop and is calculated based on the crop area using coefficients of water use, with different coefficients used for different crops and accounting for location effects (e.g. soil types, geography and climate).

3.197 In principle an amount of abstracted water is retained at the end of each accounting period for use in the next accounting period, for example in storage tanks. However, this volume of water is relatively small in comparison to the overall flows of water during an accounting period and is also small relative to the stock of water held in the total inland water system and therefore, in practice, the net changes in the accumulation of abstracted water over an accounting period is not generally recorded.

Table 3.5.1 Physical supply and use table for water (Cubic metres of water)

Physical supply table for water resources

			Abstraction of water; Production of water; Generation of return flows									Flows from the Rest of the world	Flows from the Environment	Total supply
			Agriculture, forestry and fishing	Mining & quarrying, Manufacturing and Construction	Electricity, gas, steam and air conditioning supply	Water collection, treatment and supply		Sewerage	Other industries			Imports		
						Total	*of which* Households							
Sources of water														
	Inland water resources	Surface water												
		Groundwater												
		Soil water												
		Total												
	Other water resources	Precipitation												
		Sea water												
		Total												
	Total abstracted water													
Abstraction														
	Water for distribution	By Water collection, treatment and supply												
		By Other industries												
	Water for own-use													
Flows of wastewater and resused water														
	Wastewater produced and sent for treatment													
	Reused water produced	For distribution												
		For own use												
Return flows of water														
	To inland water resources	Surface water												
		Ground water												
		Soil water												
		Total												
	To other sources													
	Total Return flows													
Evapotranspiration and water incorporated into products														
TOTAL SUPPLY														

Physical use table for water resources

			Abstraction of water; Intermediate consumption; Return flows							Final consumption	Accumulation	Flows from the Rest of the world	Flows to the Environment	Total use
			Agriculture, forestry and fishing	Mining & quarrying, Manufacturing and Construction	Electricity, gas, steam and air conditioning supply	Water collection, treatment and supply		Sewerage	Other industries	Households		Exports		
						Total	*of which* Households							
Sources of water														
	Inland water resources	Surface water												
		Groundwater												
		Soil water												
		Total												
	Other water sources	Precipitation												
		Sea water												
		Total												
	Total abstracted water													
Use of abstractions														
	Distributed water	From Water collection, treatment and supply												
		From other sources												
	Water for own use (incl undistributed water)													
Flows of wastewater and reused water														
	Wastewater received from other units													
	Reused water used													
	Total													
Return flows of water														
	Returns of water to the environment													
		To inland water resources												
		To other sources												
	Total return flows													
Evapotranspiration and water incorporated into products														
TOTAL USE														

3.198 Sea water is generally abstracted either for cooling purposes - the corresponding wastewater flow is generally returned to the original source of water (i.e. the sea or ocean) – or for desalination processes. In the latter case, desalinated water could be returned to the inland water resource and constitute a resource.

Distribution and use of abstracted water

3.199 Water that has been abstracted must either be used by the same economic unit which abstracts it, (referred to as water for own use), or be distributed, possibly after some treatment, to other economic units (referred to as water for distribution). Most of the water for distribution is removed by ISIC 36, *Water collection, treatment and supply.* However, there may be other industries that abstract and supply water as a secondary activity. Flows of water for own use are shown as being circulated in the economy.

3.200 The second part of the supply table, “Abstractions”, shows the supply of abstracted water by the industries undertaking the abstraction with the differentiation as to whether the water is for own use for distribution. This part of the supply table also records imports of water from the rest of the world. The total of water abstracted for own-use, distribution and imports is the total water available for use in the economy.

3.201 The use of this water is shown is the second part of the use table, “Use of abstractions”, where the total water available for use is shown as the intermediate consumption of industries, the final consumption of households or exports to economic units in the rest of the world.

3.202 The distribution and use of water recorded in the second parts of the supply and use tables corresponds to the recording of product flows in the general PSUT framework described in Section 3.2. Consistent with the definition of products and the production boundary of the SNA, water is considered produced once it is abstracted from the environment.

3.203 The water received from other economic units refers to the amount of water that is delivered to an industry, households or the rest of the world by another economic unit. This water is usually delivered through systems of pipes (mains), but other means of transportation are not excluded (such as artificial open channels, trucks, etc.).

3.204 Within the economy, water can be exchanged between water producers and distributors before being effectively delivered to users. These water exchanges are referred to as intra-sectoral sales. These are the cases, for example, when the distribution network of one distributor/producer does not reach the water user and hence water must be sold to another distributor in order for the water to be delivered. These exchanges are not recorded in the PSUT as they are exchanges between units in the same industry and do not influence the total supply or use of water reflected in the accounts. Depending on the volumes of water involved it may be useful to present these intra-industry flows in a supplementary table.

The flows of wastewater and reused water

3.205 After accounting for the distribution and use of water it is necessary to consider flows of wastewater between economic units. Wastewater is discarded water that is no longer required by the owner or user. Wastewater can be discharged directly into the environment (in which case it is recorded as a return flow), supplied to a treatment facility (ISIC 37) (recorded as wastewater to Sewerage) or supplied to another industry for further use (reused water).

3.206 In situations where wastewater flows to a treatment facility or is supplied to another industry flows of water are recorded in the third part of the supply table, “Flows of wastewater and reused water” and the third part of the use table, “Flows of wastewater and reused water”. Flows of wastewater are generally residual flows between economic units since it is usually the case that the flow of wastewater to a treatment facility is also accompanied by a payment of a service fee to the treatment facility – i.e. the treatment facility does not purchase the wastewater from the supplier.

3.207 Reused water is wastewater supplied to a user for further use with or without prior treatment, excluding recycling of water within economic units. It is also commonly referred to as reclaimed wastewater. Reused water may be either a product or a residual depending on whether payment is made by the receiving unit.

3.208 Reused water excludes the recycling of water within the same establishment (on site). Information on recycled water, although potentially useful for analysis of water use efficiency, is not generally available. However, a reduction in the total volume of water used, while maintaining the same level of output, can provide an indication of an increase in water use efficiency which, in turn, may be due to the use of recycled water within an industry.

3.209 Once wastewater is discharged into the environment (e.g. into a river), its abstraction downstream is not considered as a reuse of water in the accounting tables, but as a new abstraction from the environment.

Return flows of water to the environment

3.210 All water that is returned to the environment is recorded as being supplied to the environment in the fourth part of the supply table, “Return flows of water”. In some cases these flows will comprise flows of wastewater direct to the environment from industries and households – i.e. flows of wastewater not sent to treatment facilities. In other cases these flows will comprise flows of water from treatment facilities following treatment. In the supply table these flows are shown as being supplied by the various industries and households to either inland water resources or other sources including the sea. Matching volumes of water are recorded in the fourth part of the use table, “Return flows of water”, with the flows shown as being received by the environment.

3.211 Some return flows of water to the environment are losses of water. Consistent with the general definition of losses outlined in Section 3.2, losses of water comprise flows of water that do not reach their intended destination or have disappeared from storage. The primary type of losses of water are losses during distribution. Losses during storage are not recorded, consistent with the treatment of quantities of water in storage which are generally not recorded.

3.212 Losses during distribution occur between a point of abstraction and a point of use or between points of use and reuse of water. These losses may be caused by a number of factors such as evaporation when, for example, water is distributed through open channels, and leakages when, for example, water leaks from pipes or distribution channels (including rivers in some cases) into the ground. In practice, when losses during distribution are computed as a difference between the amount of water supplied and received, they may also include errors in the meter's readings, malfunctioning meters, and theft.

3.213 A significant flow of water concerns urban runoff. Urban runoff is that portion of precipitation on urban areas that does not naturally evaporate or percolate into the ground, but flows via overland flow, underflow, or channels, or is piped into a defined surface water channel or a constructed infiltration facility. Urban runoff that is collected by a wastewater treatment or similar facility is recorded as a residual flow recovered from the environment in the supply table. It may then be treated before returning to the environment or it may be treated and distributed as reused water. Urban runoff that is not collected by a wastewater treatment or similar facility but flows directly to inland water bodies is not recorded in the PSUT.

3.214 Although separate estimates for urban runoff may be available in some countries, these flows generally cannot be measured directly. Estimates may be obtained by measuring the difference between the volumes of wastewater discharged by economic units (industries and households) into sewers and the volumes of wastewater collected from the sewerage system.

Evapotranspiration and water incorporated into products

3.215 To fully account for the balance of flows of water entering the economy through abstraction and returning to the environment as return flows of water, it is necessary to record two additional physical flows. The first is evapotranspiration and the second is water incorporated into products. In both cases the water is removed from and does not return to the inland water system.

3.216 Flows of evaporation occur when water is distributed between economic units after abstraction, for instance when distribution via open channels or while in water storage tanks and similar structures. The transpiration of water occurs when distributed surface water used for crop irrigation or soil water is absorbed by cultivated plants as they grow and is released to the atmosphere.

3.217 Amounts of water incorporated into products (for example, water used in the manufacture of beverages) is shown as supplied by the relevant industry, commonly a manufacturing industry.

3.218 The supply and use of evapotranspiration and water incorporated into products is recorded in the fifth set of rows of the supply and use tables. Ideally, these two flows would be recorded separately with the flows of evapotranspiration shown as flowing to the environment from the relevant water user and the flow of water incorporated into products shown as retained in the economy in the accumulation column. In practice, direct measurement of these flows is usually not possible and hence a combined flow is recorded – as shown in Table 3.5.1. In Table 3.5.1 the combined flow is recorded as a flow to the environment in the use table.

3.5.4 Water aggregates

3.219 Water accounting provides a useful tool for improved water management. Many indicators can be derived from PSUT and, using the structured framework, these data can be linked to data from the economic accounts in physical and monetary terms, to derive measures of intensity and productivity of water use.

3.220 A significant proportion of return flows of water can be immediately abstracted again from inland water resources. Consequently, a common aggregate used in water statistics, termed hydrological water consumption in the SEEA is used by hydrologists and water statisticians to reflect the water that is no longer immediately available to the economy. In terms of the variables contained in the PSUT (Table 3.5.1) hydrological water consumption is equal to evapotranspiration plus water incorporated into products. For analytical purposes it may be useful to separate hydrological water consumption into those amounts due to evaporation and transpiration and those amounts incorporated into products.

3.221 An aggregate can also be defined that is equivalent to the economic use of energy, namely the economic use of water. The economic use of water is the total amount of water that has been used within the economy for production, consumption, or accumulation activities during the period and that after its use can no longer be used for any other economic activity by the economy. In terms of the variables contained in the PSUT (Table 3.5.1) economic use of water is equal to total return flows of water (including losses of water) plus evapotranspiration plus water incorporated into products.

3.222 Within the PSUT for water there are other aggregates that are aligned with the concept of consumption as applied in economics and the national accounts. The two main economic consumption aggregates are intermediate consumption by industries and household final consumption. Intermediate consumption of water in physical terms is equal to the total use of water by industry received from other economic units (including reused water) plus water abstracted and retained for own use. The final consumption of water is equal to the use of water by households received from other economic units (including reused water) and water abstracted and retained for own use.

3.223 The aggregates and indicators just described do not cover all changes in the stock of water in inland water resources. Of particular interest may be losses of water through evaporation, particularly from artificial reservoirs. These losses are recorded in the asset accounts for water resources described in Chapter 5.

3.6 Physical flow accounts for materials

3.6.1 Introduction

3.224 A third sub-system of physical flow accounting concerns materials. In contrast to energy and water materials are a far more diverse set of natural inputs, products and residuals. Consequently, although in principle a complete accounting for materials on the basis of the mass of each type of material may be accomplished, in practice accounting for materials tends to focus either on particular materials or on specific types of purposes or flows.

3.225 In addition, there is interest in focussing on particular parts of the overall material flow cycle. For example, Section 3.2 defined emissions as a type of residual that are releases of substances by establishments into the air, water or soil as a result of production, consumption or accumulation processes. The focus on accounting for emissions is therefore not on the complete cycle through the economy of the particular substances that comprise emissions but rather only on the flow from the economy to the environment. Similar considerations apply in the accounting for solid waste.

3.226 This section discusses the main areas in which development of physical flow accounting for materials has taken place – (i) product flow accounting, (ii) accounting for air emissions, (iii) accounting for emissions to water and associated releases to economic units, (iv) accounting for solid waste and (v) economy wide material flow accounting (EW-MFA). In all cases the accounting systems work within the principles and structures outlined in Sections 3.2 and 3.3

3.6.2 Product flow accounting

3.227 For the management of specific products it may be useful to trace the physical flows of an individual material from the environment, through the economy and back into the environment. At a very detailed level it is possible to trace elements such as mercury that may be of interest due to their hazardous nature. Using similar methods, nutrient balances in the soil might be traced in terms of the uptake of nutrients by crops and the embodiment of these nutrients in other products.

3.228 As materials flow through the economy, they can become embodied in products that are more complex. These material flows can be analysed by combining the physical flow data with the economic relationships in standard supply and use tables. In this way it is possible to estimate materials required to yield final products. This type of information is relevant for demand based analysis of material flows and for the calculation of the upstream requirements of production that are necessary for life cycle analysis and related techniques.

3.229 A particular example of this type of material flow accounting is the compilation of nutrient balances. Nutrient balances trace the flows of soil nutrients (Nitrogen (N), Phosphorous (P) and Potassium (K)) from the soil through various products. Nutrient balances, particularly if calculated at a broad scale, necessarily require the use of multiple coefficients in order to estimate not only the total amount of inputs, but also the extraction of nutrients in products (harvested crops and grasses and fodder used for livestock grazing).

3.230 Three major types of physical flows are used to construct nutrient balances on a broad scale. First, product flows of fertilizer products, which may be organic or inorganic and are measured in tonnes of nutrients. Second, other organic inputs, which includes own-account production of nutrients on farms through use of manure and natural cycling processes such as natural fixation that occur during the accounting period. These other organic input flows are estimated in a variety of ways depending on the type of flow, e.g. by using data on populations of livestock and other information related to natural processes. Third, nutrients removed from the system by crops that are harvested (and thus removed from the system) and other plants and grasses used for grazing by livestock. These flows are also estimated by applying relevant coefficients to data on physical supply of crops, grasses and fodder. The difference between the total inputs and the removals is sometimes called the nutrient balance and represents the surplus or deficit of nutrients resulting from the production process.

3.231 The nutrient balance, is related to the dissipative use of products (described in Section 3.2.4) of N, P and K resulting from agricultural and forestry activities. It should be noted that positive nutrient balances, or residuals from the dissipative use of products, are not necessarily lost to the relevant production unit (e.g. the farm). Depending on a number of factors, some of the residuals could remain in the soil as a surplus that may be useful for crop production in future harvests. However, a proportion of the positive balance for a given nutrient also commonly leads to degradation of nearby surface and groundwater as well as emissions to air, e.g. in the form of nitrous oxide (a greenhouse gas). A negative balance, i.e. the case where removals exceed inputs for N, P, or K, can be an indicator of a lack of sustainability in production since, ultimately the production of crops cannot continue without an appropriate balance of each of the major nutrient categories as inputs from the soil.[21] There are no residual flows in this situation.

3.232 While product flow accounting may be undertaken following different accounting rules suited or tailored to an individual product, it is recommended that accounting be undertaken consistently with the boundaries and definitions outlined in section 3.2 and 3.3. If this is done it permits a much broader range of linkages and analysis.

[21] More information and guidelines for calculating nutrient balances are available from FAO, OECD and Eurostat. See for example, "OECD/Eurostat Gross Nitrogen Balances Handbook", December 2003.

3.6.3 Accounting for air emissions

3.233 ***Emissions to air are gaseous and particulate substances released to the atmosphere by an establishment or household as a result of production, consumption and accumulation processes.*** The SEEA air emission account records the generation of air emissions by resident economic units by type of substance.

3.234 In some situations the gaseous and particulate substances generated through economic activity may be captured for use in other production processes (for example the capture of methane gas from landfill sites to generate energy) or may be transferred between economic units for use in production or for storage (for example the storage of carbon). To fully account for the flows of particular gaseous and particulate substances there may be interest in recording the releases of these substances to economic units, in addition to emissions to air. This extension is not described in this section but in accounting terms it follows the same general principles outlined in this chapter.

3.235 Since the focus is on the generation and release of residuals there is no requirement to construct a complete PSUT. Rather, emphasis is on determining an appropriate scope for the measurement of air emissions that aligns with the scope and boundaries used in the compilation of the economic accounts.

3.236 The SEEA air emission account is presented in Table 3.6.1. Its structure is a reduced and reoriented version of the general PSUT presented in Table 3.2.1. The left hand part of the table is the supply table and shows the generation of emissions by industries and households by type of substance. For the purpose of accounting for emissions of carbon dioxide it is recommended that, where possible, carbon dioxide emissions resulting from the burning of fossil fuels should be distinguished from carbon dioxide emissions from biomass.

Table 3.6.1 Air emissions account

Table 3.6.1 Air emissions account		**(Mass units - tonnes)**											
		Supply table for air emissions										**Use table for air emissions**	
		Generation of emissions								**Accumulation**	**Total supply of emissions**	**Flows to the Environment**	**Total use of emissions**
		Industries					Households			Emissions from landfill		Emissions released to the environment	
		Agriculture	Mining	Manufacturing	Transport	....	Transport	Heating	Other				
Type of substance													
	Carbon dioxide												
	Methane												
	Dinitrogen oxide												
	Nitrous oxides												
	Hydroflourocarbons												
	Perflourocarbons												
	Sulphur hexaflouride												
	Carbon monoxide												
	Non-methane volatile organic compounds												
	Sulphur dioxide												
	Ammonia												
	Heavy metals												
	Persistent organic pollutants												
	Particulates (incl PM10, dust)												

3.237 The column for accumulation shows the release of air emissions from controlled landfill sites as these reflect a release of emissions from production, consumption and accumulation activity in earlier periods. These emissions should be attributed to the waste management units that operate the landfill sites.

3.238 Air emissions by households are broken down by purpose (transport, heating, other). Additional purposes may be added depending on analytical requirements and available information.

3.239 The right hand part of the table is the use table which shows only the release of emissions to the atmosphere.

Issues in the measurement of air emissions

<u>Economic boundary with respect to air emissions</u>

3.240 Consistent with the general definition of the economic boundary using the principle of residence some air emissions will occur when economic units undertake activity in other countries. Consequently, while the majority of air emissions will be released into the national environment, some air emissions from resident economic units will be released into the environment of the rest of the world. The use of the concept of residence means that air emission accounts for a nation will exclude emissions released within a national territory by non-residents such as tourists and foreign transportation operations, whereas the emissions abroad of resident economic units will be included.

<u>Environmental boundary with respect to air emissions</u>

3.241 The nature of air emissions means that it is quite possible for air emissions released in one country to be carried through the atmosphere into the territory of another country. While these flows may be of considerable interest in understanding the state and quality of the atmosphere of a national environment, these flows are out of scope from air emission accounts as they are flows that take place within the environment.

3.242 Air emission accounts also do not cover the capture or embodiment of gases by the environment, for example carbon captured in forests and soil.

<u>Other scope and boundary issues</u>

3.243 Included within the scope of air emissions in the air emission account are the emissions from cultivated livestock due to digestion (primarily methane) and emissions from soil as a consequence of cultivation. Emissions from natural processes such as unintended forest and grassland fires and human metabolic processes are excluded.

3.244 Secondary emissions occur when emissions from various economic processes combine in the atmosphere to create new substances. These new combinations should be considered as changes occurring in the environment and excluded from air emission accounts.

3.245 Flaring and venting of residual gaseous and particulate materials into the atmosphere is part of the process of extracting natural gas and crude oil. These releases are included in the air emission accounts.

3.246 Emissions from manure collected and spread on agricultural land are within scope of the air emission accounts. The use of manure is considered the dissipative use of a product and following the general guidelines in section 3.2 the emissions from the manure are considered flows from the economy to the environment rather than flows within the environment.

3.247 The air emissions generated by industries and households are recorded in the supply table at the point they leave an establishment. Thus they should be measured after the substances have passed through any relevant filtering or emission reduction technology within the establishment.

Attribution of air emissions

3.248 Air emissions are released due to production, consumption and accumulation processes of industries and households. In order to permit effective linking of physical flow data to monetary data the physical flows of emissions should be classified using the same classifications used by the national accounts. For household consumption, it is necessary to consider both the purpose of the consumption and the actual product being used by households. This requires consideration of data classified by COICOP (the Classification of Individual Consumption by Purpose) and by CPC.

3.249 Attribution of air emissions is of particular relevance in the consideration of air emissions from durable goods such as cars. Air emission accounts should attribute the emissions to the nature of the activity for which the durable goods are being used rather than by the characteristics of the durable good. Thus emissions from a car used for private household transport should be classified to households while emissions from a car used for the delivery of goods by a retailer should be classified to the retail industry.

3.250 In addition to air emissions that are released through operation of durable goods there may also be emissions that are leaked into the atmosphere both during the operating life and after the good has been discarded. These leakages should be recorded as they occur and attributed to the owner of the good at the time of the leakage. It may be that the "ownership" of the discarded good is a landfill site in which case the leakages should be reflected as part of the overall air emissions from the landfill site and attributed to the waste management industry operating the site.

3.251 Landfill sites may generate air emissions but may also capture these gases to produce other outputs – for example, the production of energy from methane captured on-site – thereby releasing other air emissions direct to the atmosphere that should also be recorded.

Those emissions that leave the establishment should be attributed to the waste management industry within which the management of landfills is one activity.[22]

3.252 At the same time, usually emissions from solid waste in landfill sites will not relate directly to inflows of solid waste and other materials to the site during the current accounting period but instead are emissions due to the accumulation of solid waste over time. For this reason there may be analytical interest in only considering those emissions generated through the day to day operation of the landfill sites (e.g. fuel for trucks and machines) and excluding emissions from solid waste in landfill sites as the emissions from solid waste cannot be directly related to broader measures of economic activity in the current period.

3.253 Following the general accounting treatment for the activity of general government units, air emissions generated by government are recorded against the relevant industry activity (for example, public administration). It is noted that often waste management units are operated as part of general government activity and it may be difficult to separate out these operations from a broader general government unit within which they may be managed. Nonetheless, given the importance of waste management activities in accounting for air emissions it is recommended that all efforts be made to identify separately these activities within the broader suite of general government activities.

The relationship between air emission accounts and other accounting frameworks

3.254 There is significant policy interest in air emissions particularly carbon dioxide and other greenhouse gas emissions. For different reasons a number of other accounting frameworks are of particular importance in relation to the SEEA air emission accounts.

3.255 The first is the accounting for emission inventories under the auspices of the United Nations Framework Convention on Climate Change (UNFCCC). Many countries compile relevant statistics on emission inventories on a regular basis and there are close parallels in the accounting for air emissions as described in the SEEA. The main adjustments required to bridge between SEEA air emission accounts and UNFCCC required data concern the emissions of residents abroad and non-residents in the territory. The focus of these adjustments is on land, water and air transport and national fishing vessels operating abroad.

3.256 The second important framework is the energy accounts described in Section 3.4. Because a significant source of carbon dioxide and greenhouse gas emissions is from the burning of fossil fuels in the production of energy there are important connections between the measurement of air emissions and the measurement of energy accounts. Indeed, it is common for relevant sections of air emission accounts to be compiled based on data contained in energy accounts.

[22] Emissions from landfill sites will include both emissions from accumulated solid waste and emissions from equipment used to operate the site.

3.6.4 Accounting for emissions to water and associated releases to economic units

3.257 ***Emissions to water are substances released to water resources by an establishment or household as a result of production, consumption and accumulation processes.*** Emissions to water resources can constitute a major environmental problem and cause the quality of water bodies to deteriorate. Some of the substances emitted into water resources are highly toxic and thus affect negatively the quality of the receiving water body. Similarly, other substances, such as nitrogen and phosphorus, can lead to eutrophication, or organic substances can have effects on the oxygen balance thus affecting the ecological status of the receiving water body.

3.258 Within the SEEA framework it is relevant to account for both emissions of substances to water resources and releases of the same substances to the sewerage system by establishments and households. These releases are received and treated by wastewater treatment facilities before emission to water resources. The accounting coverage is therefore gross releases of substances to water resources and the sewerage system by establishments and households.

3.259 Accounts for gross releases to water, commonly referred to as water emission accounts, present information on the activities responsible for the emissions and releases, the types and amount of substances, as well as the destination of the emissions (e.g. water resources and sea). Water emission accounts are a useful tool for designing economic instruments, including new regulations to reduce emissions into inland water resources or seas and oceans. When analysed in conjunction with the technology in place to reduce gross releases and treat wastewater, they can be used in impact studies concerning the efficiency of current technologies in reducing substances in the water and concerning the potential of new technologies.

Coverage of water emission accounts

3.260 Water emission accounts record the quantity of substances added to water by an establishment or household during an accounting period and are expressed in terms of mass (kilograms or tonnes, depending on the substance under consideration). Water emission accounts cover: (a) substances added to wastewater and collected in the sewerage network; (b) substances added to wastewater discharged directly to water bodies; and (c) substances from non-point sources, for example, emissions and releases from urban runoff and emissions from agriculture. The water emission accounts thus provide the description of the wastewater flows described in the PSUT for water in Section 3.5, in terms of substances resulting from economic activity. The direct discharge to water resources of heavy metals (in solid state) and hazardous waste not through wastewater is not covered in water emission accounts but in the solid waste accounts as it involves the discharge of solid waste.

3.261 Sources of water emissions and releases are classified as point source and non-point source. Point source water emissions and releases are those for which the geographical location of the discharge of the wastewater is clearly identified. They include, for example, water emissions and releases from wastewater treatment plants, power plants and other industrial establishments. Non-point (or diffuse) sources of water emissions and releases are sources without a single point of origin or a specific outlet into a receiving water body. Water emissions are generally carried off the land by urban runoff or may be the result of a collection of individual and small scale activities which, for practical reasons, cannot be treated as point sources. By convention, the emissions and releases associated with urban runoff are allocated to the sewerage industry.

3.262 Emissions relating to returns of irrigation water and rainfed agriculture are described in terms of the substances that are added to the return flows from agricultural land, i.e. fertilizers and pesticides spread on the soil during infiltration into groundwater or run-off to surface water.

Water emission account

3.263 The structure of the SEEA water emission account is shown in Table 3.6.2. Its structure is a reduced version of the general PSUT presented in Table 3.2.1. The top half of the table is the supply table and shows the generation of water emissions and releases by industries and households by type of substance and the treatment of releases by the wastewater treatment industry. The bottom half of the table is the use table and shows the collection of releases in wastewater for treatment by the wastewater treatment industry and the emissions to the environment.

3.264 The level of industry detail in the table is dependent on data availability and analytical interest. Where focus is on a particular type of substance, the rows of the table may be structured to reflect the destinations of the emissions and releases generated. Thus, for any particular industry or household it is possible to show the quantity of emissions that flow directly to the environment and releases that flow to wastewater treatment plants. The environment column may also be disaggregated to show releases to the inland water resources or to the sea.

3.265 For analytical reasons it may also be useful to reallocate the emission of substances by the wastewater treatment industry to the economic unit responsible for the original release. This is often difficult to calculate as the wastewater industry usually treats flows of wastewater coming from diverse users of the sewage system in aggregate. Therefore, in general, the allocation is obtained by applying global treatment or abatement rates of the water treatment plant to all releases collected by the treatment plant.

3.266 The exchange of relevant substances with the rest of the world (imports and exports) covers the exchanges of substances associated with the release of wastewater from one economy to a wastewater treatment plant in another economy. Also included are emissions of relevant substances from non-resident vessels operating within a country’s water bodies (for example, due to corrosion or fuel leaks). Water emission accounts do not include 'imports' and 'exports' of substances through natural flows of water resources. Thus, the quantity of relevant substances in rivers crossing country borders and/or flowing to the open sea are not recorded in the water emission account.

Table 3.6.2 Water emissions account		(Mass units)					
Physical supply table for gross releases of substances to water							
		Generation of gross releases to water			**Flows with the rest of the world**	**Flows from the environment**	**Total supply**
		Water treatment industry	Other industries	Households	Imports		
Emissions by type of substance							
	BOD / COD *						
	Suspended solids						
	Heavy metals						
	Phosphorous						
	Nitrogen						
Releases to other economic units							
	BOD / COD *						
	Suspended solids						
	Heavy metals						
	Phosphorous						
	Nitrogen						
Physical use table for gross releases of substances to water							
		Collection of emissions to water			**Flows with the rest of the world**	**Flows to the environment**	**Total use**
		Water treatment industry	Other industries	Households	Exports		
Emissions received by the environment							
	BOD / COD *						
	Suspended solids						
	Heavy metals						
	Phosphorous						
	Nitrogen						
Collection by other economic units							
	BOD / COD *						
	Suspended solids						
	Heavy metals						
	Phosphorous						
	Nitrogen						

* BOD (biological oxygen demand) and COD (chemical oxygen demand) are measures of substances that have an unfavourable influence on the oxygen balance. More specifically, BOD is the mass concentration of dissolved oxygen consumed under specific conditions by the biological oxidisation of organic and/or inorganic matter in water; and COD is the mass concentration of oxygen consumed under specific conditions by the chemical oxidisation with bichromate of organic and/or inorganic matter in water.

3.6.5 Solid waste accounts

3.267 Solid waste accounts are useful in organising information on the generation of solid waste and the management of flows of solid waste to recycling facilities, to controlled landfills or directly to the environment. Measures of the amount of waste in aggregate or of quantities of specific waste materials may be important indicators of environmental pressure. The construction of solid waste accounts allows these indicators to be placed in a broader context with economic data in both physical and monetary terms.

The definition of solid waste

3.268 Following the definition provided in Section 3.2, solid waste covers discarded materials that are no longer required by the owner or user. Where the unit discarding the materials receives no payment for the materials then the flow is considered a residual flow of solid waste. Where the unit discarding the materials receives a payment but the actual residual value of the material is small, for example in the case of scrap metal sold to a recycling firm, this flow is considered a product flow of solid waste.

3.269 Discarded materials sold for significant values – for example the sale of a second hand car or furniture – should be treated as flows of products and not treated as solid waste. In the determination of whether the residual value is significant consideration may be given to the extent to which the receiving unit will need to treat, repair or otherwise process the material for use in production or further sale.

3.270 In practice, in many countries, statistics on solid waste will be based on legal and administrative lists of materials determined to be solid waste. However, the principles above should provide a basis for the measurement of solid waste in countries where legal or administrative processes concerning waste do not exist or are limited in scope. These principles may also provide a basis for the establishment or amendment of lists of solid waste materials.

Structure of the solid waste account

3.271 The structure of the solid waste account is presented in Table 3.6.3. It follows the logic of the general PSUT described in Section 3.2. There is no standard international classification of solid waste but for illustrative purposes the table includes an indicative listing of types of solid waste based on the European Waste Catalogue – Statistical version (EWC-Stat).

3.272 The upper half of the table is the supply table. The first part of the supply table, "Generation of solid waste residuals", shows the generation of solid waste by industries and households. It also shows the supply of solid waste from the rest of the world (recorded as imports) and also solid waste recovered from the environment (for example, oil recovered following an off-shore oil spill, debris collected following a natural disaster, or the excavation of soil from locations at which hazardous chemicals were used).

3.273 The bottom half of the table is the use table. The first part of the use table, “Collection and disposal of solid waste residuals”, shows the collection and disposal of solid waste by various activities within the waste collection, treatment and disposal industry and by related activities in other industries. It also shows the flow of solid waste to the rest of the world as exports and the flow of solid waste direct to the environment.

3.274 The columns of the table highlight the various activities of the waste collection, treatment and disposal industry. These are landfill operation, incineration of solid waste of which incineration of solid waste to produce energy is separately identified, recycling and reuse activities and other treatment of solid waste. Other treatments include the use of physical-chemical processes, the use of mechanical-biological processes and the storage of radioactive waste. More industry detail may be provided depending on analytical requirements and available information. Of particular interest may be the identification of cases where the activities just listed are undertaken as secondary or own-account production within other industries.

3.275 It is noted that the accumulation of waste in landfill sites is not presented in a distinct accumulation column as in the general PSUT. This is done such that all information on the waste collection, treatment and disposal industry can be presented as a single group.

3.276 In the second part of the supply table, “Generation of solid waste products” and in the second part of the use table, “Use of solid waste products”, the flows of solid waste that are products rather than residuals are recorded following the distinction described above. The flows recorded here relate to cases when a solid waste product is identified at the time of disposal by the discarding unit. The flow is recorded in the second part of the supply table matched by a use of solid waste products in the second part of the use table. Sales of scrap metal would be recorded in this way.

3.277 Sales of recycled products should not be included. For example, flows of paper discarded by households that is collected by a charitable organisation and subsequently sold in bulk to a paper recycling firm are only recorded in the solid waste account in respect of the initial flow from households.

Table 3.6.3 Solid waste account		**(Mass units - kilograms/tonnes)**									
Physical supply table for solid waste											
		Generation of solid waste							**Flows with the rest of the world**	**Flows from the environment**	**Total supply**
		Waste collection, treatment and disposal industry					Other industries	Households	Imports of solid waste	Recovered residuals	
		Landfill	Incineration		Recycling and reuse	Other treatment					
			Total	Of which: Incineration to generate energy							
Generation of solid waste residuals											
	Chemical and healthcare waste										
	Radioactive waste										
	Metallic waste										
	Other recyclables										
	Discarded equipment and vehicles										
	Animal and vegetal wastes										
	Mixed ordinary waste										
	Mineral wastes and soil										
	Combustion wastes										
	Other wastes										
Generation of solid waste products											
	Chemical and healthcare waste										
	Radioactive waste										
	Metallic waste										
	Other recyclables										
	Discarded equipment and vehicles										
	Animal and vegetal wastes										
	Mixed ordinary waste										
	Mineral wastes and soil										
	Combustion wastes										
	Other wastes										

Physical use table for solid waste											
		Intermediate consumption; Collection of residuals						**Final consumption**	**Rest of the world**	**Environment**	**Total use**
		Waste collection, treatment and disposal industry					Other industries	Households	Exports of solid waste		
		Landfill	Incineration		Recycling and reuse	Other treatment					
			Total	Of which: Incineration to generate energy							
Collection and disposal of solid waste residuals											
	Chemical and healthcare waste										
	Radioactive waste										
	Metallic waste										
	Other recyclables										
	Discarded equipment and vehicles										
	Animal and vegetal wastes										
	Mixed ordinary waste										
	Mineral wastes and soil										
	Combustion wastes										
	Other wastes										
Use of solid waste products											
	Chemical and healthcare waste										
	Radioactive waste										
	Metallic waste										
	Other recyclables										
	Discarded equipment and vehicles										
	Animal and vegetal wastes										
	Mixed ordinary waste										
	Mineral wastes and soil										
	Combustion wastes										
	Other wastes										

3.6.6 Economy wide Material Flow Accounts (EW-MFA)

3.278 The purpose of economy-wide material flow accounts (EW-MFA) is to provide an aggregate overview, in tonnes, of material inputs and outputs of an economy including inputs from the environment and output to the environment and the physical amounts of imports and exports. EW-MFA and associated balances constitute the basis from which a variety of material flow based indicators can be derived. Also, given their generally close alignment with PSUT, EW-MFA may be a useful starting point for the development of a fully articulated PSUT for the whole economy.

3.279 EW-MFA are well aligned with PSUTs as described in this chapter but they do not attempt to focus on the detail of physical flows, particularly as concerns flows within the economy. They generally focus on the mass of material entering the economy from the environment – natural resources and other natural inputs, and the mass of residuals flowing to the environment. Given their economy wide focus, EW-MFA also focus on physical flows of goods and services to and from the rest of the world. With a macro-purpose in mind some practical choices on treatment have been made such that flows within the EW-MFA system can be estimated in a more straightforward way. These choices are outlined below.

3.280 A full description of EW-MFA accounting and the associated indicators can be found in Economy-wide material flow accounts and derived indicators – A methodological guide (Eurostat, 2001). Useful background information may also be found in the OECD publication “Measuring Material Flows and Resource Productivity, Volume II: The Accounting Framework” (OECD, 2008)

Differences in treatment between EW-MFA and PSUT

3.281 International trade. EW-MFA estimates of physical flows of imports and exports are typically based on international trade data. While some adjustments are made to account for significant items such as fuel purchases abroad by resident economic units, a full adjustment of the trade data to a residence basis of recording is not currently attempted in EW-MFA accounts.

3.282 Recording of flows associated with biological resources. In EW-MFA the treatment of cultivated crops, trees and other harvested plants, differs from the treatment in the SEEA PSUT in that the flow from the environment to the economy is recognised at the point of harvest rather than as growth occurs. Consistent with drawing the boundary in this way, the uptake of soil nutrients and water and the inputs associated with photosynthesis are considered flows within the environment (between the soil and atmosphere and the plant itself) whereas in the general PSUT the plants are considered to be already within the economy and hence these flows are considered inputs from the environment to the economy and are hence recorded as natural inputs (see Section 3.2). In effect, by recording the amount harvested rather than the input flows from the soil and the atmosphere, the EW-MFA assumes that the harvested amounts embody all of the different natural inputs. Since the harvested amounts can be more easily measured at an aggregate level this different boundary is appropriate for EW-MFA analysis.

3.283 For cultivated livestock, aquatic and other animal resources the flows from the environment to the economy are treated in the same way in both the EW-MFA and the PSUTs. Thus, as explained in Section 3.2 the growth of cultivated livestock and fish is recorded as it occurs rather than at the point of harvest or slaughter.

3.284 The treatment of natural biological resources, both plants and animals, is also the same in both approaches in which all wild plants and animals are recorded as entering the economy at the point of harvest.

3.285 Because of the treatment of cultivated plant resources, many natural inputs are not directly recorded in the EW-MFA. However, some inputs from air are recorded in relation to the respiration of livestock and the inputs absorbed during combustion. These inputs are referred to as input balancing items in EW-MFA.

3.286 These differences in treatment, particularly with regard to the use of the "harvest" production boundary in the EW-MFA means that the EW-MFA boundary and the SEEA boundaries are not aligned.

REVISION OF THE SYSTEM OF ENVIRONMENTAL - ECONOMIC ACCOUNTS (SEEA)

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Chapter 4: Monetary flow accounts

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4.1 Introduction

4.1 An important component of environmental and economic accounting is the recording of the transactions between economic units that may be considered environmental. Generally, these transactions concern activity undertaken to preserve and protect the environment. As well, there are a range of transactions, such as taxes and subsidies, that reflect efforts by governments to influence behaviours of producers and consumers with respect to the environment.

4.2 Most of these environmental transactions are recorded within the core national accounts framework but many cannot be easily identified due to the structure of the accounts or the types of classifications that are used. This chapter describes approaches that have developed for recognising these transactions and provides appropriate definitions and accounts for the organisation of information on environmental transactions.

4.3 A strong motivation for undertaking this work is to identify an environmental component within the key aggregates of the SNA. Further, in combination with information on the changing pressures on the environment, information on these transactions may be used to assess whether economic resources targeted at reducing the pressures on the environment and maintaining the capacity of the environment to deliver benefits is being used effectively and different policies may be compared and contrasted.

4.4 The general approach to identifying transactions related to a particular theme or topic is described in the SNA in its discussion of satellite accounts. A satellite account is formed through the adaptation and rearrangement of the core structures of the SNA to suit particular objectives. For the objective of identifying environmentally related transactions, the rearrangement is based on considering the purpose underlying each transaction and using so-called functional classifications. The compilation of accounts, known as functional accounts, using these alternative classifications requires that underlying statistics can also be reorganised to provide the requisite information.

4.5 As explained in this chapter, the first task is to define environmental activities and the associated products and producers. This is done in section 4.2.

4.6 Section 4.3 explains the compilation of two sets of information for the analysis of environmentally related transactions – the Environmental Protection Expenditure Account (EPEA) and statistics on the Environmental Goods and Services Sector (EGSS). Both the EPEA and the EGSS provide information that assists in understanding society’s response to the challenge of environmental degradation and depletion of natural resources and the potential for economic activity to be based on environmentally friendly and more resource efficient activities. However, each set of information presents a different coverage and perspective on environmental activities.

4.7 The final section, section 4.4, considers a range of other environmentally related transactions, including environmental taxes and subsidies, permits and licences to use environmental assets and transactions relating to fixed assets used in economic activities related to the environment.

4.2 Environmental activities, products and producers

4.2.1 Introduction

4.8 The traditional industry and product classifications are not sufficient to identify the economic activities, products, and producers that are characteristic of the environment. Alternative classifications are needed to discriminate between those products and industries frequently associated with the environment. This is done by considering the purpose of different activities. Using a purpose based approach, this section defines the environmental activities in the central framework and presents their scope and classification.

4.9 A distinction is drawn between those economic activities that should be considered environmental, and other economic activities that are closely associated with the environment or that use the environment directly in their production processes – for example, the extraction of mineral and energy resources. These activities may be considered "environmentally related" but, to some degree, all economic activities require a functioning environment and interact with the environment in some way. Hence an exhaustive categorisation and description of all environmentally related activities is not pursued in the SEEA.

4.10 The last parts of the section present the different sets of environmental goods and services that are relevant in measuring the extent of environmental activities and the associated groups of environmental producers.

4.2.2 The scope and definition of environmental activities

4.11 The scope of environmental activities is those economic activities whose primary purpose is to reduce or eliminate pressures on the environment or to make more efficient use of natural resources. Examples of these activities are restoring polluted environments, conservation and resource management, and investing in technologies designed to prevent or reduce pollution.

4.12 These various activities are grouped into two broad types of environmental activity - environmental protection and resource management. ***Environmental protection activities are those activities whose primary purpose is the prevention, reduction and elimination of pollution and other forms of degradation of the environment.*** These activities include, but are not limited to, the prevention, reduction or treatment of waste and wastewater; the prevention, reduction or elimination of air emissions; the treatment and disposal of contaminated soil and groundwater; the prevention or reduction of noise and vibration levels; the protection of biodiversity and landscapes, including their ecological functions; monitoring of the quality of the natural environment (air, water, soil, groundwater); research and development; and the general administration and training and teaching activities oriented towards environmental protection.

4.13 ***Resource management activities are those activities whose primary purpose is preserving and maintaining the stock of natural resources and hence safeguarding***

against depletion. This includes actions and activities aiming at reducing the withdrawals of natural resources (recovery, reuse, recycling, substitution of natural resources) as well as restoring natural resource stocks (increases or recharges of natural resource stocks). It also includes the general management of natural resources (including monitoring, control, surveillance and data collection), and the production of goods and services used to manage or conserve natural resources.

4.14 Resource management activities may result in associated secondary environmental benefits such as protection and restoration of wildlife and natural habitats. However, activities specifically for biodiversity or landscape protection (for example, management of protected forests) and activities aimed at preserving certain functions or the quality of the natural environment should be treated as environmental protection.

Determination of primary purpose

4.15 While some economic activities may only be undertaken for a single purpose, many activities are often undertaken for a variety of purposes. Following general principles of classification, activities are deemed to be environmental activities only if the primary purpose of the activity is consistent with the definitions of the two types of environmental activity listed as environmental – i.e. environmental protection or resource management. In practice, the primary purpose must be applied to particular transactions or groups of transactions as recorded in the accounts in terms of production, consumption or accumulation.

4.16 In determining the primary purpose, a variety of motivations for undertaking the activity may be relevant. The activity may be undertaken on a purely voluntary basis or in order to comply with relevant legislation or regulation or within the framework of a voluntary agreement.

4.17 In some situations, it is necessary to consider the suitability of various goods and services for achieving environmental purposes through consideration of the good or services from a technical perspective. This is particularly relevant in the assessment of whether certain goods are cleaner or more environmentally friendly than other similar goods. The issues of determining primary purpose are discussed further in Section 4.3.

4.2.3 Other economic activities related to the environment

4.18 Many economic activities may be considered as being related to the environment. Historically, two broad types of economic activity have been discussed in this context, in addition to the environmental activities of environmental protection and resource management. They are natural resource use activities and activities associated with the minimisation of the impact of natural hazards.

4.19 Natural resource use activities involve the abstraction, harvesting and extraction of natural resources, including relevant exploration and development. These activities are not considered environmental but due to the specific and direct effect of their production processes on the environment, these activities may be of particular interest in the assessment of environmental impacts and the development of environmental policy.

4.20 A specific area of interest in this regard is activities associated with the abstraction and distribution of water. Functional accounts that cover both the use and management of water resources have been developed that consider the investment in water storage and abstraction facilities and the associated economic activity of abstracting and managing water resources.

4.21 Often, information on natural resource use activities is described in standard presentations of economic statistics and the national accounts following the standard classifications of economic activity. However, the level of detail required to target only the natural resource use activity may be hidden due to varying levels of integration of associated economic activity undertaken by the establishments involved (e.g. processing of fish caught at sea). Information on natural resource use activity is of particular importance in the compilation of asset accounts for environmental assets as described in Chapter 5.

4.22 The second set of economic activities related to the environment concerns the minimization of the impact of natural hazards on the economy and society. These activities could include research, observation and measurement networks, surveillance, administration of hazard warning systems, provisions for fighting the effects of floods, forest fires and other natural hazards (including equipment), provisions for the evacuation of the population, and the building of structures to prevent hazards (for example, fire barriers in forests, avalanche prevention barriers, dams to slow down water flows, and renaturalisation of river banks and other landscapes). In some cases the primary purpose of these activities may be environmental protection in which case they should be recorded as part of environmental protection activities as defined above.

4.23 The collection and organisation of information on minimising the impact of natural hazards may be of particular interest in understanding the economic response to natural hazards and also provide indicators of the economic impacts of environmental changes to landscapes and water systems, including environmental changes due to climate change. It is noted that economic activity associated with adaptation to climate change is not considered an environmental activity but it is recognised that information on this activity may be of particular interest.

4.24 At this stage there has been little development of functional classifications or accounts relating to activities concerning the minimisation of the impact of natural hazards. Consequently, no recommendations regarding the measurement scope, classification or the compilation of tables are provided in the central framework.

4.25 As well as activities aimed at protecting the environment and managing natural resources, there are activities aimed at avoiding or treating damage resulting from an already polluted environment. Examples include expenditure associated with avoiding local noise or air pollution by moving house or changing job; expenditure on cleaning and restoring dirty or damaged buildings resulting from air pollution; and hospital treatment for people adversely affected by poor quality environments. The common focus of these activities and expenditures is that they relate to protecting and managing the impact of environmental changes on people and produced assets rather than protecting and managing the environment. Consequently, these activities are not considered environmental activities and are not discussed further in this chapter.

4.2.4 Classification of environmental activities

4.26 Section 4.2.3 described the environmental activities in scope of the central framework. This section outlines the classification of these environmental activities – the Classification of Environmental Activities (CEA).

4.27 The CEA is a functional classification used to classify environmental activities, environmental products, and environmental expenditures and other transactions. It covers the two types of environmental activities (environmental protection and resource management). The top level classes for the two groups of the CEA are outlined in Table 4.2.2. Within Group I: Environmental Protection, the activities are classified by environmental domain such as air, waste, and water. For Group II: Resource management, the activities are classified by type of resource, broadly following the classification of environmental assets described in Chapter 5. Activities that are broad ranging, such as those relating to management and research, are allocated to classes at the end of each group.

Table 4.2.2 Classification of Environmental Activities - Overview of groups and classes

Group	Classes
I: Environmental Protection (EP)	1 Protection of ambient air and climate
	2 Wastewater management
	3 Waste management
	4 Protection and remediation of soil, groundwater and surface water
	5 Noise and vibration abatement (excluding workplace protection)
	6 Protection of biodiversity and landscapes
	7 Protection against radiation (excluding external safety)
	8 Research and development for environmental protection
	9 Other environmental protection activities
II: Resource Management (RM)	10 Management of mineral and energy resources
	11 Management of timber resources
	12 Management of aquatic resources
	13 Management of other biological resources (excl. timber and aquatic resources)
	14 Management of water resources
	15 Research and development activities for resource management
	16 Other resource management activities

4.28 A particular boundary issue concerns the treatment of activities associated with the production of energy from renewable sources and the treatment of activities associated with energy saving. To a large extent the treatment is likely to depend on the structure of the energy supply in each country. The treatment should be determined on the basis of the application of the primary purpose of the activity whether it is for environmental protection, for resource management or for the general production of energy.

4.29 Where activity related to energy saving and renewable energy sources is of considerable importance, the allocation of this activity to different classes in different situations may impact on the comparability of aggregates relating to environmental protection and resource management over time and across countries. In general, countries should therefore include the production of renewable energy and energy saving activity under resource management unless there are clear reasons for classifying part of these activities elsewhere.

4.2.5 Environmental goods and services

4.30 Based on the definitions of environmental activities, it is possible to define environmental goods and services and environmental producers. Environmental goods and services are different from ecosystem services and ecological goods and services which are terms used to describe various flows within the environment and from the environment to the economy and society. In contrast, environmental goods and services in the SEEA are flows of products produced within the economy.

4.31 In general terms, environmental goods and services comprise the following types of products:

i. Environmental specific services that are “characteristic” or typical of either environmental protection or resource management (for example, waste and wastewater management and treatment services);

ii. Products that are used only in undertaking environmental protection or resource management activity, known as either “connected” or “sole-purpose” products depending on the type of statistics being compiled (examples of these products include catalytic converters, septic tanks and rubbish containers); and

iii. Adapted goods, often known as “cleaner” or “environmentally friendly” goods (for example, energy efficient washing machines, and glass bottles made from recycled glass).

4.32 In addition, there is often interest in “end-of-pipe” and “integrated” technologies that are for environmental protection or resource management purposes.

4.33 In practice, the definition and measurement scope of these different products varies depending on the type of account or set of statistics being compiled. Hence, the relevant definitions of environmental goods and services for measurement purposes are separately described for Environmental Protection Expenditure Accounts (EPEA) and statistics on the Environmental Goods and Services Sector (EGSS) in Section 4.3

4.2.6 Environmental producers

4.34 Relevant sets of environmental producers can be defined but, as for environmental goods and services, the measurement scope varies depending on the type of account or set of statistics being compiled. The main type of producer recognised in the different accounts and statistics is specialist producers whose primary activity is the production of environmental goods and services. Also separately identified are non-specialist producers (who produce environmental goods and services for sale but for whom this is not their primary activity) and own-account producers. The relevant definitions of environmental producers for measurement purposes are described separately for EPEA and statistics on EGSS in Section 4.3.

4.35 Some general comments on environmental producers do apply however. Own-account producers are units that produce characteristic products but do not sell the products to other economic units and instead consume the outputs themselves. Examples of this type of production include depollution of exhaust gases and the own-account incineration of waste. Since this own-account production is not the primary activity of these units, they are not treated as specialist producers but rather together with non-specialist producers.

4.36 Following the SNA, own account production is not normally separately identified and rather the costs of undertaking the activity are assumed to be part of the overall costs of producing the primary or secondary output of the establishment. However, in the SEEA, given the need to focus on specific environmental activities, wherever they occur in the economy, it is recommended that own-account production activities be separately identified wherever possible. This separate identification allows a complete coverage of environmental activities and also allows analysis of changes in the extent of outsourcing of these activities to other establishments compared to undertaking the activity "in-house".

4.37 Many producers of environmental goods and services are government units that may either be specifically established to deliver these outputs (and hence are considered specialist producers) or they may be part of larger government agencies. Some of these units may be non-market producers. Since the output of non-market units is measured in quite a different way (as the sum of costs) it is recommended that all relevant government producers be clearly separated.

4.38 Many environmental protection and resource management activities are undertaken by household units. Where production is undertaken for sale, these units are treated in the same way as any other specialist or non-specialist producer. Where the production is done on own-account, the output should also be recognised in line with the measurement of own-account production as discussed above. In this case, the value of own-account production will be reflected as household final consumption or gross fixed capital formation depending on the type of output produced.

4.3 Environmental activity accounts and statistics

4.3.1 Introduction

4.39 This section describes two different sets of information concerning environmental activity. The first set concerns the recording, within an accounting framework, of expenditures and related national accounts flows in relation to environmental activities. Accounts of this type have been developed in relation to environmental protection. These Environmental Protection Expenditure Accounts (EPEA) and supporting statistics on environmental protection expenditure are widely available. Similar accounts and statistics for resource management activities are not as developed but can be compiled following the same concepts and definitions as for EPEA.

4.40 The scope of the EPEA is defined from a demand perspective by the expenditures undertaken by economic units for environmental protection purposes. In addition, for environmental protection specific services, which are considered characteristic or typical of this activity, both the supply and use of these services is considered within the EPEA framework. Thus while the EPEA does not provide a complete view of the supply side for relevant goods and services, it does provide information on the supply of some of the more important environmental protection goods and services. A full EPEA therefore requires information from both purchasers and suppliers of environmental protection goods and services.

4.41 EPEA are a type of functional account as described in the SNA.[23] The construction of EPEA closely follows the concepts, definitions and accounting rules of the core national accounts. However, a degree of deviation from the SNA is applied to either consider specificities of environmental aspects or the measurement objectives of the EPEA that are more targeted than the broader macro-economic focus of the core national accounts.

4.42 The second set of information focuses on the supply of environmental goods and services and is composed of a set of statistics describing major components of the Environmental Goods and Services Sector (EGSS). These statistics include information on the production of the range of environmental goods and services including environmental protection and resource management specific services, environmental sole-purpose products and adapted goods. Unlike the EPEA, statistics on the EGSS are not compiled in a full accounting format but the statistics that are included are defined and measured in a manner consistent with general national accounts data.

4.43 There is a reasonable degree of overlap between the EPEA and the EGSS but there are important differences. The final part of this section describes the relationship between EPEA and EGSS statistics.

4.44 The compilation of EPEA and EGSS statistics requires the collection and organisation of data from a variety of sources. This section does not provide details on how these data can be obtained. Compilation guidance and additional detail regarding these two sets of information can be found in SERIEE – Environmental Protection Expenditure

[23] See 2008 SNA, Chapter 29.

Accounts : Compilation Guide (Eurostat, 2002) and The Environmental Goods and Services Sector: A Data Collection Handbook (Eurostat, 2009).

4.3.2 Environmental Protection Expenditure Accounts (EPEA)

Purpose of EPEA

4.45 The reason to establish accounts for environmental protection is to identify and measure society's response to environmental concerns through the supply and demand for environmental protection goods and services and through the adoption of production and consumption behaviour aimed at preventing environmental degradation. Directly, the EPEA provides information on the value of environmental protection specific services produced across the economy and on the expenditure of resident units on all goods and services for environmental protection purposes.

4.46 Using this information, the EPEA can be used to analyse the extent of environmental protection activities and to assess how expenditure on environmental protection is being financed. The accounts can also be used to derive indicators to highlight change in key areas, such as the resources spent on pollution prevention and abatement, the contribution that environmental protection activities make to the economy, and the shift to pollution preventing technologies.

4.47 Measuring the financial commitment of an economy to environmental protection helps to evaluate the influence of environmental protection costs on international competitiveness, the execution of the polluter pays principles and cost-effect analyses of environmental control mechanisms. Monetary data may also be used to examine the extent to which different economic agents internalise the actual costs of environmental protection in their decision-making. In this regard, data on environmental taxes may provide useful complementary information (see Section 4.4).

4.48 Additional analysis may also be supported by linking expenditure on environmental protection to physical data such as the amount of waste treated or the level of air emissions. Models may be developed that link potential changes in environmental pressures, such as air emissions, to future economic activity given particular levels of expenditure on environmental protection.

EPEA tables

4.49 There are three main, interlinked EPEA tables. The first table presents information on the production of characteristic environmental protection products, i.e. environmental protection specific services by resident producers in the form of a combined production and generation of income account. The second table presents a supply and use table for these specific services. It incorporates the total supply of specific services from resident producers and the rest of the world and the use of those environmental protection specific services by various economic units.

4.50 The third table broadens the scope of the EPEA to include connected products and adapted goods purchased by those undertaking environmental protection activities. It also adds in capital formation for environmental protection activities by specialist, non-specialist and own-account producers, and relevant environmental protection transfers. The addition of these flows provides an estimate of the total outlays by an economy on environmental protection that is reflected in the aggregate, national expenditure on environmental protection.

4.51 The environmental goods and services presented in the tables in this section can be further disaggregated by classifying the relevant production and expenditure according to the environmental protection classes of the Classification of Environmental Activities as presented in Section 4.2.

Production of environmental protection specific services

4.52 Environmental protection specific services are those products that are "characteristic" or typical of environmental protection activity. Hence, ***environmental protection specific services are environmental protection services produced by economic units for sale or own-use.*** Examples of environmental protection specific services are waste and wastewater management and treatment services.

4.53 The production of environmental protection specific services is shown in Table 4.3.1. The production of environmental protection services is broken down by specialist producers, non-specialist producers and own account producers. In addition government specialist producers are separately identified.

4.54 Specialist producers in the EPEA are establishments whose primary activity is the production of environmental protection specific services. Non-specialist producers are those establishments that produce environmental protection specific services as secondary or own-account output but have a different primary activity. The EPEA does not present information on the producers of other environmental goods and services.

4.55 The table shows output of environmental protection specific services and goes on to show a full range of relevant variables including intermediate consumption, value added, and compensation of employees. Where possible the intermediate consumption of these producers should be split into the intermediate consumption of environmental protection specific services and the intermediate consumption of other goods and services.

4.56 An additional entry is made for gross fixed capital formation and acquisitions less disposals of non-produced, non-financial assets (such as land) by producers of environmental protection specific services. Since the activity of specialist producers is primarily targeted toward environmental protection, all of their expenditure, including the purchase of capital equipment to undertake their production, is within scope of environmental protection expenditure. This does not apply to other producers where only capital formation for characteristics activities i.e. capital formation targeted towards the production of specific services should be included.

Table 4.3.1 Production of environmental protection specific services

	Producers				Total
	Specialist producers		Non-specialist producers	Own account producers	
	Government producers	Other specialist producers			
Output of environmental protection specific services					
Intermediate consumption					
Environmental protection specific services					
Other goods and services					
Gross Value Added					
Compensation of employees					
Taxes less subsidies on production					
Consumption of fixed capital					
Net Operating Surplus					
Supplementary items					
Labour input					
Gross fixed capital formation					
Acquisition less disposal of non-produced, non-financial assets					

4.57 All of the values in Table 4.3.1 are measured in a manner consistent with the accounting conventions of the SNA. Consequently, the aggregates such as gross value added and net operating surplus can be meaningfully compared to macro-economic aggregates such as GDP as derived from the core national accounts framework.

4.58 However, it is noted that the inclusion of own-account production extends the range of entries compared to the core national accounts and hence measures of output and intermediate consumption will be larger than if this activity were not separately identified.

Supply and use of environmental protection specific services

4.59 The production of environmental protection specific services is supplemented by imports to obtain a measure of total supply. Total supply is used by other economic units in the economy and may also be exported. These flows are recorded as in Table 4.3.2. The top half of the table is the supply table. It shows the supply of specific services from output of resident producers and from imports, and the link between the output of specific services valued at basic prices and the valuation of this output at purchasers' prices. This follows the standard valuation relationships as described in Chapter 2.

4.60 The second half of the table is the use table. In this table the total supply of specific services is shown as used as (i) intermediate consumption by either specialist or other producers, (ii) final consumption by households or governments, (iii) gross fixed capital formation, or (iv) exports to the rest of the world. All entries in the use table are in purchasers' prices.

Table 4.3.2 Supply and use of environmental protection specific services

	Output at basic prices	Taxes less subsidies on products	Trade and transport margins	Output at purchasers' prices		Imports	**Total supply**
Environmental protection specific services							
	Intermediate consumption		Final consumption		Gross fixed capital formation	Exports	**Total use**
	Specialist producers	Other producers	Households	Government			
Environmental protection specific services							

Expenditure for environmental protection purposes

4.61 Table 4.3.3 outlines a table relevant for the assessment of expenditure for environmental protection purposes. The scope of information on expenditure for environmental protection purposes is not limited to the use of environmental protection services as presented in Table 4.3.2. The scope covers expenditure on all goods and services used for environmental protection. This includes (i) expenditure on environmental protection specific services, (ii) expenditure on environmental protection connected products; and (iii) expenditure on adapted goods.

4.62 In addition, the table includes the total gross fixed capital formation and acquisitions less disposals of non-produced non-financial assets by specialist and other producers for the purposes of producing environmental protection specific services. Finally, the table includes subsidies and transfers to the extent that they are not included in the value of goods and services already recorded (e.g. subsidies that reduce the market price of products are added back in, and transfers to and from the rest of the world are included).

4.63 Environmental protection specific services are defined above. ***Environmental protection connected products are products whose use directly serves environmental protection purposes but which are not environmental protection specific services or inputs into characteristic activities.***

4.64 ***Adapted goods are goods that have been specifically modified to be more "environmentally friendly" or "cleaner" and whose use is therefore beneficial for environmental protection.*** Only the extra costs paid in order to acquire an adapted good are considered as environmental protection expenditure.

4.65 Examples of connected products include septic tanks, maintenance services and other products for septic tanks, catalytic converters for vehicles, trash bags, bins, rubbish containers and compost containers. Examples of adapted goods include de-sulphurised fuels, bio-fuels, mercury-free batteries and CFC-free products. Some specific difficulties in measuring adapted goods are discussed further below.

4.66 For connected products it is important to understand the production arrangements taking place within a country. For example, when estimating the expenditure associated with the use of bins, wheeled rubbish containers, etc., those that are owned by specialist producers engaged in collecting waste should not be treated as connected products but rather included in the intermediate consumption or gross fixed capital formation of the specialist producers.

4.67 The expenditure may relate to intermediate consumption, final consumption or gross fixed capital formation. There is potential for gross fixed capital formation to be recorded for environmental protection specific services in cases where the expenditure leads to improvements in land which, following the SNA, are treated as gross fixed capital formation in land improvements. Exports are not included in Table 4.3.3 as they represent expenditure by economic units in the rest of the world.

4.68 In Table 4.3.3 all resident purchasers of environmental protection goods and services are included. These comprise producers of environmental protection specific services, other producers, households, general government and non-profit institutions serving households.

Table 4.3.3 Total national expenditure on environmental protection

<table>
<tr><td colspan="2" rowspan="4"></td><td colspan="7">Users</td></tr>
<tr><td colspan="3">Industry</td><td rowspan="3">Households</td><td rowspan="3">General government</td><td rowspan="3">Non-profit institutions serving households</td><td rowspan="3">Total</td></tr>
<tr><td colspan="2">Producers of Environmental protection specific services</td><td rowspan="2">Other producers</td></tr>
<tr><td>Specialist producers</td><td>Non-specialist and own-account producers</td></tr>
<tr><td colspan="9">Type of expenditure by product</td></tr>
<tr><td colspan="9">Environmental protection specific services</td></tr>
<tr><td rowspan="3"></td><td>Intermediate consumption</td><td>NI</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Final consumption</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Gross fixed capital formation</td><td>NI</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9">Connected products</td></tr>
<tr><td rowspan="3"></td><td>Intermediate consumption</td><td>NI</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Final consumption</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Gross fixed capital formation</td><td>NI</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="9">Adapted goods</td></tr>
<tr><td rowspan="3"></td><td>Intermediate consumption</td><td>NI</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Final consumption</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Gross fixed capital formation</td><td>NI</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Capital formation for characteristic activities</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Specific transfers for environmental protection not included above</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Environmental protection transfers to and from the rest of the world (net)</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Total national expenditure on environmental protection</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

NI – Not included in the derivation of total national expenditure on environmental protection

4.69 While Table 4.3.3 provides the broad framework for the calculation of total national expenditure, a number of factors need to be considered.

Measurement of capital formation

4.70 In addition to capital formation on environmental protection goods and services, there will be expenditure by specialist producers and other producers of environmental specific services on other capital items required for the production of environmental protection specific services. These amounts should be recorded separately.

4.71 Since the activity of specialist producers is primarily targeted toward environmental protection, all of their expenditure, including the purchase of capital equipment to undertake their production and the net acquisition and disposal of non-produced non-financial assets, particularly land, is within scope of environmental protection expenditure. This broad scope does not apply to non-specialist and own-account producers where only capital formation targeted towards the production of specific services should be included.

4.72 As the total gross fixed capital formation (GFCF) for characteristic activities by specialist, non-specialist and own-account producers is recorded in a separate row in Table 4.3.3, in principle, any such GFCF that includes purchases of environmental protection goods and services should not be counted a second time. For specialist producers, such GFCF on environmental protection goods and services is labelled "NI" in Table 4.3.3. For non-specialist and own-account producers such GFCF should also be excluded.

4.73 For non-specialist and own account producers two particular types of gross fixed capital formation for environmental protection can be distinguished:

i. 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 own-account activity because it is usually directed towards an "add on" facility which removes, transforms or reduces emissions and discharges at the end of the production process;

ii. Expenditure on "integrated" investments, also called cleaner technologies. These are new or modified production facilities designed so as to ensure that environmental protection is an integral part of the production process, thereby reducing or eliminating emissions and discharges and thus the need for end-of-pipe equipment.

4.74 Depending on the nature of the integrated investment, expenditure can be estimated from the cost of the modification of existing equipment or based on the extra cost due to pollution control, energy savings and the like (i.e. the cost of "non-polluting or less-polluting" equipment is compared with that of "polluting or more-polluting" reference equipment). It is noted that estimating the expenditure on integrated investments requires consideration of the general concerns in measuring adapted goods as described below.

Measurement of adapted goods

4.75 While the general concept of adapted goods can be explained, there are significant measurement challenges in compiling estimates of adapted goods. The primary difficulty is that adapted goods must be defined in reference to a base or equivalent normal good. With this normal good in mind it can be determined as to whether another similar good is cleaner or more environmentally friendly. Such assessments are difficult to make when reference goods no longer exist or when new goods present other advantages in addition to their beneficial effects on the environment. These may include savings on, or substitution of, raw materials; higher productivity and so on, which cannot be isolated in terms of cost.

4.76 The measurement issues may be extended because of the steady integration of environmental standards into equipment and processes. This makes it more difficult over time to distinguish between a cleaner good and the equivalent normal good. Given the different speeds at which new environmental standards are incorporated into different types of equipment and different countries, the ability to make comparisons of long time-series across industries and countries may be limited.

4.77 Once a set of adapted goods has been defined, the appropriate value of expenditure needs to be determined. For EPEA, only the net or extra cost of the adapted goods is included since it is considered that from the perspective of the purchaser it is this extra cost that represents the amount spent for environmental protection purposes.

4.78 Typically, the method used to estimate the expenditure associated with the purchase of adapted goods is based on physical information about market size (e.g. the amount of desulphurised fuels used). These estimates are then valued by the extra cost due to environmental protection features. Extra costs can be difficult to survey directly so 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).

4.79 However, while these measurement difficulties exist, a misleading picture of expenditure for environmental protection purposes would be obtained if the value of adapted goods is ignored. To support the measurement of adapted goods, lists of relevant products have been developed to form a basis for measurement.[24] Although many adapted goods may exist, experience from countries that have compiled EPEA suggests that only a few are quantitatively important and involve significant extra expenditure, and for many goods no extra costs exist.

Accounting for intermediate consumption

4.80 In general terms, intermediate consumption is equal to the expenditure on goods and services by establishments in the production of their output. The intermediate consumption of other producers recorded in Table 4.3.3 therefore reflects the purchase of environmental protection goods and services (including specific services, connected products, and adapted goods) as part of their production of other goods and services. The environmental protection goods and services are supplied by specialist or non-specialist producers, or they may be imported.

4.81 For own account producers, their output of environmental protection goods and services is valued as the sum of the costs of producing the output. These costs will include the purchase of a range of goods and services (as intermediate consumption) as well as associated salaries and consumption of fixed capital. The amount to be recorded as intermediate consumption in Table 4.3.3 is the total sum of costs (i.e. the total value of own account output) of environmental goods and services, since this is the amount that represents the value of the intermediate consumption of environment protection goods and services into the main activity of the establishment.

[24] For example see SERIEE – Environmental Protection Expenditure Accounts : Compilation Guide (Eurostat, 2002).

4.82 For specialist and non-specialist producers, since their output is sold to other establishments, the costs of producing the output, including intermediate consumption, do not need to be recorded separately since the value is captured in the expenditure on environmental protection goods and services by other units.

4.83 Special consideration is required concerning the intermediate consumption of environmental protection goods and services. For specialist producers, in order to avoid double counting, this part of intermediate consumption must be excluded from total national expenditure on environmental protection as it is also included in the expenditure of other units purchasing the environmental protection specific services from specialist producers. Hence, the relevant cells for intermediate consumption on environmental protection goods and services by specialist producers are labelled “NI – not included” in Table 4.3.3.

4.84 In principle, this adjustment should also be made in relation to the intermediate consumption of environmental protection goods and services used by non-specialist and own-account producers to the extent that these products are used as inputs into characteristic activities, i.e. used for own-account activities or used to produce and sell environmental protection goods and services on the market. In practice, it is assumed that these uses are not significant so that this adjustment is not necessary for non-specialist and own-account producers.

Adjustments for specific transfers and financing by the rest of the world

4.85 There may be transfers between economic units that affect the level of spending on environmental protection but which are not recorded in the earlier categories of expenditure shown in Table 4.3.3. For example, if government subsidises some environmental protection expenditure, then the extent of this subsidy will not be shown at purchasers’ prices in the expenditure recorded. Generally, these transfers relate to other subsidies on production and, in many countries, are not significant flows within the EPEA. It is noted that significant transfers may also be paid to and received from the rest of the world. Entries related to these transfers are recorded in the relevant rows at the bottom of Table 4.3.3.

Total national expenditure on environmental protection

4.86 With these considerations in mind, Total national expenditure on environmental protection is defined as

- Final consumption, intermediate consumption, and gross fixed capital formation on all environmental protection goods and services (specific services, connected products and adapted goods), except intermediate consumption and gross fixed capital formation for characteristic activities.

- Plus Gross fixed capital formation (including acquisition less disposal of non-produced non-financial assets) for environmental protection characteristic activities
- Plus specific environmental protection transfers by resident units not captured in the items above;
- Plus environmental protection transfers paid to the rest of the world;
- Less environmental protection transfers received from the rest of the world.

Financing environmental protection

4.87 The estimates of national expenditure on environmental protection show expenditure as undertaken by different units. This may not show who directly bears the cost because of specific transfers between units. However, such financing information provides a valuable insight regarding the source of the funds that finance the national expenditure and how changing financing structures may influence expenditure decisions. For example, if an investment grant for environmental protection is not available, an enterprise may be much less likely to undertake the capital formation in environmental protection.

4.88 The expenditure undertaken by the purchaser groups shown in Table 4.3.3 can be cross-classified to show which units are directly responsible for the expenditures and which directly bear the costs of financing them. This is shown in Table 4.3.4. For both current and capital transfers related to environmental protection, the unit making the transfer has an increase in expenditure and the unit receiving the transfers has a reduction.

4.89 Many of the specific transfers will be subsidies or investment grants where government is the payer of the transfers and it is industries, households or NPISH that benefit. An example of a transfer benefiting households may be a grant to improve house insulation or to increase the reuse of water. In these cases the expenditure can be shown against the government who is providing the funding rather than against the beneficiary.

4.90 Another type of financing arrangement for which an adjustment can be made concerns earmarked taxes. Earmarked taxes are recorded where a direct link exists between the tax revenue collected and expenditure on particular projects. Where the expenditure is for environmental protection purposes, the amount financed by earmarked taxes should be shown as being financed by the units paying the taxes.[25]

4.91 Relevant financing flows concerning the rest of the world correspond to the transfers for international cooperation in the field of environmental protection. These transfers can be financed either by the government, international organisations, corporations, or by households through non-governmental organisations.

[25] To be considered earmarked taxes, the payment must be considered a tax following the definitions of the SNA and there must be clear and unambiguous knowledge, often evidenced in legislation, that the tax revenue will be used for the specific purpose of environmental protection. Depending on their tax bases earmarked taxes may also be considered environmental taxes, see section 4.4.

Table 4.3.4 Financing of national expenditure on environmental protection (Currency units)

Financing units	Users							Total
	Producers of environmental protection specific services		Other producers	Households	Government	Non-profit institutions serving households	Rest of the world	
	Specialist producers	Non-specialist and own-account producers						
Government								
Corporations								
Specialist								
Other producers								
Households								
National expenditure								
Rest of the world								
Total Uses of resident units								

4.92 Making adjustments for these forms of transfers provides information on the source of funds but does not completely determine who ultimately bears the cost of environmental protection. Costs that are initially borne by enterprises are eventually passed on to their customers. This applies to both intermediate consumption and the costs of new capital formation. As well, all government expenditure is funded (at least in large part) by taxes and thus the cost is ultimately borne by those paying the taxes. However, further adjustments to examine the net cost burden of environmental protection are not described here.

4.3.3 Environmental Goods and Services Sector (EGSS)

Purpose of the EGSS statistics

4.93 The Environmental Goods and Services Sector (EGSS) considers environmental activities from the supply perspective and EGSS statistics present information on the production of environmental goods and services in as much detail as possible. This information is important in understanding the economic response to the challenges of environmental degradation and depletion of natural resources. Directly, EGSS statistics provide indicators of the production of environmental goods, services and technologies; the contribution of this production within the economy as a whole; and the extent of related employment, investment and exports from the sector.

4.94 Indirectly, the EGSS statistics provide an information base to assess the potential for economic activity and employment to be based on environmentally friendly and more resource efficient activities and to assess the extent to which the economy is responding to various public policies and initiatives that have this objective in mind. Defining these statistics in an internationally comparable way also permits cross-country comparison and assessment of best practice.

4.95 In principle there is a wide range of economic variables that might be considered within an EGSS context but, due to the complexity of measurement in this area, focus has been on the variables that give an indication of the relative economic size and contribution of EGSS. Thus the main variables under consideration have been the output, value added, employment, exports, and gross fixed capital formation related to the production of environmental goods and services. At this stage, a full functional account for the EGSS has not be defined.

Scope and definition of the EGSS

4.96 The EGSS consists of producers of all environmental goods and services. Thus products that can be identified as being specifically produced, designed, and manufactured for purposes of environmental protection and resource management are within scope of the EGSS. This aligns with the intent of EGSS to provide information on the extent to which the economy may become more environmentally friendly and resource efficient. The environmental goods and services in scope of the EGSS are environmental specific services, environmental sole-purpose products, adapted goods, and environmental technologies. The definitions of these goods and services are outlined in the following paragraphs.

4.97 The first type of environmental goods and services in the EGSS are environmental specific services. This set of services is defined by those products that are "characteristic" or typical of the field of study. In relation to the EGSS, the relevant characteristic activities are the production of environmental protection and resource management services. Hence, ***environmental specific services are environmental protection and resource management services produced by economic units for sale or own-use.*** Examples of environmental specific services are waste and wastewater management and treatment services, and energy and water saving activities.

4.98 Consistent with the definition of environmental protection and resource management activities, environmental specific services are those services that have the main purpose of:

i. preventing or minimising pollution, degradation, or natural resources depletion (including the production of energy from renewable sources);
ii. treating and managing pollution, degradation, and natural resource depletion;
iii. repairing damage to air, soil, water, biodiversity, and landscapes;
iv. carrying out other activities such as measurement and monitoring, control, research and development, education, training, information, and communication related to environmental protection or resource management.

4.99 The second type of environmental goods and services is known as environmental sole-purpose products. ***Environmental sole-purpose products are goods (durable or non-durable goods) or services whose use directly serves an environmental protection or resource management purpose and that have no use except for environmental protection or resource management.*** Examples of these products include catalytic converters, septic tanks (including maintenance services), and the installation of renewable energy production technologies (e.g. installation of solar panels).

4.100 The third type of environmental goods and services is known as adapted goods. ***Adapted goods are goods that have been specifically modified to be more "environmentally friendly" or "cleaner" and whose use is therefore beneficial for environmental protection or resource management.*** For the purposes of EGSS adapted goods are either:

i. "Cleaner goods" that help to prevent pollution or environmental degradation because they are less polluting at the time of their consumption and/or scrapping compared to equivalent "normal" goods. Equivalent normal goods are goods that provide similar utility except for the impact on the environment Examples are mercury free batteries and cars or buses with lower air emissions.

ii. "Resource efficient" goods, that help to prevent natural resource depletion because they contain less natural resources in the production stage (for example, recycled paper and renewable energy, heat from heat pumps and solar panels) and/or in the use stage (for example, resource efficient appliances, water-saving devices such as tap filters, desalinated water).

4.101 Compared to the definition of adapted goods in the EPEA, this scope is broader through the inclusion of goods beneficial for resource management and also through the inclusion of goods that have no extra costs.

4.102 Adapted goods differ from environmental specific services and sole-purpose products as they do not have a primary purpose of environmental protection or resource management. In EGSS, the measurement scope of adapted goods is broader than in EPEA because the full value of adapated goods is included rather than only the extra cost compared to the equivalent normal good. A consequence of this difference is that the number of adapted goods within scope of the EGSS is much larger. The same general difficulties of measuring adapted goods as described in Section 4.3.2 apply equally in the EGSS context.

4.103 The fourth type of goods and services is environmental technologies. ***Environmental technologies are technical processes, installations and equipment (goods), and methods or knowledge (services) whose technical nature or purpose is environmental protection or resource management.*** Environmental technologies can be classified as either:

i. End-of-pipe (pollution treatment) technologies which are mainly technical installations and equipment produced for measurement, control, treatment and restoration/correction of pollution, environmental degradation, and/or resource depletion. These installations and equipment operate independently of, or are identifiable parts added to, production and end-life consumption cycles. Examples include equipment to measure soil erosion, and facilities for the containment of high-level radioactive waste.

ii. Integrated (pollution prevention) technologies are technical processes, methods or knowledge used in production processes that are less polluting and resource intensive than the equivalent "normal" technology used by other national producers. Their use is less environmentally harmful than relevant alternatives.

4.104 Note that some environmental technologies may be included in the earlier categories of sole-purpose products or adapted goods.

4.105 Excluded from the scope of environmental goods and services are goods and services produced for purposes that, while beneficial to the environment, primarily satisfy technical, human, and economic needs or that are requirements for health and safety. Goods and services related to minimizing the impact of natural hazards and those related to the extraction, mobilisation and exploitation of natural resources are also excluded.

4.106 In practice, the measurement of environmental sole-purpose products and adapted goods relies on the development of lists of relevant goods and services. For sole-purpose products, the purpose of goods or services is predominantly determined based on the technical nature of the product and its technical suitability to be used for environmental protection or resource management purposes. In certain boundary cases, where the technical nature of the product does not provide a definitive guide, consideration may be given to the intent of the producer of the product. For adapted goods the lists are formed without reference to the primary purpose of the good but are formed rather on an assessment of the technical nature of the good being environmentally friendly or cleaner.

4.107 Many of the products supplied by the EGSS are also recorded in the EPEA described in Section 4.3.2. The EPEA can be an important data source for the EGSS and, in principle, the two systems can be fully reconciled. A reconcilitation would need to take into account, for example, that the EPEA includes all of the gross fixed capital formation for environmental protection characteristic activities but that not all of the products used for this gross fixed capital formation can be identified as being specifically manufactured for environmental purposes in the EGSS. Hence the EGSS output of capital goods designed for environmental protection will differ from the total gross fixed capital formation recorded in the EPEA. In practice, a full reconciliation is a complex operation that is rarely done.

4.108 In the EGSS, specialist producers are those producers whose primary activity is the production of environmental goods and services, including specific services, sole-purpose products, adapted goods, and environmental technologies. This scope is broader than the scope of specialist producers in EPEA which is limited to producers whose primary activity is the production of environmental protection specific services. In the EGSS, government producers are separately recorded as an important type of specialist producer.

4.109 Non-specialist and own-account producers, including households, are also separately identified in the EGSS. Own-account production is measured following the treatments outlined in Section 4.2.

4.110 Because of the production focus of EGSS statistics, there may be interest in structuring information by institutional sector (corporations, government, households, non-profit institutions serving households) or by type of economic activity following ISIC.

Statistics on the EGSS

4.111 The basic structure of statistics concerning the EGSS follows the format presented in Table 4.3.5. For each type of producer the output may also be classified following the relevant parts of the Classification of Environmental Activities – that is, by allocating the value of output to relevant classes of environmental protection activity or resource management activity as appropriate.

Table 4.3.5 Environmental Goods and Services Sector

			Producers			
			Specialist producers		Non-specialist producers	Own-account producers
			Government producers	Other specialist producers		
Output of environmental goods and services						
	Environmental specific services	Env. protection				
		Resource mgt.				
	Connected products	Env. protection				
		Resource mgt.				
	Adapted goods	Env. protection				
		Resource mgt.				
	End-of-pipe technologies	Env. protection				
		Resource mgt.				
	Integrated technologies	Env. protection				
		Resource mgt.				
	Total environmental goods and services produced					
Output of Other goods & services						
Total output						
Share of environmental goods and services in total output						
Intermediate consumption		Total				
		For production of environmental g&s				
Gross Value Added		Total				
		From production of environmental g&s				
Compensation of employees		Total				
		For production of environmental g&s				
Employment		Total				
		For production of environmental g&s				
Gross fixed capital formation		Total				
		For production of environmental g&s				
Exports of environmental goods and services						

4.112 The size of the EGSS is not equal to the total output of all of the producers within scope of the EGSS. Most EGSS producers will produce a range of other goods and services and therefore, the production of environmental goods and services may only be a relatively small component of their total output. This is recognised in the table by the inclusion of the row "Output of other goods and services" and the derivation of the share of environmental goods and services in total output.

4.113 Output is measured following standard national accounts conventions and principles. Variables other than output such as intermediate consumption, gross value added, compensation of employees, employment, gross fixed capital formation and exports should only refer to an establishment's production of environmental goods and services should not be related to the establishment's total output. Where direct estimates of these variables with respect to the production of environmental goods and services cannot be obtained, an estimation approach is to multiply the total estimate of the variable (e.g. total intermediate consumption) by the output share for environmental goods and services. Since this assumes that the production function for the producer is the same for environmental goods and services and other goods and services, estimates obtained using this approach should be assessed in conjunction with expert advice as available.

4.3.4 Relationship between EPEA and EGSS

4.114 While both EPEA and EGSS are focused on the measurement of environmental activities they so do from different perspectives and, consequently, there are important differences between them. The main differences are described in the following paragraphs and summarised in Table 4.3.6.

4.115 Accounting structure. The EPEA follows a more complete functional accounting structure. It links the supply and use of environmental protection specific services with expenditure on connected products and adapted goods and other relevant environmental protection transactions (such as taxes and subsidies) in the sequence of accounts. The EGSS, at this stage of its development, focuses only on statistics related to the production of environmental goods and services.

4.116 Coverage of environmental activities. The EPEA covers only environmental protection characteristic activities while the EGSS covers production activity for both environmental protection and resource management activity. It is noted however that the accounting structure of EPEA can be applied in the development of a resource management expenditure account.

4.117 Coverage of environmental goods and services. Given its demand perspective, the EPEA includes all goods and services that are used in undertaking environmental protection activity, not all of which are produced by EGSS producers. For example, fixed assets related to environmental protection expenditure will cover any specialised equipment purchased, and will also include the more general expenditure on buildings, cars, computers, etc required by specialist producers of environmental protection services. The EGSS, on the other hand, focuses on environmental goods and services from the production perspective and defines the scope of these products from a technical product-based perspective.

4.118 Coverage of environmental producers. In the EPEA, the information concerning production is limited to environmental protection specific services, thus the specialist producers in the EPEA are only those establishments whose primary activity is the production of environmental protection specific services. In the EGSS, production is the main focus and in these statistics specialist producers are those whose primary activity is the production of *any* environmental good or service.

4.119 Valuation of adapted goods. When valuing output the EGSS includes the total value of adapted goods. For the EPEA, the focus is on the cost incurred for environmental protection purposes and hence only the *extra* cost associated with the purchase of adapted goods is included. The expenditure on cleaner goods which are not more costly is not included in the EPEA at all.

4.120 Coverage relating to international trade. Both EGSS and EPEA record imports and exports of goods and services consistently with the national accounts. However, in the EPEA the expenditure of residents includes imports *from* the rest of the world while in the EGSS the production of resident producers includes exports sent *to* the rest of the world. Comparison of aggregate measures of expenditure and production from each set of statistics should take this difference into account.

4.121 Treatment of taxes and subsidies. When valuing output the EGSS measures are valued at basic prices and hence exclude taxes on production and include subsides on production. Measures of expenditure in the EPEA are valued at purchasers' prices, thus including taxes on production and excluding subsidies on production. Also, the measure of national expenditure on environmental protection includes any additional environmental protection related subsidies that are not already captured in the value of expenditure on environmental goods and services themselves, as well as transfers to and from the rest of the world.

Table 4.3.6 Comparison of EPEA and EGSS

Area of difference	**EPEA**	**EGSS**
Accounting structure	Full functional account	Table of production related statistics
Coverage of environmental activities	Environmental protection characteristic activities	Production of goods and services used for Environmental protection and Resource management
Coverage of types of environmental goods and services	All	All
Coverage of environmental producers	Producers only included in relation to environmental protection specific services	Producers included in relation to all environmental goods and services
Valuation of adapted goods	Net / extra cost only	Full value (at basic prices)
Coverage relating to international trade	Imports included in aggregate measures of expenditure	Exports included in aggregate measures of production
Treatment of taxes and subsidies	Valuation of expenditure at purchasers' prices	Valuation of output at basic prices

4.4 Accounting for other environmentally related transactions

4.4.1 Introduction

4.122 There is a wide range of transactions related to the environment that are recorded in the core framework of the national accounts. Many of these transactions have been discussed in the previous section on the measurement of EPEA and EGSS. In that section, emphasis was placed on the purpose of the transaction either from the perspective of the producer or from the perspective of the purchaser and the types of transactions considered primarily related to output, intermediate consumption, final consumption and gross fixed capital formation.

4.123 This section focuses on other transactions in the core national accounts framework that may be of interest in the analysis of the economic aspects of the environment and hence be considered as environmentally related. Some of these transactions might also be identified as having an environmental purpose as discussed in Section 4.2 and hence are considered environmental transactions. Of particular interest in this regard are flows of environmental taxes and subsidies.

4.124 The role of government in the interactions between the economy and the environment is of particular interest to many. For politicians and government officials, there is interest in whether various incentives or penalties can be effectively used to influence economic and human behaviour in relation to the environment. For households and businesses there is interest in knowing the costs and benefits involved in using natural resources and ecosystem services, such as using the atmosphere as a sink for pollution.

4.125 Many of the mechanisms by which economic behaviour is influenced toward meeting environmental policy objectives involve payments to government, most commonly in the form of taxes, permits and rent; and payments by government in the form of subsidies and other transfers. These transactions are recorded in the national accounts framework but are generally not separately identified as environmentally related. In order to permit the organisation of information about these transactions and to allow comparisons over time and across countries, the section describes the relevant definitions and boundary issues.

4.126 Environmental taxes and subsidies must be considered within a broader framework of payments to and from government. This is required because following national accounting and government finance statistics guidelines there is generally a focus on how the payment relates to the production or consumption process rather than on the purpose of the payment. Thus, for example, taxes on income are clearly distinguished from taxes on goods and services.

4.127 The SEEA only records taxes and subsidies for which an actual transaction takes place between institutional units. In some cases there is interest in the value of so-called implicit subsidies, for example via tax exemptions or preferential tax rates. However, as there are no transactions recorded in relation to these amounts following standard national accounts principles, no estimates of the values of these flows are included in the SEEA.

4.128 In addition to payments to and from government, there are other transactions of a similar nature recorded in the national accounts that may be considered environmentally related and hence of interest in the analysis of environmental matters. Examples are donations made by households and firms to non-profit environmental groups. Table 4.4.1 describes a broader framework of payments to and from government and similar transactions between other sectors. Potentially, all of these types of transactions may be environmentally related in nature.

Table 4.4.1 Selected payments to and from government and similar transactions

		Payments received by				
		Government	**Corporations**	**Households**	**NPISH ***	**Rest of the world**
Payments made by	**Government**	Transfers between levels of government	Subsidies Investment grants	Current & capital transfers	Subsidies Current & capital transfers	Current and capital transfers
	Corporations	Taxes Fines Fees & charges Rent	Rent	Rent	Donations	Donations to NPISH in ROW
	Households	Taxes Fees & charges Fines			Donations	Donations
	NPISH *	Taxes	Current and capital transfers	Current and capital transfers		Current and capital transfers
	Rest of the world	Taxes Current transfers			Donations	

* Non-Profit Institutions Serving Households

4.129 The final type of environmentally related transactions are transactions concerning the use of environmental assets and transactions concerning fixed assets used in economic activities related to the environment. Transactions concerning the use of environmental assets include payments of rent, the granting of permits and licences, and other similar payments. A particular focus of discussion in this section is the appropriate accounting entries to record permits for the use of environmental assets as a sink.

4.130 Transactions concerning fixed assets used in economic activities related to the environment primarily concern the accounting entries required to consider the full cost of fixed assets and in particular, the cost of disposing of fixed assets at the end of their operational life and the remediation of the surrounding environment.

4.131 This section is structured to discuss environmentally related payments by government; then environmentally related payments to government, primarily environmental taxes; next payments for the use of environmental assets; and finally, transactions in fixed assets used in economic activities related to the environment.

4.4.2 Environmentally related payments by government

4.132 Payments by government are recorded in a number of places in the national accounts and government finance statistics. The treatment largely depends on how the payments relate to production and consumption and whether they are considered to be current or capital in nature.

4.133 All of the payments to be considered in this section are transfers. A transfer is a transaction in which one institutional unit (in this case the government) provides a good, service or asset to another unit without receiving from the latter any good, service or asset in return as a direct counterpart.[26] Consequently, this section does not include payments by government in the purchase of goods and services.

4.134 Often transfers by government are generically referred to as "subsidies". However, in economic accounting, only certain transfers are treated as subsidies. The following paragraphs outline the relevant definitions for the various transfers by governments.

Environmental subsidies and similar transfers

4.135 An environmental subsidy or similar transfer is a transfer that is intended to support activities which protect the environment or reduce the use and extraction of natural resources. It includes those transfers defined by the SNA as subsidies, social benefits to households, investment grants and other current and capital transfers.[27]

- Subsidies are current unrequited payments that government units, including non-resident government units, make to enterprises on the basis of the levels of their production activities or the quantities or values of the goods or services that they produce, sell or import.
- Social benefits to households are current transfers received by households intended to provide for the needs that arise from certain events or circumstances, for example sickness, unemployment, retirement, housing, education or family circumstances.
- Investment grants consist of capital transfers made by governments to other residents or non-resident institutional units to finance all or part of the costs of their acquiring fixed assets.
- Other current transfers consist of all current transfers between resident institutional units, or between resident and non-resident units, other than current taxes on income, wealth, etc, social contributions and benefits and social benefits in kind. It includes transfers between levels of governments, between general government and foreign governments, and transfers to and from non-profit institutions.

[26] 2008 SNA, paragraph 8.10

[27] For detailed descriptions of these transfers refer to 2008 SNA paragraphs 7.98 – 7.106, 8.87 – 8.140 and 10.200 – 10.212.

- Other capital transfers consist of all capital transfers except capital taxes and investment grants. Examples include transfers from central government to units at lower levels of government; and legacies, large gifts and donations by households or enterprises to non-profit institutions intended to finance the purchase of fixed assets.

4.136 The decision as to whether a particular transfer by government is environmental is based on consideration of the purpose of the transfer. From an analytical perspective the primary focus is to determine how much expenditure is being allocated towards achieving environmental outcomes. Thus, a subsidy or similar transfer should be treated as environmental when the primary intent or purpose of the government is that resources be used for either environmental protection or resource management purposes.

4.137 In theory, a decision as to whether the primary purpose of a transfer is environmental should be made for each individual transfer. Then, once a decision on the primary purpose has been made the total value of the transfer is treated as being for that primary purpose.

4.138 In practice, information on transfers by government is usually contained in budget and other government expenditure data. Generally, these data do not show individual transactions and more commonly will show information by type of government program thus including a large number of individual transfers. It will usually be the case that such programs have multiple purposes and hence determining the number and value of individual transfers that have a primary purpose of environmental protection or resource management may require additional information.

4.139 In these situations, it may be necessary to estimate the share of the value of transfers for a given government program that reflects the value of individual transfers within the program that have environmental protection or resource management as their primary purpose.

4.140 The treatment should not be determined based on whether the use of the resources by the recipient of the transfer results in positive outcomes for the environment. Thus while it is reasonable to consider that the purpose of the government in making the transfer and the purpose of the recipient are the same, it may not be the case that the expenditure of the transferred resources results in beneficial environmental outcomes even if this was the intent.

4.141 For analytical purposes, an aggregate measure of these different payments may be compiled. The aggregate measure of environmental subsidies and similar transfers paid by government is the summation of all those types of transfers listed above that are considered to be environmental based on the primary purpose of the payment.

Classification of environmental subsidies and similar transfers

4.142 Since the definition of environmental subsidies and similar transfers is based on the assessment of environmental protection and resource management purposes then, in principle, it is possible to consider the use of the Classification of Environmental Activities

(CEA) Part I (Environmental Protection Activities) and Part II (Resource Management Activities).

4.143 For accounting and analytical purposes, it is necessary to separate the transfers into those of a current and capital nature following the definitions in the SNA.[28] It may also be useful to classify the transfers by the industry or institutional sector of the recipients using ISIC or standard SNA institutional sector classifications.

Potentially environmentally damaging subsidies

4.144 The definition of environmental subsidies and similar transfers focuses on the government's intention rather than on the effect on the state of the environment from the use of the resources provided. Another perspective that may be taken is whether the size and structure of payments from governments are environmentally beneficial or environmentally damaging. A measure reflecting this perspective is Potentially Environmentally Damaging Subsidies (PEDS), encompassing subsidies and similar transfers that support activities that are considered environmentally damaging. In some definitions this measure also includes so-called implicit (or indirect) subsidies, such as preferential tax rates. A definition of PEDS is not included in the SEEA.

4.4.3 Environmentally related payments to government

Environmental taxes

4.145 The majority of the different payments made to government are taxes. Taxes may be labelled in different ways and thus care must be taken to ensure that the underlying basis of the payment is well understood.

4.146 Taxes are compulsory, unrequited payments, in cash or in kind, made by institutional units to government units[29]. They are grouped in the following categories

- Taxes on products consist of taxes payable per unit of some good or services. Taxes on products include value added type taxes, taxes and duties on imports, and export taxes.
- Other taxes on production consist of all taxes except taxes on products that enterprises incur as a result of engaging in production. Examples include taxes payable on land, fixed assets or labour employed in the production process.
- Taxes on income consist of taxes on incomes, profits and capital gains.
- Other current taxes consist of current taxes on capital (such as taxes on land, buildings and net wealth) and miscellaneous current taxes (such as payments by households to obtain certain licences).

[28] 2008 SNA, paragraph 8.10

[29] For details on the definitions of the different types of taxes refer to 2008 SNA paragraphs 7.71 – 7.97, 8.52 – 8.64 and 10.207.

- Capital taxes consist of taxes levied at irregular and infrequent intervals on the values of assets or net worth owned by institutional units or on the values of assets transferred between institutional units as a result of legacies, gifts inter vivos or other transfers.

4.147 The decision as to whether a payment regarded by the SNA as a tax is environmental is based on consideration of the tax base. Specifically, an environmental tax is a tax whose tax base is a physical unit (or a proxy of it) of something that has a proven, specific negative impact on the environment. In practice, this definition is applied by looking at all of the various taxes levied in a country and making an assessment as to whether the tax base in each circumstance is something that has a negative environmental impact.

4.148 Since the application of this definition may vary across countries, for the purposes of international comparison of environmental taxes, lists of relevant taxes bases that satisfy this definition have been developed by the Organisation for Economic Cooperation and Development, the European Environmental Agency and Eurostat.[30]

4.149 The consideration of the tax base in the determination of the environmental status of a tax is an exception to the general approach to defining the environmental status on the basis of the purpose of the transaction. However, in the case of taxes, generally the payer does not know in advance as to what the tax payment might be used for by the government. Indeed, the primary purpose of taxation in many cases will be the raising of funds to pay for general social services such as health and education.

4.150 In cases where the intended purpose of the tax is known, these taxes are considered "earmarked taxes". Those taxes that are earmarked for environmental protection are relevant in the calculation of environmental protection expenditure and are discussed in section 4.3.

Environmental tax bases and categories

4.151 There are four broad categories into which environmental taxes are generally grouped - energy, transport, pollution and resources.

i. *Energy taxes* This category includes taxes on energy products used for both transport and stationary purposes. The most important energy products for transport purposes are petrol and diesel. Energy products for stationary use include fuel oils, natural gas, coal and electricity. Taxes on fuel used for transport purposes should be shown as a separate sub-category of energy taxes.

   Taxes on carbon are included under energy taxes rather than under pollution taxes. There are several reasons for this. First, it is often not possible to identify carbon taxes separately in tax statistics, because they are integrated with energy taxes, for example

[30] See *Statistical Framework on Environmental Taxes in OECD Member Countries*, OECD, 1997 and *Environmental taxes – a statistical guide*, Eurostat, 2001.

via differentiation of mineral oil tax rates. In addition, they are partly introduced as a substitute for other energy taxes and the revenue from these taxes is often large compared to the revenue from the pollution taxes. This means that including carbon taxes with pollution taxes rather than energy taxes may distort international comparisons. If they are identifiable, carbon taxes should be reported as a separate sub-category within energy taxes. A special type of carbon taxes are payments for tradable emission permits. The treatment of these permits is discussed later in this section.

ii. *Transport taxes* This category mainly includes taxes related to the ownership and use of motor vehicles. Taxes on other transport equipment (e.g. planes), and related transport services (e.g. duty on charter or scheduled flights) are also included here as are taxes related to the use of roads. The transport taxes may be 'one-off' taxes related to imports or sales of the equipment or recurrent taxes such as an annual road tax. Taxes on petrol, diesel and other transport fuels are included under energy taxes.

iii. *Pollution taxes* This category includes taxes on measured or estimated emissions to air and water, and the generation of solid waste. An exception is taxes on carbon, which are included under energy taxes as discussed above. Taxes on sulphur are included here.

iv. *Resource taxes* This category typically includes taxes on water abstraction, extraction of raw materials and other resources (e.g. sand and gravel, forests). Consistent with the general scope of environmental taxes, payments to government for the use of land or natural resources are treated as rent and therefore are excluded from resource taxes. For detail on the treatment of rent see paragraph 4.150.

4.152 Table 4.4.2 shows a possible recording of environmental taxes. Where other payments to government are of particular significance they could be added within a table of this type. For some types of taxes, particularly energy taxes, a breakdown of payments by industry is relevant. An industry breakdown should be aligned to the breakdown used for the recording of related physical flows as shown in Chapter 3. Thus, for energy taxes, an industry breakdown following the structure of the air emission accounts would be relevant.

Treatment of Value Added Tax

4.153 Generally, Value Added Taxes (VAT) are excluded from the definition of environmental taxes because they are considered to have no influence on relative prices in the same way that other taxes on environmental tax bases do (i.e. VAT is levied on a broad range of goods and services regardless of their impact on the environment). This lack of direct influence is also reflected in the deductible nature of VAT for many tax payers.

4.154 There is one, relatively minor, exception to this general treatment. In principle, where VAT is calculated on a price that includes a duty or tax already determined to be an environmental tax, the relevant amount of non-deductible VAT (equal to the VAT rate multiplied by the amount of the environmental tax) can also be considered to be part of environmental taxes and classified based on the nature of the underlying tax base. Such a situation may occur when VAT on petrol/gasoline is calculated including the fuel duty paid on hydrocarbon oils. In practice, the ability to isolate this amount of VAT may require additional information.

Table 4.4.2. Environmental taxes

	Type of tax						**Total**
	Taxes on products	Other taxes on production	Taxes on income		Other current taxes	Capital taxes	
			Corporations	Households			
Type of environmental tax							
Energy taxes							
Carbon taxes							
Taxes on fuel used for transport							
Other energy taxes							
Transport taxes							
Pollution taxes							
Resource taxes							
Total environmental taxes							
Non-environmental taxes							
Total taxes							
Share of environmental taxes							

Other environmentally related payments to government

4.155 Only those payments that are considered to be taxes according to the definitions of the SNA are within scope of environmental taxes in the SEEA. At the same time, there may be particular interest in recording other payments to government that may be considered environmentally related such as payments of rent, some sales of goods and services, and some fines and penalties. In determining the environmental status of these payments focus should remain on the basis for the payment rather than on either the name used to describe the payment or the purpose for which the revenue raised may be used. The following paragraphs describe these other types of payments to government.

<u>Rent</u>

4.156 There are certain environmental assets, particularly mineral and energy resources, that are owned by government and payments to government are often required to be made by extractors of the resources since the government in these situations acts as both owner and taxation authority. These payments are treated as rent. Payments of rent in respect of mineral and energy resources are commonly referred to as royalties and, in resource endowed countries, these payments may represent an important component of total government revenue.

4.157 The income receivable by the owner of an environmental asset for putting the asset at the disposal of another institutional unit is rent. Rent is paid on the use in production of non-produced assets such as land and sub-soil mineral and energy resources. Rent is distinct from rentals that are paid by users of produced assets to the owners of those assets. Examples of rentals include payments for the hire of buildings or equipment and for the hire of cars for transport by tourists. Rentals are treated as payments for services.

4.158 Rent relates to a payment due for the use of an environmental asset for one accounting period. There may be a longer term lease permitting the extractor to operate for an extended period of time but the payment of rent is usually set on an annual basis. Payments of rent usually depend on the level of output of the extractor, usually determined on the basis of the value of sales of extracted resource (quantity extracted multiplied by the resource price).

4.159 As the government is the taxation authority, it is possible for different arrangements to be established by which the government collects the rent it is due as owner of the environmental asset. Some of these arrangements may be in the nature of taxes on profits as defined in the SNA. In principle, amounts of taxes on profits that relate to the income earned from the extraction of environmental assets should be treated as rent. In practice, separating the taxes on profits that relate to income from extraction activity as opposed to other income earned by the extracting company may be difficult. Chapter 5 discusses the estimation of resource rent and the determination of the proportion that accrues to the different economic units.

Sales of goods and services

4.160 In a number of situations the government undertakes a range of activities that provide goods and services to households and businesses. Such provision of goods and services constitute production by government units and payments made by users are often referred to as “fees”. A common situation is the payments made to general government units that operate waste collection schemes for the disposal of waste. In some cases making the distinction as to whether these payments are purchases of goods and services or taxes can be difficult to assess, since it must be determined as to whether the purchaser has received a service from the government in return for the payment. The general guidance in the SNA should be followed.[31]

[31] See 2008 SNA paragraphs 7.80 and 8.64.

Fines and penalties

4.161 Fines and penalties are distinguished from taxes as being compulsory payments imposed on institutional units by courts of law or quasi-judicial bodies.[32] These payments to governments are treated as miscellaneous current transfers. It may well be that some fines and penalties are related to illegal activities of interest in the context of environmentally related payments to government. The recording of fines and penalties also arises in the case of the use of environmental assets as sinks (see Section 4.4.5).

4.4.4 Environmental transfers by non-government institutional units

4.162 While taxes and subsidies are flows that, by definition, are received by or paid by government units, the other types of transfers outlined in this section can take place between other institutional units as shown in Table 4.4.1. For example, households may donate money to conservation groups recorded as other current transfers.

4.163 Where information on these flows is of interest, the amounts to be recorded as environmental should follow the same principles as applied in the case of government flows, i.e. transfers paid to other institutional units should be based on whether the primary purpose of the payer is environmental protection or resource management. Further, payments for the use of environmental assets should be considered environmentally related payments. These types of payments are discussed in more detail in section 4.4.5.

4.164 A particular instance of transfers between institutional units concerns flows between international organisations and national governments and other resident institutional units. In certain countries these flows may be significant. In line with the general principles outlined here transfers paid by international organisations to institutional units within a country should be considered to be environmental if the primary intent of the international organisation is that the money is spent for environmental protection or resource management purposes.

4.4.5 Permits to use environmental assets

4.165 A common and important mechanism for managing the interaction between the economy and the environment is the use of permits and licences to access, extract or use environmental assets. In some cases the permits and licences may relate to the physical removal of environmental assets, such as in the case of fishing licences, and in other cases they may relate to the use of the environment as a sink for emissions.

4.166 Permits and licences relate to the general concept of property rights and in this context it is important to distinguish between the right to the use of an asset and the asset itself. The right to use, or exercise control over, an environmental asset may come about by a number of mechanisms. For example, property rights may arise through the recognition of traditional rights, the ownership of some environmental

[32] See 2008 SNA paragraph 8.135.

assets may come to be regulated by government who then allocates or sells rights to use or control, or the government may issue entitlements to use an asset for free or may auction or otherwise sell the asset.

4.167 In certain cases the property right obtained represents an asset of the holder. To satisfy the definition of being an asset the property right must be conveyed for a period exceeding one year. In addition, there is a range of factors that should be taken into consideration in determining whether a particular arrangement represents an asset. These factors are discussed in detail in 2008 SNA Chapter 17, Part 5.

4.168 Payments for property rights through the purchase of permits, licences and similar arrangements are economic transactions and are important in the context of complete environmental and economic accounting. Increasingly, the permits that are granted can be traded in markets thus creating potential benefits for the holders of the permits beyond the benefits that are obtained from the use of the environmental assets themselves.

4.169 This section outlines the range of different arrangements that are generally encountered and describes the appropriate treatment of the payments following the treatments defined in the SNA. It is noted that compilers will often need to make on balance decisions on the appropriate treatment depending in the precise nature of the way in which the permits and licences are granted and can be exercised. The section is structured by first considering payments to extract and harvest natural resources and then considering payments to use the environment as a sink for emissions.

Permits to extract and harvest natural resources

4.170 The SNA outlines a range of general considerations that should be taken into account in determining an appropriate treatment.[33] The following is structured to consider relevant issues from the perspective of different types of natural resources and the common licensing and permit arrangements.

Mineral and energy resources

4.171 Mineral resources differ from other natural resources in that all extraction necessarily reduces the amount of the resource available for the future. The owner (in many but not all circumstances government) generally does not have a productive activity associated with the extraction but generally payments of rent are made on a regular basis based on the amount of the resource that is extracted. Payments of rent are discussed in Section 4.4 and the appropriate asset and income account entries to record the ownership and use of mineral and energy resources are discussed in Chapter 5, Section 5: Asset accounts for mineral and energy resources.

[33] See 2008 SNA paragraphs 17.313 – 343.

Land

4.172 Land (and the associated natural resources) may be sold outright when the legal ownership is transferred from one institutional unit to another. Land is also the type of asset most frequently subject to a lease. Commonly, farmers leasing land pay regular rent to the owner of the land and these flows are recorded in the allocation of primary income account.

Timber resources

4.173 It is common for logging to be allowed under strict limits with a fee payable per unit volume of timber removed. The limits are usually such that the harvest of timber satisfies conditions required for a sustainable yield and so the payments are recorded as rent in the allocation of primary income account. The acquisition and disposal of forest land including the value of the timber resources should be recorded in the capital account.

Aquatic resources

4.174 Fishing quotas established by national and international agreement may be allocated in perpetuity or for extended periods to particular institutional units. In such circumstances the quotas may be transferable and if so, there may be a well developed market in them. Fishing quotas may therefore be considered as permits to use a natural resource that are transferable and in these situations the quotas are considered assets in their own right.

4.175 An alternative regime is to issue a permit for a strictly limited period of time, less than a year, to a nominated institutional unit, often a non-resident. This is a common practice in some islands in the South Pacific, for example. In these cases the revenue from the licences should be recorded as rent in the allocation of primary income account.

4.176 A licence granted to a household for recreational fishing is considered, by convention, as payment of a tax.

Water resources

4.177 A body of water with an economic value can be sold in its entirety either as part of the land that surrounds it or as a separate entity.

4.178 It is possible that the use of an area of water could be permitted under a long term arrangement recreational purposes, for example. The treatment of payments for such arrangements should be as for land.

4.179 Of increasing interest is the extraction of water from water bodies. Regular payments for the extraction of water (as opposed to the delivery of it) should be treated as rent.

Permits for the use of the environment as a sink

4.180 In addition to recording transactions in relation to payments for the right to extract and access environmental assets, a separate set of considerations is required to record transactions related to the use of the environment as a sink. Specifically, this relates to the right to use the environment, i.e. the soil, water, air and associated environmental assets, as a sink for emissions from economic activity.

4.181 A number of treatments may apply depending on the nature of the arrangements. The following scenarios and treatments are the most common. The treatments align with the definitions of the various payments to government outlined earlier in this section and the same considerations should be considered in the following scenarios.

i. The government may require payments to be made in situations where there are illegal emissions of pollutants beyond certain levels. If these payments are intended to reduce or inhibit discharge and emissions in the future, they should be treated as fines.

ii. If the payments are linked to remedial action following the release of the emission or discharge, the payment is treated as a payment for a service unless the amount charged is out of all proportion to the remedial costs involved, in which case the payment should be treated as a tax.

iii. If a limited number of permits to discharge or emit are issued with the intent to ultimately restrict the overall quantity of discharges and emissions, the treatment of any payment associated with the permits depends on the ownership of the environmental asset into which the emission has been or will be released.

a. Where the economic ownership is established following the principles of the SNA, most commonly this occurs with land and soil, and the necessary conditions are met concerning the terms on which the discharge is permitted, then the payment for the permit should be treated in the same way as the payment for a licence to use an environmental asset.

b. Where the economic ownership is not established following the principles of the SNA then the payment for the permit should be treated as a tax. This is the common situation with regard to the atmosphere, inland water resources and the seas and this treatment generally applies to carbon emission permit schemes.

4.182 In all of these scenarios it is assumed that the permits issued are not tradable. Thus the timing of recording of the payments and the economic units involved can be determined in a relatively straightforward manner using standard accounting principles.

4.183 Increasingly, permits are issued that are tradable and there is an active market in them. Permits concerning carbon emissions are the most significant for most countries. The potential to trade the permits generates a range of accounting complexities concerning the timing of recording, the treatment of changes in the value of permits and the specific economic units involved.

4.184 The complete accounting treatment for tradable permits is still the subject of international discussion under processes managed by the Inter-Secretariat Working Group on National Accounts. The treatment for the final draft of this document will be determined following resolution of the treatment through the ISWGNA processes.

4.185 Although the final accounting treatment for tradable emission permits has not been determined, there is a range of quantity data on emission permits that may be compiled to assist in the analysis of this issue. Table 4.4.3 shows the type of information that can be used regarding the quantity of emission permits – expressed in terms of the millions of tonnes of CO_2. The table is structured along the lines of an asset account showing the opening and closing stock of permits and the various changes in the stock through new issues, purchases, sales and surrenders. Where possible distinctions between flows of free permits, non-free permits and permits from multinational schemes should be recorded.

4.186 Depending on the purpose of analysis and data availability, the columns in the table may reflect the holding of permits by industry (classified following ISIC) or by institutional sector (as shown in the table). While the focus of emission trading schemes is generally on governments and corporations, a significant proportion of permits may be purchased by non-profit institutions.

Table 4.4.3 Account for tradable emission permits (million tonnes CO_2)

	Institutional sector				
	Corporations	General government	Households	NPISH*	Total
Opening stock of permits					
Permits allocated free of charge					
Permits purchased					
Permits sold					
Losses (cancelled permits)					
Permits surrendered to offset emissions					
Closing stock of permits					

* Non-profit institutions serving households

4.4.6 Transactions concerning fixed assets used in environmentally related activities

4.187 Fixed assets cover the range of produced assets that contribute to production processes over a number of accounting periods. They include buildings, machines, various types of equipment including transportation equipment, land improvements, and intellectual property products such as software and research and development expenditure. In undertaking different economic activities different types of fixed capital will be used. Often there is interest in the fixed assets used to extract and harvest natural resources and there is also interest in the amount of investment that takes place in fixed assets for environmental protection or resource management purposes. For example, information on the amount of investment in equipment to capture energy from renewable energy sources may be of interest.

4.188 There are no strict boundaries on which fixed assets may be of interest and no definition of environmentally related fixed assets is provided in the SEEA. Rather, the measurement scope will depend on the focus of the activities being accounted for. For example, fixed assets related to environmental protection expenditure will cover any specialised equipment purchased and also the more general expenditure on buildings, cars, computers, etc required by specialist producers of environmental protection services. In all cases the accounting treatment for fixed assets should follow the treatments outlined in the SNA. These assets are included in the accounts described in Section 4.3.

4.189 It is noted that some fixed assets are also considered environmental assets, for example animals that produce outputs on an ongoing basis such as various breeding stock, dairy cows for milk and sheep for wool; and plants that yield multiple outputs such as vineyards, orchards and rubber plantations. The accounting for these assets is explained in Chapter 5.

4.190 A particular issue in the case of environmental accounting is the appropriate accounting for the costs of the disposal of fixed assets, a process that can have significant environmental impacts. Because of its importance this topic is covered in detail in the remainder of this section.

Environmental consequences of disposing of fixed assets

4.191 To provide a complete accounting for fixed assets it is necessary to consider the costs incurred to prevent environmental problems when production or operation ceases and use of fixed assets ends. For example when

i. Nuclear power plants are decommissioned and final storage of nuclear waste must be provided;

ii. Oil rigs and other mining equipment are dismantled and removed;

iii. Landfills are sealed, gas and leakage collection systems completed, and monitoring equipment installed,

iv. Mines are closed and mining slag heaps are treated to minimise leaching.

4.192 In aggregate these costs are referred to as decommissioning costs. Two types of decommissioning costs are defined – terminal costs and remedial costs. Terminal costs are costs that can and should be anticipated during the production periods prior to closure. Provision should be made to meet them during the life of the asset. Remedial costs are incurred when production has already ceased with no provision having been made for the taking of remedial action while production was in progress. Examples are the rehabilitation of sites contaminated by past activities, for example, fuel storage sites, and former landfill and abandoned mining sites.

4.193 The key distinction between terminal and remedial costs relates to timing of the costs (see below) and who incurs these costs since the nature of the goods and services purchased may be very similar. Terminal costs are incurred by the enterprise that owns the associated asset (oil rig, nuclear power plant etc.) and form part of the link between the value of the asset to the enterprise and the value of services rendered by the asset over its life. In principle they should be anticipated by the owner of the asset even if the expenditure only takes place at the end of the operation of the asset.

4.194 On the other hand, remedial costs are incurred after operations at a site have ceased and, often, are incurred by a unit other than the operator of the site.[34]

Consumption of fixed capital

4.195 As decommissioning costs are associated with measuring the use of fixed assets in the SNA, this discussion commences with a short introduction to the concept of consumption of fixed capital and its links to the value of fixed assets. Broadly, the economic assumption is that the cost of purchasing an asset, at any stage of its useful life, is equal to the net present value (NPV) of the expected stream of income arising from the use of the asset over the remainder of its asset life.

4.196 The using up of an asset over time through its use in production is accounted for by means of an allowance for consumption of fixed capital (commonly known as depreciation). This allowance should be deducted from income and recognised as a cost of production.

The treatment of terminal costs

4.197 In principle, once price changes and other changes in volume[35] are taken into account, the difference between the acquisition and disposal values should be equal to the value of consumption of fixed capital cumulated over the life of an asset. In the case of

[34] There may be cases in which a particular operation ceases but the owner of the site remains the same, e.g. land owned by government. The relevant costs should be considered remedial if they cannot be attributed financially to the original operation.

[35] Other changes in volume are those changes in assets that are not due to transactions between economic units or consumption of fixed capital. Examples include losses due to catastrophic events, uncompensated seizures and the discovery of natural resources. These flows are recorded in the SNA other changes in assets accounts (see 2008 SNA, Chapter 12).

assets with actual costs at the time of disposal, this means that consumption of fixed capital should cover anticipated terminal costs since these costs lower the disposal value. Terminal costs should therefore be written off over the whole life of the asset, regardless of the number of owners during the life of the asset.

4.198 Immediately before the disposal, the asset will have a negative value that is reduced to zero when the terminal costs incurred are treated as gross fixed capital formation. The apparent oddity of an asset with negative value reflects the fact that the owner not only could not sell it but would have to pay another unit to take over responsibility for the asset[36].

4.199 To estimate anticipated terminal costs, it is necessary to estimate not only the extent of these costs, but also their likelihood. In this regard terminal costs present a dual problem— (i) it is often difficult to anticipate their final size, and (ii) the original owner or operator may no longer be an active business able to cover the costs as they have ceased business, declared bankruptcy or an associated surety was based on under-estimated terminal costs.

4.200 There is the added factor that between the initial estimate of terminal costs and the time at which the terminal costs actually incurred, community standards may have changed markedly—meaning that the final terminal costs are meeting very different standards to those initially anticipated. This is especially true of operations conducted over very lengthy time periods.

4.201 Nonetheless, there are a number of indications that terminal costs can reasonably be expected: (i) if an upfront bond (or some other form of surety) has been provided; (ii) if the enterprise is required to progressively put in place contributions to fund the final decommissioning activities; (iii) the past record of the enterprise; and (iv) the strength and commitment of the government of the country in which operations are taking place.

4.202 Terminal costs should be recorded as gross fixed capital formation only at the time incurred but the deduction of these costs from income via consumption of fixed capital should be made progressively over the life of the asset. That is, consumption of fixed capital is charged against income before the disposal/terminal costs are incurred (or fully known). A practical difficulty in estimating terminal costs is that the asset life of the underlying fixed asset may change over time thus requiring changes in the estimates of terminal costs.

4.203 Since terminal costs must be estimated before being incurred, the following four accounting scenarios need to be considered.

i. In situations where the terminal costs ultimately incurred exceed the cumulated consumption of fixed capital allowance, the full costs are still treated as gross fixed capital formation and any amount not already covered by consumption of fixed capital during the life of the asset is written off at the time the costs are incurred as consumption of fixed capital. This is a pragmatic recommendation and will lead to

[36] 2008 SNA, paragraph 10.161

net value added to be over-stated during the periods the asset is in use and under-stated in the period when the remaining costs are incurred[37].

ii. Where no estimates of terminal costs have been made during the life of the asset any terminal costs should be treated as gross fixed capital formation and then immediately written off as consumption of fixed capital, provided that they are paid by the operator.

iii. Where terminal costs are anticipated and a consumption of fixed capital allowance is recorded but the terminal costs are never actually incurred by the operator, the initial estimate of terminal costs must be removed from the balance sheet via the other changes in volume of assets account.[38] Any subsequent decommissioning costs incurred by units other than the operator are treated as remedial costs.

iv. If terminal costs are overestimated compared to actual terminal costs subsequently incurred, this overestimate is corrected in the asset account through an entry in the of other changes in volume of assets account.

Treatment of remedial costs

4.204 Costs of a remedial nature are often incurred after a site has been closed and the operator has left. There are two main types of remedial costs (i) expenditures to restore land to allow its use for some other purpose; or (ii) expenditures to ensure no harmful emissions from deposits of pollutants and other residuals created by past activity are able to leach into surroundings and cause environmental damage. In both cases the relevant expenditures should be treated as gross fixed capital formation and give rise to a fixed asset – land improvement.

4.205 For remedial costs there is no special consideration required as to the timing of reporting or questions over whether the costs are anticipated, since, by definition, these costs are incurred after the operations at the site have ceased and are not incurred by the operator of the site who caused the need for the remediation.

4.206 In cases where environmental protection expenditures are incurred on an ongoing basis such that environmental damage is either inhibited or reduced on a continuing basis then these expenditures should be treated as intermediate consumption of the owner at the time they are incurred and not recorded as either terminal or remedial costs.

[37] 2008 SNA paragraph 10.162

[38] See 2008 SNA, Chapter 12

REVISION OF THE SYSTEM OF ENVIRONMENTAL - ECONOMIC ACCOUNTS (SEEA)

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Chapter 5: Asset accounts

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5.1 Introduction

5.1 Assets are considered items of value to society. In economics, assets have long been defined as stores of value that, in many situations, also provide inputs to production processes. More recently, there has been consideration of the value inherent in the components that comprise the environment and the inputs the environment provides to society. The term environmental asset has been used to denote the source of these inputs which may be considered in both physical and monetary terms.

5.2 One motivation for considering environmental assets is the concern that the current patterns and practices of economic activity are depleting and degrading the available environmental assets more quickly than they can regenerate themselves and hence there are concerns about sustainability. Another motivation is that current generations can be seen as "stewards" for the range of environmental assets on behalf of future generations. Overall, there is a general aim to improve the management of environmental assets taking into account the sustainable use of resources and the capacity of environmental assets to continue to provide inputs to the economy and society.

5.3 Combined, these motivations are a key driver for the development of the SEEA and in particular for the measurement of assets and the compilation of asset accounts. In this context, the aim of asset accounting in the SEEA is to measure the quantity and value of environmental assets and to record and explain changes in those assets over time.

5.4 For environmental assets, the physical and monetary changes over the period include additions to the stock of environmental assets (such as additions due to natural growth and discoveries) and reductions in the stock of environmental assets (such as those reductions due to extraction and natural loss).

Chapter structure

5.5 This chapter focuses on accounting for environmental assets. Section 5.2 provides more detail on the definition of environmental assets in the Central Framework working from the general definition of environmental assets outlined in Chapter 2. Section 5.3 describes the structure of the accounts and the accounting entries that are required to compile asset accounts including opening and closing stocks, additions to stock, reductions in stock and revaluations.

5.6 Section 5.4 describes two key areas in the compilation of asset accounts. First, there is description of the principles of defining depletion of environmental assets in physical terms with particular focus on the depletion of renewable environmental assets such as aquatic and timber resources. Second, in relation to monetary asset accounts, there is a discussion of approaches to the valuation of environmental assets and in particular the net present value (NPV) approach. An annex to the chapter provides additional material explaining NPV.

5.7 Sections 5.5 – 5.11 outline asset accounting for a range of individual environmental assets. Detail is provided on the measurement scope of each of these assets, the structure of the relevant asset accounts and other relevant conceptual and measurement issues. While there are general principles that can be applied across all environmental assets, each environmental asset has individual characteristics that must be taken into consideration.

5.2 Assets in the System of Environmental and Economic Accounts

5.2.1 Introduction

5.8 As defined in Chapter 2, environmental assets are the naturally occurring living and non-living components of the Earth, together comprising the bio-physical environment, that may provide benefits to humanity. In the Central Framework, environmental assets are considered from the perspective of the individual components that comprise the environment with no account taken of the interactions between these components as part of ecosystems. A discussion on accounting for ecosystems and ecosystem services is presented in SEEA Experimental Ecosystem Accounts.

5.9 This section provides an explanation of the general measurement boundary for environmental assets in the Central Framework including a description of the Classification of Environmental Assets and articulation of the relationship between environmental and economic assets.

5.2.2 Environmental assets in the Central Framework

5.10 The scope of environmental assets in the Central Framework is defined through a focus on the individual components that comprise the environment. The scope comprises those types of individual components that may provide resources for use in economic activity. Generally, the resources may be harvested, extracted or otherwise moved for direct use in economic production, consumption or accumulation. The scope includes land and other areas of a country (such as inland waters and coastal waters) that provide space for undertaking economic activity.

5.11 The individual components of the environment that are considered environmental assets in the Central Framework are mineral and energy resources, land, soil resources, timber resources, aquatic resources, other biological resources (excluding timber and aquatic resources), and water resources. These individual components have been the traditional focus for the measurement of environmental assets through the development of specific asset or resource accounts. Other sections in this chapter discuss asset accounts for these types of environmental assets and the relevant measurement boundaries in physical and monetary terms.

5.12 The coverage of individual components in the Central Framework does not extend to the individual elements that are embodied in the various natural and biological resources listed above. For example, carbon and nitrogen are not considered individual environmental assets in the Central Framework. Nonetheless, the asset accounting framework can be extended to account for these individual elements. This extension is discussed in SEEA Experimental Ecosystem Accounts.

5.13 The measurement scope of the environmental assets of a country is limited to those contained within the economic territory over which a country has control. This includes all land areas, including islands; coastal waters including waters and sea-beds within a country's Exclusive Economic Zone; and any other water or sea beds in international waters over which the country has a recognised claim. The extension of geographic scope beyond environmental assets on land is of particular relevance in the measurement of stocks of aquatic resources and mineral and energy resources.

5.14 In physical terms the conceptual scope for each individual component is broad extending to include all of the resources that currently provide or could provide benefits to humanity. However, in monetary terms the conceptual scope is limited to those individual components that have an economic value based on the market valuation principles of the SNA. For example, all land within a country is within scope of the SEEA to allow for a full analysis of changes in land use and land cover. In the SNA only land considered to have economic value is within scope. The broader scope applied in physical terms aims to account better for the environmental characteristics of the individual components. Issues concerning the valuation of environmental assets are described in more detail in Section 5.2.3.

Classification of environmental assets in the central framework

5.15 Based on a focus on individual components a classification of environmental assets in the Central Framework is presented in Table 5.2.1. For each of these environmental assets a measurement boundary in physical and monetary terms must be drawn for the purposes of asset accounting. These boundaries are described in the relevant section for each asset type (see Sections 5.5 – 5.11).

Table 5.2.1: Classification of Environmental Assets in the SEEA Central Framework

	Mineral and energy resources	
		Oil resources
		Natural gas resources
		Coal and peat resources
		Non-metallic mineral resources (excluding coal and peat resources)
		Metallic mineral resources
	Land and other areas*	
		Land
		Inland waters
	Soil resources	
	Timber resources	
		Cultivated timber resources
		Natural timber resources
	Aquatic resources	
		Cultivated aquatic resources
		Natural aquatic resources
	Other biological resources (excluding timber resources and aquatic resources)	
	Water resources	
		Surface water
		Groundwater
		Soil water

* The classification of Land and other areas presented here reflects higher level categories relating to land use. Land may also be classified by type of land cover. Section 5.6 discusses the issues regarding classification of land.

5.16 The volume of water in the ocean is not considered in scope of water resources in the Central Framework because the stock of water is too large to be meaningful for analytical purposes. The exclusion of the ocean in terms of a volume of water resources does not in any way limit the measurement of ocean-related individual components such as aquatic resources (including fish stocks on the high seas over which a country has harvesting rights) and mineral and energy resources on the ocean floor.

5.17 Although oceans and the atmosphere are excluded, the measurement of exchanges and interactions with them is of particular interest. In this context, the interactions between the economy and the oceans, and between the economy and the atmosphere, are recorded in the Central Framework in various ways. For example, measures of the abstraction of sea water are included in the asset accounts for water resources, and measures of emissions from the economy to the atmosphere and oceans are recorded in physical flow accounts.

Natural resources

5.18 Natural resources are a sub-set of environmental assets. ***Natural resources include all natural biological resources (including timber and aquatic resources), mineral and energy resources, soil resources and water resources. All cultivated biological resources and land are excluded from scope.***

Land and other areas

5.19 For most environmental assets in the central framework it is straightforward to conceptualise the supply of materials to economic activity – for example in the form of fish, timber and minerals. The exception to this is land.

5.20 The primary role of land in the SEEA is its provision of space. The land and the space it represents defines the locations within which economic and other activity is undertaken and within which assets are situated. Although not physical, this role of land is a fundamental input to economic activity and can have significant value. This is most commonly observed in the varying valuations given to similar dwellings in locations that have different characteristics in terms of landscape, access to services, etc. This conceptualisation of land can also be applied to marine areas over which a country has a recognised claim, including its Exclusive Economic Zone (EEZ).

5.21 The term "land" as applied in the SEEA also encompasses areas of inland water such as rivers and lakes. For certain measurement purposes, variations in this boundary may be appropriate, for example to consider the use of marine areas for aquaculture, conservation or other designated uses. These details are explained in Section 5.6.

5.22 A clear distinction is made between land and soil resources. The physical inputs of soil are reflected in the volume of soil and its composition in terms of nutrients, soil water and organic matter. This distinction is discussed further in sections 5.6 and 5.7.

5.23 In the valuation of land and in the context of the measurement of ecosystems, both the location of an area and its physical attributes (i.e. topography, elevation, climate, etc) are important considerations. The valuation of land is discussed in Section 5.6 and the definition and measurement of ecosystems is described in SEEA Experimental Ecosystem Accounts.

Timber, fish and other biological resources

5.24 Biological resources include timber and fish resources and a range of other animal and plant resources such as livestock, orchards, crops and wild animals. Like most environmental assets they provide physical inputs to economic activity. However, for biological resources, a distinction is made between whether the resources are cultivated or natural. This distinction is based on the extent to which there is active management over the growth of the resource.

5.25 Maintaining this distinction in the central framework is important to ensure that clear links can be made to the treatment of these resources in the production accounts and asset accounts of the SNA.

5.26 There is a wide range of ways in which biological resources can be cultivated. In some cases the management activity is very active such as in the case of battery farming of chickens or the use of greenhouses for horticultural production. In these situations the unit undertaking the production creates a controlled environment, distinct from the broader biological and physical environment.

5.27 In other cases there may be relatively little active management, for example in the case of broad acre cattle farming or the growing of plantation timber. In these cases, the biological resource is exposed constantly to, and interacts as a part of, the broader biological and physical environment. Of course, there are cases between these two extremes.

5.28 Cultivated biological resources that are managed in such a way that they do not interact with the broader biological and physical environment should not be considered environmental assets since they do not deliver benefits from the bio-physical environment.

5.29 In practice, it may be difficult to distinguish between different types of cultivated biological resources by virtue of the manner of their production.

5.30 Many cultivated biological resources may be grown and harvested over a short period of time. Where the cultivation occurs within an accounting period then there are no opening or closing stocks of these assets to be recorded. However, depending on the time of the growing and harvesting season relative to the times of the accounting period there may be cultivated biological resources to be recorded and in these cases they should be recorded as part of environmental assets.

Forests

5.31 In the SEEA, forests are considered a form of land cover, forestry is a category of land use and forests are a type of ecosystem. Often forests are seen predominantly in terms of timber resources, i.e. the volume of standing timber, but forests produce a wide range of other benefits and hence forests and timber resources should not be equated. It is also the case that timber resources are not found solely in forests and in many countries other types of land cover, for example, other wooded land, contain timber resources. As a result of this distinction between forests and timber resources, and given the resource focus for environmental assets in the Central Framework, the classification of environmental assets in Table 5.2.1 includes forests within the sub-categories of land and distinguishes the timber resources located on this land as a separate environmental asset. Asset accounts for forests and other wooded land are described in Section 5.6 and asset accounts for timber resources are described in Section 5.8.

5.2.3 Valuation of environmental assets

5.32 In the Central Framework, consistent with the SNA, the scope of valuation is limited to valuing the benefits that accrue to economic owners. In principle, all of the benefits delivered by environmental assets can be valued in monetary terms. However, there are many complexities in undertaking these broad valuations including the quantification of the benefits themselves and the consideration of the value of benefits to society as a whole rather than only the value to individuals. These measurement issues are discussed in SEEA Experimental Ecosystem Accounts.

5.33 ***An economic owner is the institutional unit entitled to claim the benefits associated with the use of an asset in the course of an economic activity by virtue of accepting the associated risks.*** Further, following the SNA, ***an asset is a store of value representing a benefit or series of benefits accruing to the economic owner by holding or using the entity over a period of time***.[39] Examples of economic assets include houses, office buildings, machines, computer software and financial assets.

5.34 The benefits underlying the definition of economic assets are economic benefits. ***Economic benefits reflect a gain or positive utility arising from economic production, consumption or accumulation.*** They are recorded in the accounts in the form of operating surplus from the sale of extracted natural resources and cultivated biological resources, in the form of rent earned on permitting the use or extraction of an environmental asset, or in the form of receipts when an environmental asset is sold.

5.35 Economic assets in the SNA are classified as produced assets, non-produced assets or financial assets and the relevant concepts and measurement approaches to construct these estimates are fully described in the SNA. ***Produced assets are assets that have come into existence as outputs of processes that fall within the production boundary of the SNA.*** Produced assets include fixed assets (e.g. buildings, machines); inventories (e.g. stores of wheat for future use); and valuables that are held as stores of value and expected to increase in value over time (e.g. artworks and precious metals).

5.36 Cultivated biological resources are a type of produced asset in the SNA and also a type of environmental asset in the SEEA. They may be either fixed assets (e.g. sheep for wool, breeding stock and orchards) or inventories (e.g. livestock for slaughter, certain trees for timber). Other types of produced asset are often relevant in the measurement of

[39] 2008 SNA paragraph 10.8

economic activity related to the environment but they are not considered environmental assets.

5.37 ***Non-produced assets are assets that have come into existence in ways other than through processes of production.*** They include natural resources; contracts, leases and licences and purchased goodwill and marketing assets. In the SNA natural resources include all those assets considered to be natural resources in the SEEA and land is also considered part of natural resources.[40] While some contracts, leases and licences and purchased goodwill and marketing assets may be relevant in the assessment of economic activity related to the environment, none of these types of non-produced asset are also environmental assets.

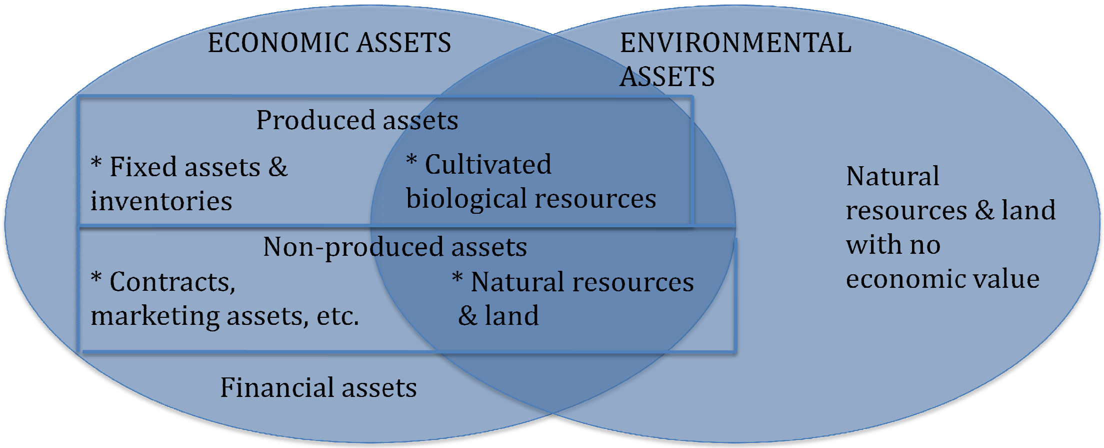
5.38 Financial assets, and the corresponding financial liabilities, relate to claims to future payments, or series of payments between economic units. They are defined in detail in the SNA. While some financial assets may be relevant to assessment of economic activity related to the environment, no financial assets are also environmental assets.

Relationship between environmental and economic assets

5.39 Many environmental assets are also economic assets. In particular, natural resources and land are considered non-produced assets, and cultivated biological resources may be either fixed assets or inventories depending on their role in production. Figure 5.2.1 shows the relationship between the classes of environmental assets and the high level asset classes within the SNA. All environmental assets that are classed as cultivated must be recorded as either fixed assets or inventories.

[40] The 2008 SNA also includes radio spectra within its scope of natural resources as the utilisation of the radio spectra generates significant income for various economic units. In the SEEA, radio spectra are not considered part of the bio-physical environment and hence are excluded from the scope of environmental assets.

Figure 5.2.1 Relationship between environmental and economic assets



5.40 In physical terms, the scope of environmental assets measured in the Central Framework may be greater than the scope of environmental assets measured in monetary terms following the SNA definition of economic assets. This is because there is no requirement in physical terms that environmental assets must deliver benefits to an economic owner. For example, remote land and timber resources should be included within the scope of the environmental assets of a country even if they do not currently or are not expected to deliver benefits to an economic owner.

5.41 Consequently, there may be environmental assets that are recorded in the Central Framework in physical terms but which have zero value in monetary terms and hence are excluded from environmental assets measured in monetary terms. Where such assets are recorded in physical terms, the quantities should be separately recorded from quantities of environmental assets that do deliver benefits to economic owners.

Economic assets used in activities related to the environment

5.42 There is interest in economic assets, primarily produced assets, that have a role in activities related to the environment but are not themselves environmental assets. They include assets relevant to undertaking environmental protection and resource management activities and assets used in the extraction and harvest of natural resources such as water dams, fishing vessels, and cutting and drilling equipment for mining. A discussion of these types of assets is included in Chapter 4 primarily in the context of Environmental Protection Expenditure Accounts (EPEA). Produced assets for natural resource extraction are also important considerations in the calculation of resource rent and the valuation of environmental assets. These measurement issues are discussed in Section 5.4.

5.3 The structure of asset accounts

5.3.1 Introduction

5.43 The recording of flows for environmental assets takes place in asset accounts. These accounts record both the opening and closing stock of assets and the changes over the accounting period. This section outlines the basic form of asset accounts in physical and monetary terms and describes the relevant accounting entries. Sections 5.5 – 5.11 describe in more detail the relevant asset accounts for each type of environmental asset.

5.3.2 Conceptual form of the physical asset account

5.44 Physical asset accounts are usually compiled for specific types of assets rather than for a range of different assets because each asset will usually be recorded in different units. This also means that aggregation across different assets in physical terms is generally not possible.[41] While aggregation is only broadly possible in monetary terms, the physical asset account entries are essential in the compilation of monetary estimates.

5.45 Estimates of the opening or closing stock of an asset should always be compiled with information pertaining to the reference date of the specific opening or closing stock. If information in respect of those dates is not directly available, other relevant information may need to be time-adjusted for use in compilation. From time to time, new information will arise that leads to a change in the assumptions underlying a set of estimates. When incorporating additional information it is important that the estimates continue to reflect the quantities and values that could reasonably be expected at the reference date.

5.46 The entries concerning the changes between opening and closing stocks of each asset are broadly divided into (i) additions to the stock and (ii) reductions in the stock. However, within these broad categories there are many different types of flows and often the flows are labelled differently by type of asset. For example, the term extraction is generally used in relation to mineral and energy resources, while the term abstraction is generally used for water resources. Both of them however relate to the removing environmental assets through processes of economic production.

5.47 Table 5.3.1 presents the range of accounting entries for physical asset accounts by type of asset. It gives an overview of the structure of physical asset accounts that are elaborated in detail for each asset in sections 5.5 – 5.11.

5.48 The table provides a complete listing of possible flows for each asset type. In practice, only certain flows are likely to be important and not all cells that show the possibility of an entry in Table 5.3.1 should be shown separately in the published accounts for each type of asset.

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[41] In a limited number of situations it is possible to aggregate across assets in physical terms, for example, physical quantities of energy resources can be aggregated using joules or similar conversion units.

Table 5.3.1 General structure of the physical asset account for environmental assets (physical units)

	Mineral & energy resources	Land (incl. forest land)	Soil resources	Timber resources		Fish resources		Water resources
				Cultivated	*Natural*	*Cultivated*	*Natural*	
Opening stock of resources	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Additions to stock of resources								
Growth in stock	na	Land reclamation	Soil formation Soil deposition	Natural growth	Natural growth	Growth	Growth	Precipitation Returns
Discoveries of new stock	Yes	na	na	na	na	Yes*	Yes*	Yes*
Upwards reappraisals	Yes	na	Yes*	Yes*	Yes*	Yes*	Yes*	Yes*
Reclassifications	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total additions to stock								
Reductions in stock of resources								
Extractions	Extractions	na	Soil extraction	Removals	Removals	Harvest	Gross catch	Abstraction
Normal reductions in stock	na	na	Erosion	Natural losses	Natural losses	Normal losses	Normal losses	Evaporation
Catastrophic losses	Yes*	Yes*	Yes*	Yes	Yes	Yes	Yes	Yes*
Downwards reappraisals	Yes	na	Yes*	Yes*	Yes*	Yes*	Yes*	Yes*
Reclassifications	na	Yes	Yes	Yes	Yes	Yes	Yes	na
Total reductions in stock								
Closing stock of resources	Yes	Yes	Yes		Yes		Yes	Yes

na – not applicable

* - An asterisk indicates that this flow is not usually a significant flow for the resource or it is typically not separately identified in the source data. In practice, not all cells that show the possibility of an entry here should be shown separately in the published accounts for each type of resource.

5.49 There are four types of additions to the stock of a resource.

i. Growth in stock. These additions reflect increases in the amount of the stock of resources over an accounting period due to growth. For biological resources the growth may be natural or cultivated and is often estimated net of normal losses of stock. Increases in the total area of land of a country, for example through land reclamation projects, should be recorded as growth in stock.

ii. Discoveries of new stock. These additions concern the arrival of new resources to a stock and commonly arise through exploration and evaluation.

iii. Upwards reappraisals. These additions reflect changes due to the use of updated information that permits a reassessment of the size of the stock. The use of updated information may require the revision of previous estimates to ensure a continuity of time series.

iv. Reclassifications. Reclassifications of environmental assets will generally result from situations in which an environmental asset is used for a different purpose – for example increases in forest land due to afforestation are recorded here. An increase in one category of an asset should be offset by an equivalent decrease in another category meaning that for the environmental asset as a whole reclassifications have no impact on the total physical quantity of an individual asset type.

5.50 There are five types of reductions in the stock of a resource.

i. Extraction. These are reductions in stock due to the physical removal or harvest of an environmental asset through a process of production. Extraction includes both those quantities that continue to flow through the economy as products and those quantities of stock that are immediately dispersed to the environment after extraction because they are unwanted – for example by-catch in fishing.

ii. Normal reductions in stock. These reductions reflect expected losses to stock during the course of an accounting period. They may be due to natural deaths of biological resources or losses due to accidental causes that are not significant enough to be considered catastrophic and might reasonably be expected to occur in most accounting periods based on past experience.

iii. Catastrophic losses. Losses due to catastrophic and exceptional events are recorded when large scale, discrete and recognizable events occur that may destroy a significantly large number of assets within any individual asset category. Such events will generally be easy to identify. They include major earthquakes, volcanic eruptions, tidal waves, exceptionally severe hurricanes and other natural disasters; acts of war, riots and other political events; and technological accidents such as major toxic spills or release of radioactive particles into the air. Included here are major losses such as destruction of biological resources by drought or outbreaks of disease.

iv. Downwards reappraisals. These reductions reflect changes due to the use of updated information that permits a reassessment of the size of the stock. The use of updated information may require the revision of previous estimates to ensure a continuity of time series.

v. Reclassifications. Reclassifications of environmental assets will generally result from situations in which an environmental asset is used for a different purpose – for example decreases in forest land due to permanent defforestation are recorded here. An decrease in one category of an asset should be offset by an equivalent increase in another category meaning that for the environmental asset as a whole reclassifications have no impact on the total physical quantity of an individual asset type.

5.51 The depletion of natural resources is related to the extraction of resources and the physical using up of the resource thus limiting the potential to extract amounts in the future. For non-renewable resources the quantity depleted is the same as the quantity extracted but this is not the case for renewable resources that can regenerate over time. The definition of depletion in physical terms is covered in detail in section 5.4.

5.52 It may not be possible to directly estimate all of the accounting entries outlined in the conceptual form of the physical asset account in Table 5.3.1. Consequently, some entries may need to be estimated using appropriate models or derived on the basis of other accounting entries. Depending on the particular flow and its importance in the overall accounting for changes in the stock of a resource, it may also be appropriate to combine some accounting entries for the purposes of constructing physical asset accounts for publication.

5.53 All of the details regarding the definition and measurement of these flows in relation to individual resources are contained in Sections 5.5-5.11.

Accounting entries for institutional sector accounts

5.54 The compilation of asset accounts by institutional sector may be of interest for particular types of environmental assets where the ownership of resources is of policy or analytical concern. Examples might include the attribution of mineral and energy resources between government units and extracting units and the assessment of ownership of land.

5.55 To construct institutional sector accounts there are two additional types of entries that are required compared to those shown in Table 5.3.1 in order to account for transactions and other exchanges between sectors. These entries are

i. Acquisition and disposals of environmental assets. These entries are recorded when transactions take place between institutional units in different sectors. The acquisition of environmental assets represents an addition to the stock of the acquiring sector and the disposal represents a reduction in the stock of the other sector.

ii. Uncompensated seizures. These changes in stock occur when institutional units take possession of or remove environmental assets without providing appropriate compensation to the owner. An addition to stock is recorded for the sector that takes ownership of the environmental asset and a corresponding reduction in stock is recorded for the sector that previously owned the asset.

5.56 It is also noted that reclassifications between sectors may be common entries in institutional sector accounts.

5.57 Although not common it is also possible that entries are required at a national level for the acquisition and disposal or uncompensated seizure of environmental assets. This would arise in the case of transactions in land between countries or in situations in which political changes lead to changes in the overall area of a country. Since these entries are not commonly required they are not incorporated into the standard form of the physical asset account presented in Table 5.3.1.

5.3.3 Conceptual form of the monetary asset account

5.58 The general form of the monetary asset account is presented in Table 5.3.2. There are close links to structure of the physical asset account.

Table 5.3.2 Conceptual form of the monetary asset account (monetary units)

Opening stock of resources		
Additions to stock of resources		
A1	Growth in stock	
A2	Discoveries of new stock	
A3	Upwards reappraisals	
A4	Reclassifications	
	Total additions to stock	
Reductions in stock of resources		
R1	Extractions	
R2	Normal loss of stock	
R3	Catastrophic losses	
R4	Downwards reappraisals	
R5	Reclassifications	
	Total reductions in stock	
Revaluation of the stock of resources		
Closing stock of resources		

5.59 The definitions of the flows presented in the monetary accounts align exactly with the same flows as defined in physical terms. Thus, the monetary account reflects a valuation of physical flows as recorded in the physical asset account, noting that for some environmental assets the measurement scope is broader in physical terms (e.g. timber resources not used for wood supply are included in physical terms but excluded in monetary terms). For most environmental assets it will be the case that measurement requires the estimation of the physical flows followed by estimation of the monetary flows.

5.60 The only additional flow recorded in the monetary asset account compared to the physical asset account concerns revaluations. Revaluations relate to changes in the value of assets due to price changes and reflect nominal holding gains and losses on environmental assets. The nominal holding gain for environmental assets is calculated in the same way as for non-financial assets as the increase in value accruing to the owner of the asset as a result of a change in its price over a period of time.

5.61 As discussed in Chapter 2, changes in price should be distinguished from both changes in the quantity and changes in the quality of the relevant asset. For environmental assets, the quality of an asset (e.g. land or water resources) may change due to the effects of pollution or the treatment of previous environmental damage. Ideally, where the price of the asset changes to reflect a different quality this should be considered a change in the volume of the asset rather than as a revaluation. In effect, there has been a reclassification between different qualities of the same asset.

5.62 As well as the nominal holding gain, it is interesting to know how the change in value compares with the general measure of inflation. If the value of an asset rises over an accounting period at the same rate as the general inflation rate this amount of gain is referred to as a neutral holding gain. The difference between the nominal holding gain and the neutral holding gain is referred to as a real holding gain.

5.63 Revaluations should also incorporate changes in the monetary value of environmental assets due to changes in the assumptions made in the valuation models that are often used to estimate the value of environmental assets, in particular the Net Present Value model. The assumptions that should be taken in account are those regarding future rates of extraction and natural growth, the length of the asset/resource life and the discount rate.

5.64 As with physical asset accounts it may not be possible to directly estimate all of the accounting entries outlined in the conceptual form of the monetary asset account in Table 5.3.2. Consequently, some entries may need to be estimated using appropriate models or derived on the basis of other accounting entries. Depending on the particular flow and its importance in the overall accounting for changes in the stock of a resource, it may also be appropriate to combine some accounting entries for the purposes of constructing asset accounts for publication.

Relationship to SNA accounting entries[42]

5.65 Rather than a broad separation into additions and reductions in the stock, the SNA focuses on (i) changes due to transactions and (ii) other change in volume of assets. To support the links between the SEEA and the SNA, the relevant SNA entries may be appended to the monetary asset account. They can be derived directly from the information as structured in the monetary asset account. These derivations are shown in Table 5.3.3.

5.66 The scope of the SNA accounting entries is different depending on whether the environmental asset is produced or non-produced. In the SEEA, this distinction is

[42] The detailed description of the relevant accounting entries are contained in Chapters 10, 12 and 13 of the 2008 SNA.

reflected in whether an environmental asset is cultivated (i.e. produced in SNA terms) or natural (i.e. non-produced in SNA terms). For SNA purposes a further distinction is needed for cultivated assets as to whether they are fixed assets or inventories.[43]

5.67 For fixed assets the relevant accounting entry is gross fixed capital formation, for inventories the relevant accounting entry is change in inventories. For natural environmental assets the relevant SNA entries are economic appearance of non-produced assets and economic disappearance of non-produced assets. There are also SNA entries related to the range of other additions and reductions in stock. These entries are defined equivalently between the monetary asset account in Table 5.3.2 and the SNA.

Table 5.3.3 Derivation of accounting aggregates (monetary units)

	Cultivated biological resources		**Natural environmental assets**
	Fixed assets	**Inventories**	
Accounting aggregates			
Gross fixed capital formation	A1 less R1	na	na
Changes in inventories	na	A1 less R1	na
Economic appearance	na	na	A1 + A2 + A3
Economic disappearance	na	na	R1 + R2 + R4

na – not applicable
A and R codes defined in Table 5.3.2

5.68 In addition to the monetary accounting entries shown in Tables 5.3.2 and 5.3.3 there are two entries, depletion and consumption of fixed capital, that relate to the physical using up of assets over time. Consumption of fixed capital relates to the using up of fixed assets and in the context of cultivated biological resources is reflected in the value of the normal losses of stock.

5.69 Depletion relates to the physical using up of natural resources through extraction. In monetary terms it represents the decline in future income that can be earned from a resource due to extraction. Details on the definition and measurement of depletion in physical and monetary terms are presented in Section 5.4.

Institutional sector accounts in monetary terms

5.70 Institutional sector asset accounts may also be compiled in monetary terms and indeed these accounts may be of particular interest since they can be connected directly to the full sequence of institutional sector accounts as presented in the SNA. A key aggregate that can be compiled from a full recording of asset accounts by institutional sector is net worth by sector.

[43] Also see paragraph 5.24-30.

5.71 The accounting entries required to compile monetary asset accounts by institutional sector are the same as those required to compile physical asset accounts by institutional sector with the only addition being the inclusion of entries for revaluations (as outlined in paragraph 5.55).

5.4 Principles of asset accounting

5.4.1 Introduction

5.72 Accounting for changes in the stocks of environmental assets presents some measurement challenges. The challenges commence in accurately measuring the physical stock of environmental assets which all have their own unique characteristics including, in some instances, the capacity to regenerate over time. Understanding the population dynamics is therefore important in making a reasonable assessment of certain environmental assets.

5.73 In addition to calculating estimates in physical terms, estimates of the values of environmental assets in monetary terms should also be compiled. Aside from land and soil resources, few environmental assets are actively traded before they are extracted and hence determining their *in situ* valuation is not straightforward.

5.74 Although there are challenges involved, a range of techniques and underlying concepts have developed that permit the compilation of asset accounts. Section 5.4.2 describes a key challenge in physical asset accounting – the measurement of depletion in physical terms. This is followed in section 5.4.3 by a discussion on valuation approaches and, in particular a presentation of the net present value approach. The section concludes with a discussion on the potential uses and limitation of valuation approaches and a description of the relationship between resource rent and depletion in monetary terms. The application of the various definitions and principles of asset accounting are described for each environmental asset in sections 5.5 – 5.11.

5.4.2 Defining depletion in physical terms

5.75 In the compilation of asset accounts the measurement of depletion is often a particular focus. The depletion of environmental assets relates to the physical using up of environmental assets through extraction and harvest by economic units, including households, such that there is a reduced availability of the resource. Depletion does not fully account for all possible changes in the stock of an asset over an accounting period and hence should not be linked directly to measures of sustainability. Assessments of the sustainability of environmental assets should take into account a broader range of factors, such as the extent of catastrophic losses or discoveries and potential changes in the demand for inputs from environmental assets.

5.76 ***Depletion, in physical terms, is the decrease in the quantity of the stock of a natural resource over an accounting period that is due to the extraction of the natural resource by economic units occurring at a rate that will not permit the same quantity of resource to be extracted in all future periods.*** This is a general definition that requires refinement in the case of renewable natural resources such as timber resources and aquatic resources.

5.77 ***Depletion, in monetary terms, is the decline in value of a stock of a natural resource over an accounting period that is due to the extraction of the natural resource by economic units occurring at a rate that does not permit the same economic benefits to be earned from the resource in all future periods.*** A measure of depletion in monetary terms must be underpinned by a measure of depletion in physical terms, i.e. if there is no reduction in the available quantity of the resource over an accounting period due to economic activity, there can be no depletion, and instead any changes in value must be attributed to other factors.

5.78 Depletion is not recorded when there is a reduction in the quantity of an environmental asset due to unexpected events such as losses due to extreme weather or pandemic outbreaks of disease. These reductions are recorded as catastrophic losses. Rather, depletion must be seen as a consequence of the extraction of natural resources by economic units.

5.79 In physical terms, the depletion of non-renewable natural resources, such as mineral and energy resources, is equal to the quantity of resource that is extracted since a given stock of resources at the beginning of a period cannot regenerate itself on human time scales.

5.80 For renewable natural resources such as timber resources and aquatic resources, the equality in physical terms between depletion and extraction does not hold. The ability for these resources to regenerate naturally means that under certain management and extraction situations, the quantity of resources extracted may be matched by a quantity of resources that are regenerated and there is no overall physical depletion of the environmental asset in this situation. The following paragraphs outline in more detail the measurement of depletion in physical terms for renewable natural resources.

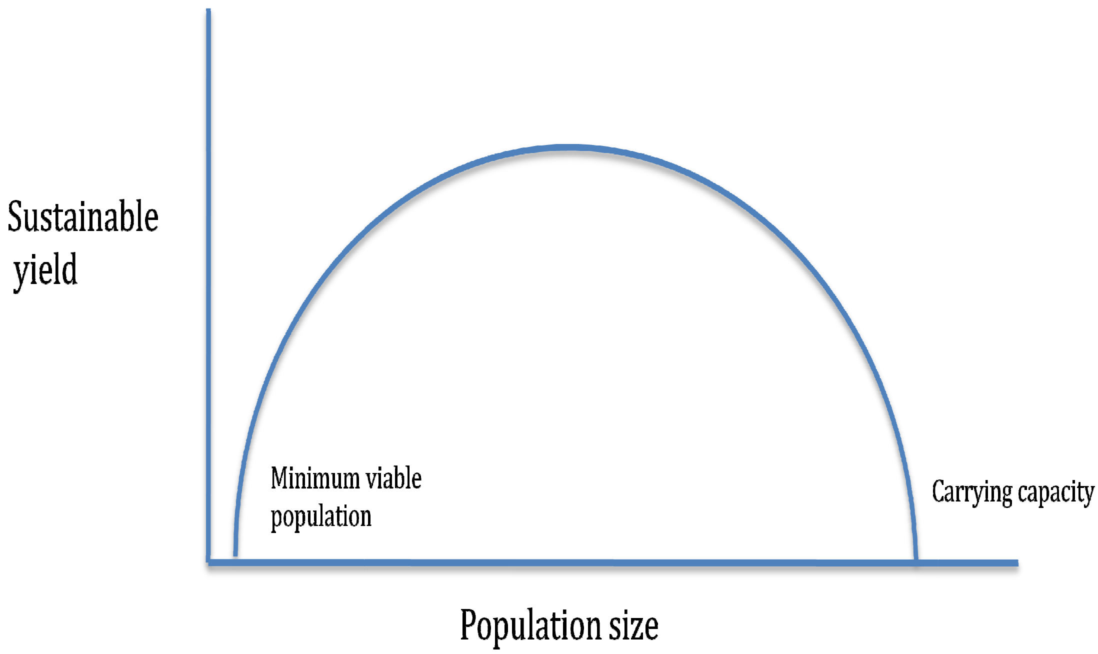
Depletion of renewable natural resources in physical terms

5.81 Renewable natural resources are able to reproduce and grow over time. Thus, in the estimation of depletion, it is necessary to consider both the extraction and the regeneration of the resources. While the rates of extraction can be directly observed, measurement of the rates of regeneration requires consideration of biological models. These models have the general form that when the stock or population of the specific type of resource is small, the rate of growth will be small but, as the population increases, the rate of growth will also increase. Eventually, as the population within a given area reaches the carrying capacity of the area, i.e. the density reaches a maximum, the rate of growth in the population will return to being small.

5.82 Based on this general model, at any given population size, it is possible to calculate the number of animals or volume of plants that may be removed from the population without affecting the capacity of the population to remain at the current size (i.e. opening stock equals closing stock). In effect there is a quantity of “surplus” or excess animals or plants that can be harvested from the existing stock. In biological models, this surplus is known as the sustainable yield.

5.83 The level of the sustainable yield rises and falls in line with the overall size of the population. At low population levels where the growth rates are low, the sustainable yields are also low. At high population levels, i.e. near carrying capacity, sustainable yields are also low. These relationships are shown in Figure 5.4.1. It is noted that the same level of extraction will have a different relationship to the sustainable yield depending on the population size. Referring to Figure 5.4.1, a given level of extraction may be above, on or under the sustainable yield curve.

Figure 5.4.1 Stylised sustainable yield curve



5.84 For a given population size, if the amount of extraction is less than the sustainable yield, i.e. points under the curve in Figure 5.4.1, no depletion should be recorded. In this situation, assuming no catastrophic losses or other changes, it would be expected that the stock would increase over the accounting period and that extraction by economic units will not reduce the potential for the same quantity of resources to be extracted in the future.

5.85 In principle, depletion should be measured wherever the amount of extraction is greater than the sustainable yield corresponding to the population size. This corresponds to points above the curve in Figure 5.4.1 and reflects quantities of extraction being greater than the growth in the population that is achievable at the given population size.

5.86 However, for most populations of natural biological resources, the estimation of sustainable yield is difficult as the natural processes of growth and death, the relationship to other species (including predators) and the impact of extraction are usually non-linear, variable (for example due to variations in climatic conditions) and often not fully understood in scientific terms. Thus it is recommended that some year on year variation around an estimate of sustainable yield be considered as normal. Consequently, in practice, depletion should be recorded when extraction is beyond the normal variation in sustainable yield for a particular population size.

5.87 The estimation of the required variables will involve the use of biological models and assumptions regarding the growth, death and other changes in population. If such models are unavailable other indicators of stock size and changes in stock size may be used. Possible methods are discussed in relation to timber resources in Section 5.8 and aquatic resources in Section 5.9.

The relationship between depletion and degradation

5.88 The focus in measuring depletion is on the availability of individual environmental assets in the future and changes in the availability due to extraction and harvest by economic units. There is particular focus on the provisioning services of individual environmental assets and the capacity of the extraction of the resources to generate income for the extractor.

5.89 Degradation considers the broader capacity of environmental assets to deliver the full suite of ecosystem services and the extent to which this capacity may be reduced through the action of economic units, including households. In this sense, since depletion relates to one type of ecosystem service, it can be considered as a specific form of degradation.

5.90 The measurement of degradation is complicated because the capacity of environmental assets to deliver ecosystem services is not completely attributable to individual assets and also that individual assets may deliver a number of different ecosystem services. Further, while individual environmental assets, such as water and soil resources, may have been degraded over time, separating the extent of degradation of the individual asset from the broader degradation of the related ecosystem may not be straightforward.

5.91 The measurement of degradation in physical terms is also complicated as it generally relies on a detailed assessment of the internal characteristics of environmental assets rather than the relatively simpler quantities of an environmental asset that are used in the estimation of asset accounts in physical terms and in the estimation of depletion. For example, to assess whether a body of water has been degraded assessments might be made of the amounts of various pollutants in the water. While individual accounting for each of these pollutants might be undertaken it will not be directly related to the volume of water in cubic metres that is used to account for water resources in an asset account.

5.92 Although separately identifying degradation in physical terms is complex, implicitly, the monetary value of individual environmental assets that have been degraded will be affected by the changing quality of the asset. Ideally, where the price of the asset changes to reflect a different quality this should be considered a change in the volume of the asset rather than as a revaluation. However, isolating the price change due to degradation from other causes of price change is likely to be very difficult in practice.

5.93 For these reasons the direct measurement of degradation in physical and monetary terms is not pursued in the central framework. Rather it is considered as part of SEEA Experimental Ecosystem Accounts. However, measures of the pressures leading to degradation are recorded, for example emissions to air and water.

5.4.3 Principles of asset valuation

5.94 One general advantage of applying valuation approaches is that different environmental assets can be compared using a common numéraire, a comparison that cannot be made using purely physical data. Further, environmental assets can be compared against other assets in order to assess relative returns, national wealth and other similar types of analysis. Since it is commonly the case that governments have a high degree of ownership or influence over the extraction of environmental assets, valuation of resources in monetary terms may be a useful approach to assessing future streams of income for government, for example in the estimation of future government revenue from the extraction of oil and natural gas.

5.95 It is also the case that in business accounts, enterprises involved in extraction make assessments in terms of their future income streams and it is relevant to be able to place these individual enterprise based valuations in a broader, national perspective. There is also increasing use of market based mechanisms, such as quotas, to allocate access rights to environmental assets. These mechanisms may relate directly to aggregate valuations for environmental assets.

5.96 Since many environmental assets are not purchased in a market place and have not been produced in a manner like buildings and equipment there are generally no observable prices for the value of the opening and closing stock of environmental assets or for the flows between these two dates.

5.97 It should be recognised that where market prices do not exist the estimation of values requires the use of assumptions and models. Overall, these models have proved to be sound tools to the development of meaningful valuations for produced assets. At the same time, there are complexities in the application of these models to the valuation of environmental assets that compilers and users should be aware of before applying the models in practice.

5.98 The following parts explain the principles for the valuation of assets and outline the approaches that can be used to estimate the values in monetary terms[44]. Specific measurement issues relevant to individual environmental assets are addressed in later sections of this chapter.

General principles of valuation

5.99 The prices at which assets may be bought or sold on markets are a basis of decisions by investors, producers, consumers and other economic agents. Market prices are assessed by investors and producers in relation to their expectations of the flows of income they can derive from the assets. For example, investors in renewable energy infrastructure assets (such as wind turbines) and environmental assets (such as land) make decisions in respect of acquisitions and disposals of these assets in the light of their values in the market relative to the income they expect the assets to generate over time.

[44] The principles of valuation explained here align fully to the SNA. See the 2008 SNA paragraphs 13.16-13.25

5.100 Ideally, observable market prices should be used to value all assets and every item should be valued as if it were being acquired on the date to which the estimate of the stock relates. These two recommendations enable the values of different types of assets, including environmental, financial and other economic assets to be compared in meaningful ways and allows the formation of opening and closing values of stocks that can be used to assess national and sector based estimates of wealth in monetary terms.

5.101 At the same time, market based estimates of asset values will commonly not account for all aspects that may be considered to be relevant in forming a valuation for an asset. For example, the value of a second-hand car in the market place will often be less than the value that the current owner places on the utility and flexibility of car ownership. At the same time, the car's value may not reflect the impact of emissions from operating the car on the environment. Thus while the use of market prices allows comparison across asset types they may not reflect the full value of the asset from an individual or society's perspective. This limitation of market based prices is often referred to in respect of the valuation of environmental assets.

5.102 An additional and important consideration in the application of general principles of valuation to environmental assets is that the objective is to estimate the value of the asset *in situ* rather than after its removal.

5.103 The approaches described in the SEEA, in particular the Net Present Value approach, provide reasonable proxies for observable market prices but do not take into account the full range of benefits (and costs) that might be considered relevant. The potential uses and limitations of NPV approaches are outlined later in this section.

Approaches to the valuation of assets

5.104 The ideal source of price observations for assets are values observed in markets in which each asset traded is completely homogeneous, is often traded in considerable volume and has its market price listed at regular intervals. Such markets yield data on prices that can be multiplied by indicators of quantity in order to compute the total market value of different classes of assets. These types of price observation are available for most financial assets, newly purchased produced assets including many types of transport equipment (such as cars and trucks) and livestock.

5.105 In addition to providing direct observations on the prices of assets actually traded, information from such markets may also be used to price similar assets that are not traded. For example, information on house and land sales may be used to estimate the value of houses and land that have not been sold.

5.106 When there are no observable prices because the items in question have not been purchased or sold on the market in the recent past, an attempt has to be made to estimate what the prices would be if a market existed and the assets were to be traded on the date to which the estimate of the stock relates.

5.107 One approach to a lack of information on relevant market prices is to use values obtained by accumulating and revaluing transactions. Most non-financial assets change in value year by year reflecting changes in market prices. In most cases the value of an asset will decline over time as the initial acquisition cost is reduced by consumption of fixed capital (more commonly referred to as depreciation) over the asset's expected life. Furthermore, the acquisition prices of equivalent new assets will change. Thus, in theory, the value of an asset at any given point in its life is equal to the current acquisition price of an equivalent new asset less the accumulated consumption of fixed capital over its life. This valuation is sometimes referred to as the "written-down replacement cost". When reliable, directly observed prices for used assets are not available, this procedure gives a reasonable approximation of what the market price would be were the asset to be offered for sale.

5.108 In the context of environmental assets, this approach may be applied to estimate the value of the stock of cultivated biological resources that are fixed assets, for example, orchards.

5.109 A second approach is to use the discounted value of future returns. For many environmental assets there are no relevant market transactions that would permit the use of the previous two approaches. Thus, although market prices can be found to value the output from extraction or harvest of an environmental asset, no values for the overall asset itself, in situ, are available.

5.110 The discounted value of future returns approach, commonly referred to as the Net Present Value approach – or NPV – uses projections of the future rate of extraction of the asset together with projections of its price to generate a time series of expected returns. Typically these projections are based on the history of returns earned from the use of the environmental asset. Assuming that returns earned in the current period is worth more to the extractor than returns earned in the future, the stream of expected returns is discounted to reflect values in the current period.

5.111 The next section outlines the key components of the NPV approach followed by a discussion of the uses and limitations of the approach for environmental accounting. Additional detail, including the relevant mathematical derivations related to the NPV approach, is contained in an annex to the chapter.

5.4.4 The Net Present Value (NPV) approach

5.112 There are five key aspects of NPV that require explanation: the measurement of returns on environmental assets, the determination of the expected pattern of resource rents based on expected extraction profiles and prices, the estimation of the asset life, the selection of a rate of return on produced assets and the choice of discount rate.

The measurement of returns on environmental assets

5.113 In the SEEA returns are defined using the concept of economic rent. Economic rent is best considered as the surplus value accruing to the extractor or user of an asset calculated after all costs and normal returns have been taken into account.

5.114 The surplus value, referred to as resource rent in the context of environmental assets, can be considered as the return attributable to the asset itself. The logic of NPV requires estimating the stream of resource rents that are expected to be earned in the future and then discounting these resource rents back to the present accounting period. This provides an estimate of the value of the asset at that point in time.45

5.115 One common aspect in the definition of resource rent is that the amount of rent is always derived relative to the returns earned by other firms on average over time – i.e. normal returns. It is also observed that resource rent, as a residual may be positive or negative. Economic theory would suggest that over the long term resource rents should not be negative.

5.116 The framework for the derivation of resource rent is based on the idea that environmental assets can be considered to generate a return to an enterprise in the same way as produced assets. Thus the operating surplus earned by an enterprise is considered to reflect both a return for the investment in produced assets and a return to the environmental assets used in production.

5.117 The relationship between operating surplus, returns to produced assets and returns to environmental assets is shown in Table 5.4.1. It is based on some key national accounts variables. The table shows that gross operating surplus is composed of two key parts – resource rent and the user cost of produced assets which is the terms used to describe the rent attributable to the use of produced assets. In turn, each of these rents can be decomposed into a portion that accounts for the cost of using up the assets (and hence reducing future potential income) and a portion that reflects the return to the assets after deducting these costs.[46]

[45] There are a number of different theories concerning what factors drive the generation of resource rent accruing to the extractor or user of an asset. Examples of sources of resource rent include differential rent, scarcity rent and entrepreneurial rent. Different sources of resource rent are not mutually exclusive and, consequently, the estimates of resource rent that underpin the NPV estimates in the SEEA should not be considered as emerging from any particular source of resource rent.
[46] Another common national accounting aggregate, Net Operating Surplus (NOS), can also be formed in this framework. It is calculated as Gross Operating Surplus less Consumption of fixed capital, or equivalently the sum of Resource rent and the Return to produced assets.

Table 5.4.1 Relationships between different flows and income components

<table>
<tr><td colspan="4">Output (sales of extracted environmental assets)</td></tr>
<tr><td colspan="4">Less Operating costs
Intermediate consumption (input costs of goods and services)
Compensation of employees (input costs for labour)</td></tr>
<tr><td colspan="4">Equals Gross Operating Surplus (a)</td></tr>
<tr><td colspan="2">User cost of produced assets</td><td colspan="2">Resource rent</td></tr>
<tr><td>Consumption of fixed capital</td><td>Return to produced assets</td><td>Depletion</td><td>Return to environmental assets (b)</td></tr>
</table>

(a) Strictly this accounting identity also includes Gross Mixed Income (the surplus earned by unincorporated enterprises) and should be adjusted for net taxes and subsidies on production. These details do not affect the logic of the explanation here.
(b) In principle the return to environmental assets derived here also incorporates a return to other non-produced assets (e.g. marketing assets and brands) as these assets also play a role in generating the operating surplus. These returns are ignored in the formulation described here.

5.118 Estimates of resource rent can be derived residually based on knowledge of all of the other variables and very often a residual approach is used to estimate resource rent. However, direct estimation methods are also available working within the same national accounts based framework.

Approaches to estimating resource rent

5.119 In practice, there are three main approaches to estimating resource rent: the residual value method, the appropriation method and the market price method.

5.120 The most commonly applied method is the residual value method. Under this method resource rent is estimated by deducting user costs of produced assets from gross operating surplus.

5.121 Estimates of the value of gross operating surplus may be obtained from national accounts datasets. Estimates of the user costs of produced assets are not generally available and must be constructed so as to obtain each period’s resource rent. Estimates of the user costs of produced assets are composed of two variables – the consumption of fixed capital of produced assets; and the normal return on produced assets. Both variables may be estimated within national accounts models designed to estimate the value of the fixed capital stock and related variables for various purposes including productivity analysis. If such models have not been developed then each variable may be estimated using assumptions regarding depreciation rates, asset lives and rates of return on produced assets. A full description of relevant considerations and approaches to the measurement of user costs is presented in the OECD manual, *Measuring Capital*.

5.122 One difficulty in estimating resource rents using these methods is that it is rare for the source information, particularly national accounts data, to be able to isolate only the extraction or harvesting activity, and in certain circumstances, multiple resources may be extracted at the same time, particularly in mining. Generally, data on GOS for industries that extract and harvest environmental assets will capture some downstream processing, refinement or other value added activity also undertaken by the extractor before sale. Since all of these additional activities require inputs of labour and capital, partitioning a firm's GOS into pure extraction activity relating to a single resource is not always straightforward. Nonetheless, all efforts should be made to isolate the specific GOS for the extraction activity of individual resources in the underlying data.

5.123 Estimates of resource rent may also be affected by the receipt of subsidies by the extracting or harvesting enterprise. Subsidies should be deducted in the derivation of resource rent. Even though the receipts provide support to continue the activity of extraction, the receipts do not relate to the income attributable to the underlying environmental asset.

5.124 There may be concern that in situations of overexploitation of resources the resulting gross operating surplus will generate a higher estimate of resource rent than can be sustained over the longer term. While this observation is correct it does not invalidate the measurement approach. The aim of the valuation approach is not to measure what might or should happen under ideal circumstances but to account for expected behaviour in respect of the environmental asset. Thus if overexploitation continues it should be reflected in a shorter asset life and in a greater amount of depletion (as a component of the higher resource rent) than might otherwise be the case.

5.125 The appropriation method estimates the resource rent using the actual payments made to owners of environmental assets. In many countries, governments are the legal owners of environmental assets on behalf of the country. As legal owners, governments could in theory collect the entire resource rent derived from extraction of the resources they own. This amount would, in principle be equal to GOS less user costs of produced assets of the extractor, as defined.

5.126 The collection of resource rent is generally undertaken by governments through mechanisms such as fees, taxes and royalties. In practice, the fees, taxes and royalties collected tend to understate total resource rent as the rates may be set with other priorities in mind, for example encouraging investment and employment in extracting industries. These alternative motivations should be considered before adoption of the appropriation method.

5.127 The market price method is based on the fact that access to resources may be controlled through the purchase of licences and quotas – commonly observed in the forestry and fishing industries. When these resource access rights are freely traded it is possible to estimate the value of the relevant environmental asset from the market prices of the rights. The economic logic parallels the residual value method since it is expected that in a free market the value of the rights should be equivalent to the future returns from the asset (after deducting all costs including user costs of produced assets).

5.128 Where the resource access rights that are purchased provide a very long term or indefinite access to the assets, the market value of the rights should provide a direct estimate of the total value of the asset rather than simply an estimate of the resource rent. In this case no discounting of future flows of resource rent is needed. If the rights are for a more limited period, say entitlements for one year, this can provide a direct estimate of the resource rent for that year.

5.129 In practice, in many cases the government give the rights direct to extractors for free or do so at a price less than the true market value and trading of the rights may be restricted or prohibited. In these cases there is no directly observable market valuation.

Summary of approaches to estimating resource rent

5.130 While in theory all of these methods will generate the same estimates of resource rent it is the case that the application of the appropriation and market price method are more heavily influenced by institutional arrangements in a country. For these reasons, the compilation of estimates of resource rent based on the residual value method should be compiled and, where possible, reconciled with estimates obtained using the other methods. Indeed, there may be particular analytical interest in comparing the estimates of resource rent based on the different methods.

Determination of the expected pattern of resource rents

5.131 The critical factor in the valuation of assets is not the past or current returns but the expected returns. An asset with no expected returns has no value in economic terms. Expected returns are, by definition, not observed and hence assumptions concerning these flows must be made.

5.132 The starting point is generally the estimates of resource rent in the current or immediate past periods. In the absence of any additional information on future price changes or likely changes in extraction rates, it is recommended that estimates of expected resource rent should be set equal to current estimates of resource rent thus assuming no price changes beyond the general level of inflation and a realistic rate of resource extraction.

5.133 In general, there is too much volatility in unit resource prices for meaningful assumptions about future resource price changes to be incorporated. Also, in the absence of other information, it may be reasonable to assume that extraction will continue at the same rate as in the past since this is the extraction rate for which an appropriate amount of produced assets have been acquired. At the same time, if it was known that the majority of the expected resource rent was to be earned in years 5 to 10 over a total asset life of 30 years, then this should be taken into account.

5.134 Special consideration is needed in situations where the extraction rates in any particular period fall to zero, or close to zero. In practice this is possible in any given accounting period for example, if economic circumstances change such that extraction is no longer cost effective, if natural disasters make the resource inaccessible or un-harvestable, or if access to resources is restricted to allow the recovery of stocks.

5.135 If changes in the expected extraction schedule that underpin the NPV estimates occur, the resulting NPV estimates may produce results that are difficult to interpret. However, this only highlights that when the expected extraction schedule changes, for any reason including simply the receipt of additional information, the NPV estimates must be re-estimated since it reflects a valuation based on all of the information available at that point in time.

Estimates of the asset life

5.136 Estimates of the asset life must be based on consideration of the physical stock of the asset and assumed rates of extraction and growth, in the case of renewable resources. In a very simple case the asset life may be calculated as the existing physical stock divided by the excess of expected annual extractions over expected annual growth. However, especially for renewable resources such as fish resources, it is necessary to consider biological models and associated sustainable yields of renewable resources such that the impact of changing age and sex structures is taken into account in the determination of the asset life. A description of relevant considerations is contained in section 5.4.2.

5.137 It may be that, through the use of biological and economic models, optimal extraction paths can be calculated that effectively determine the asset life through alignment between the available stock and rates of extraction. Often implicit in the determination of such extraction paths, particularly for renewable natural resources, are assumptions regarding the sustainability of the resource – for example that future management of fish stocks will ensure extraction does not exceed growth.

5.138 For the SEEA making such assumptions regarding sustainability is problematic as it may imply the adoption of behaviour that may not have been evidenced in the past. Unless there is evidence the contrary, it is recommended that estimates of asset life be based on rates of extraction and growth that have occurred in the recent past rather than through the use of general assumptions on sustainability or intended management practice.

5.139 Estimates of the asset life are required to provide the time frame over which the NPV approach is applied. In practice, depending on the choice of discount rate, if asset lives are longer than around 20 years, the NPV estimates are relatively stable. That is, the values of the expected returns in later years are relatively small. The sensitivity of the NPV estimates to the choice of discount rate over varying asset lives is shown in Annex A5.1.

Rate of return on produced assets

5.140 An expected rate of return on produced assets is required to estimate the user cost of the produced assets used in the extraction of the asset. If this cost is not deducted the resulting estimates of resource rent will be overstated.

5.141 Two approaches can be taken to estimating rates of return on produced assets – an endogenous approach and an exogenous approach. The endogenous approach sets the rate equal to the net operating surplus (gross operating surplus less consumption of fixed capital) divided by the value of the stock of produced assets. This approach implicitly assumes that there is no return attributable to non-produced assets, including environmental assets and hence is not recommended. It should, however, form an upper bound on the estimated rate of return on produced assets.

5.142 The exogenous approach is recommended in the SEEA. This approach assumes that the expected rate of return on produced assets is equal to an external (exogenous) rate of return. Ideally, the expected rate of return should take into account activity or industry specific returns thus implicitly taking into account risks in investing in particular activities. However, in many cases financial markets may not be sufficiently developed to provide robust estimates of these specific rates of return.

5.143 For this reason a realistic approach is to use an economy wide rate of return perhaps based on government bond rates where these exist.[47] In all cases a real rate of return should be used. While exogenous rates of return are unlikely to be perfect proxies for rates of return on individual produced assets, it is likely that they provide a reasonable reflection of normal returns for the derivation of estimates using the NPV approach.

Choice of discount rate

5.144 Discount rates are required to convert the expected stream of resource rents into a current period estimate of the overall value. A discount rate expresses a time preference – the preference for the owner of an asset to receive income now rather than in the future. It also reflects the owner's attitude to risk. 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 an asset than will governments. Higher rates of time preference translate into higher discount rates.

5.145 The use of a discount rate in NPV calculations can be interpreted as an expected rate of return on the non-produced assets. In an enterprise where all assets are identified and measured accurately, and where conditions of perfect competition prevail, the discount rate and the rate of return on produced assets should be equal. This is because the enterprise should only invest if the rate of return is aligned to its own time and risk preferences for receiving income.

5.146 To ensure a valuation basis that is aligned to the general concept of market prices, it is recommended that a market-based discount rate should be used equal to the assumed rate of return on produced assets (see above).

5.147 At the same time, there is also support for the use of social discount rates in the valuation of environmental assets. The rationale is that environmental assets are of broad and long term value to society as a whole and should be valued in that light rather than solely in relation to their value to a present day extractor.

5.148 One of the main arguments supporting the use of social discount rates is that generally, social discount rates are lower than market-based discount rates and lower rates will place higher relative importance on income earned by future generations. From this it is often implied that estimates of NPV that use market-based discount rates do not value future generations and the total values obtained are too small since they do not place sufficient value on these future incomes.

[47] It is also the case for technical reasons that a general rate of return is appropriate. If an industry specific rate of return is used it is also necessary to include industry specific expectations in the derivation of the revaluation term in the NPV formula and in doing this the impact of using industry specific rates of return is offset.

5.149 Annex A5.2 presents an extended discussion on discount rates and their application, including a table showing the sensitivity of valuations based on NPV to the choice of discount rate.

Calculation of Net Present Values

5.150 Using these various elements estimates of the value of an environmental asset are obtained using the following basic steps assuming the use of the residual value method to calculate resource rent.

i. Estimates of GOS and the user cost of produced assets for the extractive activity are obtained from relevant sources, most likely based on national accounts data, relevant activity specific information and assumptions regarding rates of return on produced assets.
ii. Estimate Resource rent as GOS less User cost of produced assets.
iii. Estimate the asset life based on physical assessment of the stock and projected rates of extraction and growth.
iv. Project the estimate of Resource rent over the life of the asset taking into account any expected changes in extraction pattern.
v. Apply the NPV formula using an appropriate discount rate

$$V_t = \sum_{\tau=1}^{N_t} RR_{t+\tau} / (1 + r_t)^{\tau}$$

5.151 Where possible, compilers are encouraged to compare results of NPV calculations that would be obtained using different estimates of the discount rate and also, different approaches to the estimation of resource rent. This may be possible where tradable access rights are in existence or where payments of rent are recorded. These alternative estimates of resource rent may be substituted into the general NPV formulation to derive alternative valuations.

5.152 Wherever actual market prices are available, for example on the basis of actual transactions in environmental assets, this information should be used in preference to NPV based valuations. In incorporating this information, appropriate adjustments for the scope and coverage of the transactions compared to the scope of the estimation based on NPV need to be made.

5.153 Ideally, calculation of NPV estimates should be undertaken for individual stocks, for example for a specific mineral deposit or fish stock. At this level of detail changes in the stock can be more accurately considered and assumptions evaluated. More generally, all efforts should be made to test assumptions used in the formulation of NPV valuations and, wherever possible additional information about specific individual stocks should be taken into account, for example for large discoveries of mineral and energy resources or catastrophic losses of timber resources due to exceptional weather events.

5.154 A complete articulation of the derivation and application of the NPV approach is presented in Annex A5.1.

5.4.5 Accounting for change between NPV estimates

5.155 Accounting for the change in the value of assets over an accounting period is a core part of asset accounting. As with the assessment of the value of an asset at the beginning and end of a period, the valuation of changes in the stock, such as discoveries and catastrophic losses, is also dependent on the impact that these changes have on expected incomes. Since these changes are not usually evidenced by transactions in the assets themselves, their valuation requires the use of the NPV approach to ensure alignment between stock valuations and valuations of the changes in the stock. A complete accounting for these changes within the NPV framework is presented in Annex A5.1. The following paragraphs focus on the interpretation of depletion, a key indicator of the change in value of an environmental asset.

Relationship between resource rent and depletion

5.156 Table 5.4.1 shows that the estimate of resource rent can be decomposed into depletion and the return to environmental assets. The ability to decompose resource rent in this way is an important conceptual relationship as it permits the development of estimates of depletion adjusted operating surplus and other related aggregates within the framework of the traditional national accounts.

5.157 These paragraphs describe the nature of the relationship between resource rent and depletion. Section 5.4.2, explains the basis for measuring depletion in physical terms which underpins the monetary estimates discussed in this section. Annex A5.1 explains in detail how monetary estimates of depletion can be derived within the NPV approach. Chapter 6 describes the full sequence of accounts including adjustments for depletion.

5.158 The gross operating surplus of an enterprise represents the benefit accruing to the owner of using all assets in the year in question. It can equally be described as the value of the flow of services rendered by the assets, referred to as capital services, in the same period plus a possible residual profit or loss. The value of all assets can, in principle, be estimated by calculating the NPV of the gross operating surplus (or capital services) to be generated for all future years in which the assets will be still in service.

5.159 The value of capital services is composed of two elements. First, there is an element that reflects the change in the value of the assets due to the using up of the assets over an accounting period. In effect, after each accounting period there are fewer capital services available to be delivered by the assets. Second, there is an income element, or return on assets, that reflects the fact that the owner receives a net benefit from undertaking investment in the assets. If there was no income element the owner should have invested in an alternative asset.

5.160 In relation to produced assets, the cost of using up the asset's capital services is referred to as consumption of fixed capital in the SNA. More generally it is referred to as depreciation. The difference between gross operating surplus and consumption of fixed capital is net operating surplus. Net operating surplus incorporates the return on produced assets and the full value of capital services provided by non-produced assets.

5.161 For environmental assets a similar logic can be applied. The value of capital services provided by environmental assets is referred to as resource rent and can be partitioned into two components. The first component, depletion, reflects the decline in the value of the asset due to the physical extraction of the asset. The second component, the return to environmental assets, reflects the income accruing to the extractor of the asset through the use of the extracted resource in production.

5.162 If an environmental asset has characteristics such that no amount of use of the asset in production over a year leads to a decline in its value, then there is no depletion and the entire value of the capital service represents a return to the environmental asset and is considered income. This situation can only arise if (i) the natural growth of the asset always keeps pace with extraction/harvesting; or (ii) the asset is sufficiently abundant as to render it free, with no cost arising from using up the asset.

5.163 In the case of non-renewable resources, which by definition have a finite life (even if quite long in some instances), the recognition of a depletion element is relatively straightforward since each year the total amount of income that can be earned from the resource in the future reduces due to the physical extraction of the resource.

5.164 In the case of renewable resources the recognition of depletion is less obvious. It is quite possible that the amount extracted is replaced through natural growth of the environmental asset such that the income that can be earned from the asset in the future is unchanged despite the physical extraction.

5.165 Where the amount extracted does not impact on the long term viability of the environmental asset then estimated depletion is zero and all resource rent should be considered as a return to the extractor of the environmental asset. Where the amount extracted does impact on the long term viability of the asset then depletion should be estimated. The relevant considerations and measurement approaches are explained in detail in Section 5.4.2 and also in Annex A5.1.

5.166 Where growth in the environmental asset is greater than extraction leading to an overall increase in the availability of the asset at the end of the period then this should be recorded as an addition to the stock of the environmental asset in the asset account.

5.4.6 Measurement of environmental assets in volume terms

5.167 As explained in Chapter 2, volume measures of assets are not measures of quantities but rather are estimates of changes in the value of assets after removing the effects of price change. Thus, volume measures comprise changes due to changes in quantities and changes in quality.

5.168 Volume measures of environmental assets are compiled to assist in the analysis of the changes in environmental assets over time. Removing the effect of price change may be undertaken for two primary purposes. First, the effect of price change may be removed to provide an indicator of the purchasing power of environmental assets, i.e. an estimate of the capacity of a set of environmental assets to be used to acquire a given set of goods and services. Second, the effect of price change may be removed to assess whether there has been a change in the underlying aggregate physical stock of a number of environmental assets. Both of these rationales may be important considerations when undertaking an aggregate analysis of the wealth of a country and considering the relative importance of environmental assets compared to other economic and social assets.

5.169 To estimate the purchasing power of a set of environmental assets, the volume measure is equal to the total value of environmental assets divided by an estimate of the general rate of inflation, for example the consumer price index.

5.170 To estimate changes in the aggregate physical stock, a rough assessment may be completed through analysis of the change in the physical stock of each type of environmental asset. However, this approach does not permit aggregation across assets since each will be measured in different physical units, for example hectares of land and tonnes of coal.

5.171 In order to provide a volume measure reflecting the aggregate physical stock a number of different measurement approaches can be considered. First, a volume measure can be compiled that is the aggregation of the changes in physical stocks of each asset weighted by their relative values at a given point in time. The point in time is often the beginning or end of the accounting period but the relative values may also be calculated based on an average of beginning and end of period values.

5.172 A second approach to the compilation of the volume of the aggregate physical stock can be applied in cases where the NPV formula has been used. The approach is to re-estimate the NPV at the end of the period, for each environmental asset, using the same unit resource rent as was used at the beginning of the period. The sum of these re-estimated NPVs provides an estimate of the volume of environmental assets at the end of the period. This estimate can be compared to the value of the environmental assets at the beginning of the period to provide an estimate of the change in volume. In effect the physical stocks at the beginning and end of the period are all valued using the same set of prices and hence any change reflects the volume change in environmental assets.

5.173 It is possible, using a time series of asset values, to use the unit resource rent from one reference period to re-estimate the assets at all other periods. This provides a time series of asset values at constant unit resource rents. However, the use of a single reference unit resource rent may hide changes in resource rent due to changing technology and extraction costs. Hence it is preferable to calculate the changes in volume between each period using unit resource rents relevant to that period and then link the consecutive estimates of the changes in volume together to form a single time series.

5.174 A third approach to deriving asset volumes is to divide the individual asset values at the end of the period by an asset specific price index. In many cases this may be a price index relating to the sales of extracted products (e.g. a price index for coal used to deflate the value of stocks of coal). However, a more accurate result is obtained if the price index reflects changes in the unit resource rent. This requires taking into account not only the changing prices of the extracted products but also in the changing costs of extraction. As for the second approach, the price index reflecting the changing costs of production should assume a constant technology such that these changes are captured in the volume change.

5.5 Asset accounts for mineral and energy resources

5.5.1 Introduction

5.175 Mineral and energy resources represent a unique type of environmental asset in that they can be extracted and used through economic activity but cannot be renewed on any human time scale. Since they cannot be renewed there is particular interest in understanding the rate at which these assets are being extracted and depleted, the overall availability of these assets and the sustainability of the industries that exploit them.

5.176 Asset accounts for mineral and energy resources organise relevant information including the levels and values of stocks of the resources and the changes in these over accounting periods. Flows of extraction, depletion and discoveries are central to the asset account and in turn these can provide valuable information regarding the sustainability of individual resources.

5.177 The capacity to value stocks and flows of mineral and energy resources allows important links to be made to monetary estimates of the value added and operating surplus of the extracting industries such as the derivation of depletion adjusted value added measures. Such measures provide a more holistic view of extraction activity recognising a more complete set of production costs. Monetary estimates of these assets may also be of interest in the determination of government taxation and royalty settings given that in many countries the government is the collective owner of these assets on behalf of the community.

5.178 This section defines mineral and energy resources and the relevant measurement boundary for the central framework. It then presents asset accounts in physical and monetary terms including a discussion on the estimation of resource rent. A final part of this section discusses two specific measurement issues related to mineral and energy resources – (i) the allocation of income from the extraction of mineral and energy resources, and (ii) the recording of stocks and flows for energy from renewable sources.

5.5.2 The definition and categorisation of mineral and energy resources

5.179 Mineral and energy resources include deposits of oil resources, natural gas resources, coal & peat resources, non-metallic minerals and metallic minerals. Since the resources are generally found under the ground (and hence commonly referred to as subsoil assets) it is often not known with a great deal of precision the quantity of resources that might be reasonably extracted. Consequently, a key factor in the measurement of mineral and energy resources is the concentration and quality of the minerals and energy resources in the deposit, since this will influence the likelihood and cost of extraction and the degree of confidence that exists regarding the quantity that can be extracted in the future.

5.180 ***Mineral and energy resources are defined as known deposits of oil resources, natural gas resources, coal & peat resources, non-metallic minerals and metallic minerals.***

5.181 The framework used to define the scope of known deposits is the United Nations Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC-2009). The UNFC-2009 is a generic and flexible scheme for classifying and evaluating quantities of fossil energy and mineral resources.

5.182 The UNFC-2009 categorizes mineral and energy resources by looking at whether, and to what extent, projects for the extraction or exploration of the resources have been confirmed, developed or planned. Based on the maturity of the projects the underlying natural resources are classified. The UNFC-2009 is based on a breakdown of the resources according to three criteria affecting their extraction:

- Economic and social viability (E)
- Field project status and feasibility (F)
- Geological knowledge (G)

5.183 The first criteria (E) designates the degree of favourability of economic and social conditions in establishing the commercial viability of the project. The second criteria (F) designates the maturity of studies and commitments necessary to implement mining plans or development projects. These extend from early exploration efforts before a deposit or accumulation has been confirmed to exist through to a project that is extracting and selling a product. The third criteria (G) designates the level of certainty in the geological knowledge and potential recoverability of the quantities.

5.184 Known deposits are categorised into three classes each defined according to combinations of criteria from the UNFC-2009.

i. Class A: Commercially Recoverable Resources. This class includes deposits for projects that fall in the categories E1and F1 and where the level of confidence in the geological knowledge is either high (G1), moderate (G2) or low (G3).

ii. Class B: Potentially Commercially Recoverable Resources This class includes deposits for those projects that fall in the category E2 (or eventually E1) and at the same time in F2.1 or F2.2 and where the level of confidence in the geological knowledge is either high (G1) moderate (G2) or low (G3).

iii. Class C: Non-Commercial and Other Known Deposits are resources for those projects that fall in E3 and for which the feasibility is categorised as F2.2, F2.3 or F4 and where the level of confidence in the geological knowledge is either high (G1), moderate (G2) or low (G3).

5.185 Known deposits exclude potential deposits where there is no expectation of the deposits becoming economically viable and there is a lack of information to determine feasibility of extraction or to have confidence in the geological knowledge. Table 5.5.1 gives an overview of how the classes of resources are defined based on the UNFC criteria. The UNFC is explained in more detail in Annex A5.3.

5.186 The scope of known deposits is broader than the scope of deposits that underpins the measurement of mineral and energy resources in the SNA. In the SNA the scope is limited to deposits that are commercially exploitable given current technology and relative prices.[48] The broader scope of known deposits is applied in the SEEA to ensure that as broad an understanding as possible is obtained on the availability of the stock of mineral and energy resources. Issues associated with the scope of the valuation of mineral and energy resources are discussed in section 5.5.4.

Table 5.5.1: Categorization of Mineral and Energy Resources

	SEEA Classes	**Corresponding UNFC-2009 project categories**		
		E **Economic and social viability**	**F** **Field project status and feasibility**	**G** **Geological knowledge**
Known deposits	**Class A: Commercially Recoverable Resources**[1]	E1. Extraction and sale has been confirmed to be economically viable	F1. Feasibility of extraction by a defined development project or mining operation has been confirmed	Quantities associated with a known deposit that can be estimated with a high (G1), moderate (G2) or low (G3) level of confidence
	Class B: Potentially Commercially Recoverable Resources[2]	E2. Extraction and sale is expected to become economically viable in the foreseeable future[3]	F2.1 Project activities are ongoing to justify development in the foreseeable future Or F2.2 Project activities are on hold and/or where justification as a commercial development may be subject to significant delay	
	Class C: Non-Commercial and other known deposits[4]	E3. Extraction and sale is not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability	F2.2 Project activities are on hold and/or where justification as a commercial development may be subject to significant delay Or F2.3 There are no current plans to develop or to acquire additional data at the time due to limited potential Or F4. No development project or mining operation has been identified	
Potential deposits (not included in SEEA)	Exploration projects Additional quantities in place	E3. Extraction and sale is not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability	F3. Feasibility of extraction by a defined development project or mining operation cannot be evaluated due to limited technical data Or F4. No development project or mining operation has been identified	Estimated quantities associated with a potential deposit, based primarily on indirect evidence (G4)

Notes
1. Includes on-production projects, projects approved for development and projects justified for development
2. Includes economic and marginal development projects pending and development projects on hold
3. Potential Commercial Projects may also satisfy the requirements for E1.
4. Includes unclarified development projects, non-viable development projects, and additional quantities in place
Source: UNFC-2009, Figures 2 and 3

48 See 2008 SNA, paragraph 10.179.

Classification of mineral and energy resources

5.187 There are a number of different types of mineral and energy resources such as oil, natural gas, coal and peat resources, non-metallic minerals and metallic minerals, but there is no internationally agreed detailed classification for mineral and energy resources suitable for statistical purposes.

5.5.3 Physical asset accounts for mineral and energy resources

5.188 Physical asset accounts for mineral and energy resources should be compiled by type of resource and include estimates of the opening and closing stock of mineral and energy resource and changes in the stock over the accounting period.

5.189 The units used to compile and present the relevant information will vary by type of resource. They are likely to be in tonnes, cubic metres, or barrels. For accounting purposes the same unit should be retained for a single resource to record the opening and closing stocks and the changes in the stocks over an accounting period.

5.190 It is noted that a total for each class of deposit across different resource types cannot be meaningfully estimated due to the use of different physical unit for different resources. For certain sub-sets of resources, for example energy resources, an aggregate across certain resource types may be possible using a common unit such as joules or other energy units.

Measurement of opening and closing stocks

5.191 Ideally, opening and closing stocks of each mineral and energy resource should be classified by class of resource – i.e. Class A: Commercially Recoverable Resources, Class B: Potentially Commercially Recoverable Resources, or Class C: Non-commercial and other known deposits – following the structure in Table 5.5.2.

5.192 It is not recommended that totals across all classes of individual types of resources be compiled. Because each class has a different likelihood of extraction, simple summation of the available resources for a specific resource (e.g. coal) may give a misleading indication of total available resources.

5.193 In this framework it is important to clarify those resources for which a monetary valuation is to be established. If this distinction is not made a subsequent comparison between physical and monetary accounts for individual resources may provide misleading indicators of average prices and relative availability of individual resources.

Table 5.5.2 Stocks of mineral and energy resources (physical units*)

		Class of known deposit		
		Class A: Commercially recoverable resources	Class B: Potentially commercially recoverable resources	Class C: Non-commercial and other known deposits
Type of mineral and energy resource				
	Oil resources			
	Natural gas resources			
	Coal & peat resources			
	Non-metallic minerals			
	Metallic minerals			

* Different physical units (e.g. tonnes, cubic metres, barrels) will be used for different types of resources

Physical asset account for mineral and energy resources

5.194 A basic physical asset account for mineral and energy resources is shown in Table 5.5.3.

Table 5.5.3 Mineral and energy resource account (physical units*)

		Type of mineral and energy resource (by class)				
		Oil resources	Natural gas resources	Coal & peat resources	Non-metallic minerals	Metallic minerals
Opening stock of mineral and energy resources						
Additions to stock						
	Discoveries					
	Upwards reappraisals					
	Reclassifications					
	Total additions to stock					
Reductions in stock						
	Extractions					
	Downwards reappraisals					
	Reclassifications					
	Total reductions in stock					
Closing stock of mineral and energy resources						

* Different physical units (e.g. tonnes, cubic metres, barrels) will be used for different types of resources

Additions to and reductions in the stock of mineral and energy resources

5.195 The changes in the stock in physical terms should consider the following types of changes.

i. Discoveries. Discoveries should incorporate estimates of the quantity of new deposits found during an accounting period. To be regarded as a discovery the new deposit must be a known deposit – i.e. in Class A, B or C. In situations in which a quantity of potential deposits becomes known to a higher degree of confidence, this increase should be treated as discoveries. Discoveries should be recorded by type of resource and by category of resource.

ii. Reappraisals. Reappraisals may be upwards or downwards. They should only pertain to known deposits. In general, reappraisals will relate to either additions or reductions in the estimated available stock of a specific deposit or to changes in the categorization of specific deposits between Class A, B or C based on changes in geological information, technology, resource price or a combination of these factors.

iii. Extraction. Estimates of extraction should reflect the quantity of the resource physically removed from the deposit. It should exclude mining overburden, i.e. the quantity of soil and other material moved in order to extract the resource. As well the quantity should be estimated before any refinement or processing of the resource is undertaken.
Estimates of extraction should include estimates of illegal extraction, either by residents or non-residents, as these amounts reduce the availability of the resource.
It is noted that for the extraction of natural gas the measurement of the quantity extracted may be more difficult due to the nature of the extraction process for some deposits. In cases where natural gas is found with oil, it is the pressure exerted by the natural gas that causes the oil (and some natural gas) to be expelled from the oil well. Some of the natural gas that is expelled may be flared rather than being put to direct use. Some natural gas, 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 natural gas associated with the oil is being accounted for, an allowance must be made for the decrease in the amount of natural gas available for other uses due to flaring and re-injection.

iv. Catastrophic losses. Catastrophic losses are rare in relation to most mineral and energy resources. Flooding and collapsing of mines does occur but the deposits continue to exist and can, in principle, be recovered and the issue is one of economic viability of extraction rather than actual loss of the resource itself. An exception to this general principle concerns oil wells that can be destroyed by fire or become unstable for other reasons leading to significant losses of oil resources. Losses of oil and related resources in this situation should be considered catastrophic losses.

v. Reclassifications. Reclassifications may occur if certain deposits are opened or closed to mining operations due to government decision concerning the access rights to a deposit. All other changes in the quantity of known deposits should be treated as reappraisals. Reclassifications may also be recorded if asset accounts for mineral and energy resources are being compiled by institutional sector.

5.196 Increasingly there is interest in the capacity to supply various metals and other minerals through the recycling of produced goods. The implied stock of relevant metals and minerals within an economy is not within the scope of the asset accounts presented here. Nonetheless, depending on the extent of recycling undertaken in a country, information on recycled metals and other minerals may be compiled to provide a more complete picture of the availability of these resources and hence on the demands for the extraction of these resources from the environment.

5.5.4 Monetary asset accounts for mineral and energy resources

5.197 Asset accounts in monetary terms for mineral and energy resources are based on the availability of information on the physical stock of resources. The structure of the monetary asset accounts therefore largely parallels the structure of the physical asset accounts. The basic structure is shown in Table 5.5.4.

Table 5.5.4 Mineral and energy asset account (monetary unit)

		Type of mineral and energy resource (Class A: Commercially recoverable resources)				
		Oil resources	Natural gas resources	Coal & peat resources	Non-metallic minerals	Metallic minerals
Opening value of stock of resources						
Additions to value of stock						
	Discoveries					
	Upwards reappraisals					
	Reclassifications					
	Total additions to stock					
Reductions in value of stock						
	Extractions					
	Downwards reappraisals					
	Catastrophic losses					
	Reclassifications					
	Total reductions in stock					
Revaluations						
Closing value of stock of resources						

5.198 The additional entry in the monetary asset account relates to the recording of revaluations which occur either due to changes in resource prices over the accounting period or due to changes to assumptions underlying the NPV approaches that are typically used to value mineral and energy resources.

5.199 While the measurement boundary extends to all known deposits in physical terms, it may not be possible to value all of these deposits in monetary terms due to degrees of uncertainty regarding expected extraction profiles and incomes. Consequently, the resource rents for deposits in Classes B and C cannot be determined with confidence. Therefore, it is recommended that valuation only be undertaken for deposits in Class A: Commercially Recoverable Resources. If valuation of deposits in Classes B and C is undertaken, the values for each class should be clearly distinguished. In valuing deposits in each class it is important that the likelihood and timing of extraction be taken into account in determining expected patterns of extraction and income.

Valuation of stocks of mineral and energy resources

5.200 Because there are few transactions in mineral and energy resources the valuation of these assets requires the use of NPV approaches as introduced in Section 5.4. The calculations should be undertaken at the level of an individual resource type, ideally for specific deposits of a resource, and then summed over the range of different resources in order to obtain a total value of mineral and energy resources.

5.201 Application of NPV approaches to the valuation of mineral and energy resources requires consideration of a number of specific factors most pertaining to the estimation of the resource rent.

<u>Estimation of resource rent</u>

5.202 In general the resource rent will be estimated based on information about the income and operating costs for the extraction industry. The aim is to define a resource rent that is specific to a given resource type, for example coal. In meeting this aim several factors should be borne in mind

5.203 <u>Scope of operations</u>: Consistent with the definition of quantities extracted, the scope of the income and operating costs to be considered in the derivation of resource rent should be limited to the extraction process itself and should not include any additional income earned or costs incurred through further refinement and processing of the extracted resource. The extraction process is considered to include the activity of mineral exploration and evaluation and these costs should be deducted in the derivation of resource rent.

5.204 For some mineral and energy resources, a single deposit may contain several types of resources. For example, often an oil well contains gas and, frequently silver, lead and zinc can only be extracted together. In these situations, the resource rent used in the calculation of the value of the resources should be allocated by commodity. However, since data are generally only available for a single extracting unit derivation of estimates of resource rent by type of resource based on known extraction costs for each type of resource may not be possible except by using detailed industry knowledge or general rules of thumb to allocate total extraction costs.

5.205 Price fluctuations: While operating costs for extracting resources may not fluctuate significantly, it is likely that income earned from sales of extracted resources will fluctuate. Consequently, the resource rent (which is derived as a residual), may be a quite volatile time series. In addition the aggregate amount of resource rent in any one period may be affected by extraction rates that in turn may be affected by one-off events, eg mine collapse. Since the objective is to define a resource rent which can be forecast it is recommended first, that unit resource rents be derived by dividing total resource rent for an individual resource by quantities extracted in a period and second, that, in the absence of other information on future resource prices, a moving average of unit resource rents be used as the basis for the estimation of future resource rents.

5.206 Treatment of mineral exploration and evaluation: Mineral exploration is undertaken in order to discover new deposits of minerals and energy resources that may be exploited commercially. Such exploration may be undertaken on own account by enterprises engaged in mining activities. Alternatively, specialized enterprises may carry out exploration either for their own purposes or for fees. The information obtained from exploration and evaluation influences the production activities of those who obtain it over a number of years. Hence, the expenditures are considered to be a form of gross fixed capital formation resulting in the production of an intellectual property product, a type of produced asset.

5.207 Mineral exploration and evaluation consists of the value of expenditures on exploration for petroleum and natural gas and for non-petroleum deposits and subsequent evaluation of the discoveries made.[49]

5.208 These expenditures include prelicence 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. Re-evaluations may take place after commercial exploitation of the resource has started and the cost of these re-evaluations is also included.

5.209 Consumption of fixed capital should be calculated for this asset, potentially using average service lives similar to those used by mining or oil corporations in the own accounts.

5.210 For the purpose of estimating resource rent it is necessary to deduct the user costs of produced assets including both the consumption of fixed capital and a return to the produced asset.

5.211 It is recognized that an outcome from mineral exploration is the discovery of mineral and energy resources and hence the value of mineral and energy resources on the balance sheet may in part be considered to be due to mineral exploration. The deduction of the user costs of mineral exploration and evaluation in the derivation of resource rent ensures

[49] See 2008 SNA paragraph 10.106

that the recorded value of the mineral and energy resources reflects only the value of the non-produced environmental resource.

5.212 Mine and rig decommissioning costs: Consistent with the treatment in the 2008 SNA it is recognized that in many cases costs are incurred by extractors at the end of the productive life of a deposit, generally to restore the natural environment around the extraction site. These costs, where they can be reasonably anticipated or estimated, should be considered to reduce the resource rent earned by the extractor over the operating life of the extraction site even though the actual expenditure is likely to take place at the end of the operation of the assets. Details on accounting for these costs are discussed in Chapter 4.

5.213 Aggregation of the same resource over different deposits: 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 resource life of all resources available to a country. In practice, of course, this is not the case: some oil fields will be exhausted in a relatively short time frame and extractors will then move to another.

5.214 Many reappraisals apply to established fields where extraction is already in progress. Upward revisions in quantities will extend the life of the resources and the addition to value will largely reflect the change between the previous and new resource lives since without additional investment the extraction rate is likely to remain steady.

5.215 A somewhat different situation holds for a completely new discovery. Suppose a deposit is discovered with an expected life of, say, 20 years, equal by itself to the existing reserves of a country. It is not realistic to automatically assume that the resource in the new deposit will necessarily be extracted in years 21 to 40. On the other hand, neither is it realistic to automatically assume that it will be extracted in years 1 to 20 and thus double the total extractions in these years. For these reasons, it is desirable, if at all possible, to make projections of the impacts of discoveries and reappraisals separately and ideally, on a deposit by deposit basis.

Extraction rate

5.216 Independent of assumptions about the unit resource rent, an assumption must be made about the pattern of extraction to be followed in the future. The assumption most often used is that the extraction rate 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 become 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 increased at the same time. There may be information available from government or from enterprises on projected levels of extraction that could be used, although these often tend to be based on conservative projections of the likely level of new discoveries and reappraisals.

5.217 In the absence of more precise information, a reasonable assumption is that the rate of extraction is kept constant in physical terms which effectively assumes that the efficiency of extraction process remains steady and the stock of extraction related assets remains steady in proportion to the available stock of the resource.

Resource life

5.218 At any point in time, the life of a resource is equal to the stock at that time divided by the average extraction rate. In the course of a year, the resource life will diminish by one year due to extractions and will change by the quantity of discoveries and reappraisals during the period divided by the average extraction rate. If, on balance, there are more downward reappraisals than upward reappraisals and discoveries, then the life is further reduced.

5.219 The quantity of the stock used to calculate the resource life must be consistent with the quantity to be valued. Since only Class A resources are to be valued, then the resource's life must be calculated based only on Class A resources and not on total known deposits for the resource (i.e. including also Class B and C resources).

Valuation of flows of mineral and energy resources

Value of discoveries, reappraisals, extractions, depletion and catastrophic losses

5.220 The value of additions and reductions in the stock should be calculated using the average prices of the resource over the period multiplied by the quantity discovered, reappraised, extracted, depleted or lost. This is consistent with the approach outlined in section 5.4 and explained in detail in Annex A5.1.

5.221 Of importance is the valuation of extractions which, as explained in Section 5.4, is comprised of a depletion component and an income component. While the distinction between income and depletion is not shown in the asset account, the estimation of both components is important for use in the generation and allocation of income accounts to adjust measures of operating surplus and rent for the cost of depletion.

Acquisitions and disposals of mineral and energy resources

5.222 These transactions are likely to be rare but when they occur they should be recorded. Estimates of the value of these transactions should take into account the costs of ownership transfer that should be recorded as the purchase of a produced asset – costs of ownership transfer on non-produced assets. On the balance sheet this produced asset is considered to be incorporated into the value of the underlying mineral and energy resource.

5.5.5 Other issues in the measurement of mineral and energy resources

Allocation of income from the extraction of mineral and energy resources

5.223 A general characteristic of mineral and energy resources is that the income earned from the extraction of the resources is shared between economic units. Most commonly, part of the income accrues to the extractor of the resources in the form of operating surplus and part of the income accrues to the government in the form of rent. The government earns this income, on behalf of the society, by allowing access to the resources.

5.224 Depending on the nature of the arrangements, often both the extractor and the government will have substantial assets in the form of expected future incomes from the extraction of the resources. Following the description in Section 5.4 the expected incomes (which are equal in total to the resource rent) can be separated into depletion and return to environmental assets components. Changes in the value of the assets for each unit will reflect declines due to depletion, while the return to environmental assets will be reflected in the generation and allocation of income accounts.

5.225 Within the SEEA, a specific objective is to show, within the general national accounts framework, how the incomes earned from the extraction of natural resources are impacted by the cost of depletion. In particular, the SEEA aims to define depletion adjusted estimates of operating surplus, value added and saving at both an economy wide level and for institutional sectors. Since there is only one amount of depletion for a given mineral and energy resource it must be allocated between the relevant units within the accounting framework.[50]

5.226 In the circumstances outlined, accounting for these incomes and the associated depletion is problematic in the standard national accounts framework for two main reasons. First, the incomes flows are recorded in different accounts with the value added and operating surplus of the extractor recorded in the production and generation of income accounts and the rent earned by the government recorded in the allocation of primary income account. Second, no cost of depletion is recorded against the income earned in the structure of the standard accounts (unlike for the cost of produced assets which is recorded as consumption of fixed capital). Instead, in the SNA depletion is recorded in the other changes in volume of assets account.

5.227 The following accounting treatment is recommended for the SEEA.

i. Record the total cost of depletion in the production and generation of income accounts of the extractor as deductions from value added and operating surplus. This ensures that the analysis of extractive activity and economy wide aggregates of operating surplus and value added fully account for the cost of depletion. Further, since the government has no operating surplus in regard to the extraction activity, not recording depletion in the production account of the government ensures that

[50] Note that in cases where a government owned unit undertakes extraction it should be treated as a non-financial corporation distinct from the general government who remains the legal owner.

estimates of government output (which are calculated based on input costs) are not increased due to depletion.

ii. Record the payment of rent from the extractor to the government in the allocation of primary income account. This entry is the standard national accounts entry.

iii. Record an entry for the allocation of depletion in the allocation of primary income accounts. This entry recognises (a) that the rent earned by the government includes the government's share of total depletion which must be deducted from the estimate of rent; and (b) that the saving of the extractor would be understated if the total amount of depletion were deducted in the derivation of their depletion adjusted saving. Implicitly, the payment of rent is being partitioned such that the flow to the government is, in net terms, equal to a depletion-adjusted rent.

5.228 These entries are shown in Table 5.5.5. Importantly, they ensure that the sum of the institutional sector entries for depletion adjusted aggregates is equal to the same aggregates calculated at the economy wide level.

5.229 The values of depletion shown for each unit should be consistent with the change in net worth of each unit in relation to the mineral and energy resources (assuming no other changes in the stock of resources such as discoveries). The relevant balance sheet entries may be made in different ways depending on the nature of the analysis and on the institutional arrangements within a country. In any presentation, the allocation of assets and the resulting estimates of institutional sector net worth should reflect the expected future income streams for each sector from the extraction of the resources.

Table 5.5.5: Entries to allocate the income and depletion of mineral and energy resources

	Government		**Extractor**	
Transaction	**Resources/ assets**	**Uses/ Liabil.**	**Resources/ assets**	**Uses/ Liabil.**
Production account				
Output – sales from extraction			1000	
Intermediate consumption				500
Gross Value Added			500	
Consumption of fixed capital			-150	
Net Value Added			350	
Depletion			-61	
Depletion adjusted Net Value Added			289	
Generation of income account				
Compensation of employees				200
Gross operating surplus			300	
Consumption of fixed capital			-150	
Net operating surplus			150	
Depletion			-61	
Depletion adjusted operating surplus			89	
Allocation of primary income account				
Rent	56			56
Allocation of depletion		34	34	
Depletion adjusted saving		22		67

5.230 This approach to the allocation of income and depletion from the extraction of mineral and energy resources can also be applied to other natural resources subject to depletion.

Treatment of energy from renewable sources

5.231 Energy from renewable sources (renewable energy) has been an important source of energy in many countries and increasingly is being seen as an alternative source of energy for those countries that have primarily used energy from non-renewable sources. Renewable energy can be produced in various ways, including but not limited to wind energy, hydropower energy (including run of river resources), solar energy, biomass including wood, and geothermal energy.

5.232 Setting aside energy sourced from the use of timber resources, other renewable energy sources cannot be exhausted in a manner akin to fossil energy resources and neither are they regenerated as is the case with biological resources. Thus in an accounting sense there is no physical stock of these other renewable energy resources that can be used up or sold.

5.233 Therefore, the measurement scope of SEEA in relation to these resources relates to the amount of energy that is produced given current levels of fixed assets and associated technology. Excluded from scope are potential amounts of energy that could be produced using available renewable energy sources if investment and technology were to increase in the future.

5.234 The presence of investments in renewable energy capture facilities and equipment impacts on the value of the land (including inland waters) associated with those facilities. For example, the land in a particularly windy area would be priced more highly than similar land in a non-windy area if investment was made to construct windmills to capture the energy from the wind resource. Thus, opportunities to earn resource rent based on resources like wind, solar radiation and geothermal energy are expected to be reflected in the price of land.

5.235 In situations where the only income generated from the relevant land is from the generation of renewable energy, the value of the area will, in theory, be equal to the net present value of the future income stream. However, it is also possible that other income is earned from the same area – for example agriculture may take place under wind farms and fishing may be undertaken in water used for generating hydropower. In these cases the valuation of the area must also take into account the income generated from other activities in the same area.

5.236 Nonetheless, where possible, the value of the land (including inland waters) should be partitioned to provide an estimate of the value of the land that is attributable to income arising from the generation of renewable energy.

5.237 These accounting treatments do not apply in the case of energy sourced from timber and other biomass resources. Unlike other renewable energy sources a stock of timber resources can be observed and measured. In concept the volume and value of timber resources (considered in detail in Section 5.8) encompasses all possible uses of the timber including its use as an energy source.

5.6 Asset accounts for land

5.6.1 Introduction

5.238 The consideration of land is central to economic and environmental accounting. Beyond an assessment of the ownership and use of land as part of economic production, some of the issues that can be considered in the context of land accounts include the impacts of urbanisation, the intensity of crop and animal production, afforestation and deforestation, the use of water resources and other direct and indirect uses of land.

5.239 While broad assessment of the changing shares of different land use and land cover within a country may provide useful indicators of change, increasingly the power of land accounts is reflected in the use of mapping technologies that can pin-point areas of change. The classifications and structures outlined in this section are designed to support work of this type.

5.240 Land also constitutes an important component in the assessment of national and institutional sector wealth. Land is bought and sold in combination with the physical characteristics (buildings, soil, trees) and the composite value will incorporate a value of the space itself (the location) as well as a value for the physical characteristics.

5.241 This section is structured to define the scope of land accounts and define two primary views of land for environmental accounting purposes - land use and land cover. Categories and classes for the organisation of data on land use and land cover are presented followed by a description of land accounts in physical terms. A particular focus is placed on physical land accounts for forest and other wooded land which complement the asset accounts for timber resources discussed in section 5.8. Land accounts in monetary terms are described next. The potential extension of land accounts towards ecosystem accounts building on the definitions of the land cover classes is discussed at the end of this section.

5.6.2 Definition and classification of land

5.242 Land is a unique environmental asset that delineates the space in which economic activities and environmental processes take place and within which environmental assets and economic assets are located.

5.243 While land is commonly meant to refer only to terrestrial areas, in the SEEA the term land may also apply to areas covered by water. Thus the SEEA land accounts encompass areas covered by inland water resources such as rivers and lakes and, in certain applications, the land accounts may be extended to include areas of coastal water and a country's EEZ. Together the areas of land, inland water and coastal water comprise the area of a country. The total country area should be defined as the area enclosed by all inland borders and, if applicable, the normal baselines (low-water mark) and straight baselines on the seaward side.[51]

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[51] The boundaries between the land and the sea vary considerably between countries depending on the different geographical features of a country. The conventions by which country area is determined, in

5.244 Land area is analysed in many different ways. Most often, statistical analysis will be conducted by compiling data for administratively defined regions within a country. From a more specifically economic view point there may be interest in knowing the area of land owned by different institutional sectors, such as areas of government land, and regarding data on land used by different industries.

5.245 From the perspective of environmental and economic accounting there are several other views which are of interest including topography (e.g. mountains, plains), elevation and land zoning (e.g. residential, industrial, conservation). The most important additional views in the SEEA are land use and land cover. Classifications for land use and land cover are described in this section. Particularly for statistics organised on land cover, traditional administrative boundaries become less relevant and more interest is in the relationship of the different features of the environment and the interaction between these features and the economy and society.

5.246 Countries will have considerably different patterns of land use and land cover types. For example, forest land may be of major or minor importance for a particular country and some land types, for example deserts, may not be present in all countries. Consequently, the categorizations reflected in the SEEA may require more details to be added for national purposes in order to highlight particular features and meet information requirements.

5.247 A particular feature of statistics on land use and land cover is the means by which data are collected. Broadly, two methods are used – field surveys and satellite images. Field surveys are important as they can provide a high level of specificity regarding the land cover and in particular the land use in a particular area. Satellite images are important as they enable a broader assessment of all areas in a country and, over time, more detailed resolutions of the images are permitting new forms of analysis. Increasingly, data based on combinations of field surveys and satellite images are being compiled. In the SEEA, the classifications and accounting structures are defined and described independently of the means by which relevant data are collected. However, in practice, the type of data and the level of detail that can be compiled may depend on the means by which data have been collected.

Land use classification

5.248 Estimates of area classified by type of land use may be of considerable interest in understanding issues of agricultural production, forestry management and the spread of built up areas. Additional benefit is gained through analysis of changes in land use over time.

5.249 ***Land use reflects both (i) the activities undertaken and (ii) the institutional arrangements put in place; for a given area for the purposes of economic production, or the maintenance and restoration of environmental functions.*** In effect, an area that is "used" implies the existence of some human intervention or management. Land in use therefore includes areas, for example protected areas, that are under the active

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particular the definition of baselines, focus on the boundary between land and sea and have been agreed internationally in the United Nations Convention on the Law of the Sea (UNCLOS).

management of institutional units of a country for the purpose of excluding human activity from that area.

5.250 Not all land in a country is used following the definition above. Some areas are “not in use” although they may have a use in supporting ecosystems and biodiversity. In order to provide a complete accounting for land use within a country both land in use and land not in use must be included.

5.251 The scope of land use accounts comprises areas of land and inland water. For some analytical purposes, and depending on the composition of a country’s economic territory, the measurement boundary for land use may be extended to include coastal waters and areas within a country’s EEZ.[52] Such a broader boundary is likely to be of relevance in the management of fishing rights, offshore mining and exploration, the protection of coral reefs and the understanding of other marine issues. Particularly where the area of a country’s coastal water and EEZ is a large part of its economic territory, the extension of the analysis of land use is appropriate.

5.252 The SEEA land use classification is shown in Table 5.6.1. At its highest level it is classified by the primary types of surfaces: land and inland water. The classification by type of surface reflects the primary use of the classification as a means of comparing alternative uses. Generally, the types of uses of inland water areas and land areas are quite distinct and these different areas are likely to be managed in different ways.

5.253 For land, the classification consists of seven main categories of land use: Agriculture, Forestry, Land used for Aquaculture, Use of built-up and related areas, Land used for maintenance and restoration of environmental functions, Other uses of land n.e.c., and Land not in use. For inland water there are four main categories: Inland water used for aquaculture or holding facilities; Inland water used for maintenance and restoration of environmental functions; other uses of inland water n.e.c.; and Inland water not in use. Various sub-categories and classes are listed in Annex A5.4, including a listing of classes relevant for extended analysis of coastal waters and the EEZ.

5.254 Within each type of area the classification comprises various categories of use. The categories are not defined on the basis of economic activity but rather on consideration of the general purpose and role of the user of the area. In many cases this will align with the scope of the economic activity but in some cases, particularly for forestry, the area considered to be in use may be larger than the area being used for economic production.

5.255 At the same time, for areas of forest not intended to be used for economic production (e.g. for strict nature reserves where there is no intention to harvest timber) then their primary use is more likely to be for maintenance and restoration of environmental functions or land not in use depending on the relevant designations associated with the area.

5.256 In some cases an area may support multiple uses at the same time or, over an accounting period the same area may be used for different uses at different times and there

[52] Following the UN Convention on the Law of the Sea a country’s EEZ may extend up to 200 nautical miles from the country’s normal baseline.

may be interest in recording all uses for particular areas. In general, however, the principle of primary or dominant use should be used to ensure that all of the area has been attributed.

5.257 There may be strong analytical interest in understanding the range of multiple uses and compilers should take this interest into account in developing accounts for land. In such cases it may be possible to define smaller areas that are used for particular purposes. For example, if trees are planted in defined areas on a farm to reduce water erosion or improve water quality (e.g. on river banks) then, rather than assigning the entire farm area to agriculture, the smaller area could be classified as an area used for the maintenance and restoration of environmental functions.

5.258 In some areas, particularly in areas covered by water, there may be no clearly defined use for a given area such that a primary or dominant use can be identified. For example, areas within harbours may be used to provide areas for recreation, passenger and freight transport and fishing. In order to be defined as an area in use there must be a significant degree of persistence in the use of the area. In general, areas of water will only be considered "used" where the area has been clearly zoned or delimited for a specific use.

Table 5.6.1 Land Use Classification

	Land	
		Agriculture
		Forestry
		Land used for aquaculture
		Use of built up and related areas
		Land used for maintenance and restoration of environmental functions
		Other uses of land n.e.c.
		Land not in use
	Inland waters	
		Inland waters used for aquaculture or holding facilities
		Inland waters used for maintenance and restoration of environmental functions
		Other uses of inland waters n.e.c.
		Inland waters not in use
		EEZ areas used for aquaculture or holding facilities
		EEZ areas used for maintenance and restoration of environmental functions n.e.c.
		Other uses of EEZ areas n.e.c.
		EEZ areas not in use

Land cover classes

5.259 Land cover refers to the observed physical and biological cover of the Earth's surface and includes natural vegetation and abiotic (non-living) surfaces. At its most basic level it is comprised of all of the individual features that cover the area within a country. For the purposes of land cover statistics the relevant country area includes only land and inland waters. The area of coastal waters is excluded.

5.260 The UN Food and Agriculture Organisation (FAO) has developed an international standard classification system, the Land Cover Classification System (LCCS 3)[53][54], that can be used to systematically record the biophysical characteristics of all areas of land within any territory.

5.261 Current land cover is a function of natural changes in the environment and of previous and current land use, particularly in agricultural and forestry areas. Although vegetation characteristics (such as natural or cultivated) influence the land cover within an area, they are not inherent features of the land cover. Thus, a clear and systematic description of classes of land cover allows the land cover classification to be compared to types of land use, while maintaining pure land cover criteria. The FAO LCCS provides a theoretical basis for this approach.

5.262 There are an enormous number of different land cover features that can be created with the LCCS approach. For the purposes of standardisation and harmonisation across statistical data sets a classification comprised of 14 classes is described, as presented in Table 5.6.2.

5.263 The 14 classes provide a comprehensive set of land cover types with clear boundaries based on definitions from the LCCS that are mutually exclusive and unambiguous. This set of land cover types can be used at all scales, independently from the method of observation, thus allowing cross referencing of local and regional maps with continental and global maps without loss of information.

5.264 The set of land cover types is complemented with a set of basic rules of classification to allow translation of national data sets. These rules are set out in Annex A5.4. The rules reflect the logical structure of the LCCS and determine, as the first step, the main object (the “basic object”) to be considered when undertaking a translation of data. The basic objects are simple and intuitive elements of land cover (such as trees, shrubs, buildings, etc) and the descriptions are supplemented by the inclusion information on the

[53] The LCCS provides a basis for any piece of land to be defined and classified with a rigorous syntax and clear classification criteria, starting from a set of basic objects identified purely through physiognomic criteria, i.e. on their overall appearance. When the land is vegetated, the basic objects described are the pants (divided into trees, shrubs and herbaceous vegetation). When the land has a non-vegetal cover, or no cover at all, the basic objects can be water, ice and snow, or the abiotic or artificial surface. This information in the LCCS can be supplemented with information on properties and characteristics of the basic objects. Properties are further physiognomic characterisations of basic objects such as height and cover. Characteristics are descriptive elements of the basic objects not directly related to its physiognomic aspects and distinguishing, for example, whether the area in intended for agricultural purposes or if it is natural.

[54] A higher level abstraction of the basic objects that compose land cover classes, as used in LCCS, called the “LCML” (for Land Cover Meta Language) has also been developed for use as a framework to classify land cover and compare systems internationally. This meta language allows the existing well established national and regional land cover systems to remain in place, while still allowing the data to be integrated into common world level data sets following a common land cover standard. LCML is currently undergoing the approval process to become an ISO standard as a framework to classify land cover and compare systems internationally.

"properties" (such as height, cover, etc) and "characteristics" (such as natural, cultivated, etc) of the basic objects.

Table 5.6.2 Land Cover Types

Code	Category
	Artificial surfaces (including urban and associated areas)
	Herbaceous crop
	Woody crops
	Multiple or layered crops
	Grassland
	Tree covered area
	Mangroves
	Shrub covered area
	Shrubs and/or herbaceous vegetation, aquatic or regularly flooded
	Sparsely natural vegetated areas
	Terrestrial barren land
	Permanent snow and glaciers
	Inland water bodies
	Coastal water bodies and inter-tidal areas

5.6.3 Physical asset accounts for land

5.265 The objective of land accounts in physical terms is to describe the area of land and changes in the area of land over an accounting period. A range of different physical land accounts can be envisaged – for example, accounts for land use, land cover or land ownership (by industry or institutional sector). The measurement units of land in physical terms are units of area such as hectares or square metres.

5.266 Generally the total area of land for a country will remain unchanged from one period to the next. Hence the changes between the opening and closing stock of land in physical terms will be primarily comprised of changes between different classes of land, for example classes relating to land ownership, land use or land cover.

5.267 However, there are situations where the area of land for a country may change. It may increase, for example due to reclamation of land through the construction of dykes and other barriers. It may also decrease, for example due to land subsidence or higher water levels.

5.268 As well, changes in the total area of land may occur due to political factors. For example, the total area may increase or decrease due to war and associated events and there are commonly areas of disputed territory. The area that is within scope of land cover and land use statistics should be clearly defined to avoid confusion.

Types of physical land accounts

5.269 In the first instance it is recommended that countries develop estimates of the total land area classified by land use and by land cover at the beginning and end of each accounting period.

5.270 With data structured in this way it is possible to construct tables showing land use by land cover and matrices showing the changes in land cover (or land use) over an accounting period. In assessing land cover and land use change it may be useful to determine the proportion of the opening stock of land whose cover or use has remained unchanged. To undertake this type of analysis the data must be based on spatially referenced data sources.

5.271 An additional step might be the construction of tables showing reasons for land cover change. For example, changes in land cover might be classified to show whether the change relates to urban growth and development of infrastructures (through conversion of agriculture and natural land), intensification and industrialisation of agriculture (through conversion of family farming and mosaic landscapes), extension of agriculture in general (through conversion of forest land), drainage of wetlands, deforestation (for timber production and or agriculture development), and desertification (at the expense of formerly vegetated areas).

5.6.4 Physical asset accounts for forest and other wooded land

Introduction

5.272 For particular land uses or types of land cover it is also possible to construct basic physical asset accounts as established for other resources. The most developed example of this is for forest and other wooded land. Often the compilation of physical asset accounts for forest and other wooded land is undertaken in conjunction with the compilation of asset accounts for timber resources as described in Section 5.8. However, in principle, accounts for forest and other wooded land are a type of land account.

5.273 A key distinction between the physical asset account for forest and other wooded land and the asset account for timber resources is that the scope of timber resources is not limited to timber from forest and other wooded land. Thus, for example, depending on their significance, orchards would fall within scope of timber resources but are not considered areas of forest and other wooded land.

5.274 Another key distinction is that the asset account for timber resources is focused on the volume of timber resources rather than the area of land covered by forests and other wooded land. Thus, the focus of the forest and other wooded land account is on changes in the area of land, for example, due to deforestation and afforestation, rather than on the quantity and value of timber removed from areas of forest and other wooded land.

5.275 Notwithstanding these clear distinctions in purpose and scope, there are strong connections between asset accounts for timber resources and asset accounts for forest and other wooded land. This is because the majority of timber resources are found in areas of forest and other wooded land. Consequently, there are links between the two sets of accounts that should be considered in their compilation.

Scope of the forest and other wooded land account

5.276 The scope of the forest and other wooded land account is defined consistently with the definition of in the FAO Forest Resource Assessment 2010.[55] Forest land is defined as land spanning more than 0.5 hectares with trees higher than 5 metres and a canopy cover of more than 10 percent, or trees able to reach these thresholds *in situ*. It does not include land that is predominantly under agricultural or urban land use.

5.277 Forest land is classified according to different types of forest. The primary distinction is between naturally regenerated forest and planted forest. Naturally regenerated forest is forest predominantly composed of trees established through natural regeneration. In this context, predominantly means that the trees established through natural regeneration are expected to constitute more than 50% of the growing stock at maturity.

5.278 Two broad types of naturally regenerated forest are distinguished:

i. Primary forest is naturally regenerated forest of native species, where there are no clearly visible indications of human activities and the ecological processes are not significantly disturbed. Key characteristics of primary forests are that (a) they show natural forest dynamics, such as natural tree species composition, occurrence of dead wood, natural age structure and natural regeneration processes; (b) the area is large enough to maintain its natural characteristics; and (c) there has been no known significant human intervention or the last significant human intervention was long enough ago to have allowed the natural species composition and processes to have become re-established.

ii. Other naturally regenerated forest is naturally regenerated forest with clearly visible indications of human activities. These include (a) selectively logged-over areas, areas regenerating following agricultural land use and areas recovering from human-induced fires, etc; (b) forests where it is not possible to distinguish whether they are planted or naturally regenerated; (c) forests with a mix of naturally regenerated trees and planted/seeded trees and where the naturally regenerated trees are expected to constitute more than 50% of the growing stock at stand maturity; (d) coppice from trees established through natural regeneration; and (e) naturally regenerated trees of introduced species.

5.279 Planted forests are predominantly composed of trees established through planting and/or deliberate seeding. Planted/seeded trees are expected to constitute more than 50% of the growing stock at maturity, including coppice from trees that were originally planted or seeded.

[55] The following definitions are sourced or adapted from the Global Forest Resources Assessment 2010: Specification of National Reporting Tables for FRA 2010. Forestry Department, Food and Agriculture Organization of the United Nations. Forest Resources Assessment Programme Working paper 135, Rome 2007

5.280 Other wooded land is land not classified as forest land, spanning more than 0.5 hectares; with trees higher than 5 metres and a canopy cover of 5-10 percent, or trees able to reach these thresholds in situ; or with a combined cover of shrubs, bushes and trees above 10 percent. It does not include land that is predominantly under agricultural or urban land use.

5.281 Where possible accounts should be compiled using these distinctions between types of forest and other wooded land. In addition, countries may be interested to compile accounts based on the total area of different species of tree.

5.282 A physical asset account for forests is presented in Table 5.6.6. It shows the opening and closing stock by area and changes in the area of forest and other wooded land. The area of forest and other wooded land should be measured inclusive of relevant access roads, rivers and streams.

Table 5.6.6 Physical asset account for forest and other wooded land (hectares)

		Type of forest and other wooded land				
		Primary forest	Other naturally regenerated forest	Planted forest	Other wooded land	**Total**
Opening stock of forest and other wooded land						
Additions to stock						
	Afforestation					
	Natural expansion					
	Total additions to stock					
Reductions in stock						
	Deforestation					
	Natural regression					
	Total reductions in stock					
Closing stock of forest and other wooded land						

Additions to and reductions in the stock

5.283 All changes in the area of forest and other wooded land are reclassifications either between different types of forest and other wooded land or where there are changes in the area of land between forest and other wooded land and other land types, such as agricultural land. Following are the definitions of the particular types of reclassification that apply in the case of forest and other wooded land.

5.284 Afforestation represents an increase in the stock of forest and other wooded land due to either the establishment of new forest on land that was previously not classified as forests or as a result of silvicultural measures such as planting and seeding. In particular, land previously classified as other wooded land may be converted to forest land as a result of silvicultural measures or natural restoration.

5.285 Natural expansion is an increase in area resulting from natural seeding, sprouting, suckering or layering.

5.286 Forest reforestation by natural or silvicultural measures after clear-cutting does not qualify as an increase in forest land. This land remains classified as forest land except when clear-cutting is preliminary to putting the land to an alternative use such as agriculture or construction.

5.287 Deforestation represents a decrease in the stock of forest and other wooded land due to the complete loss of tree cover and transfer of forest land to other uses (as agricultural land, land under buildings, roads etc.) or to no identifiable use. Removals of standing timber do not lead to decreases in forest and other wooded land if the use of the land does not change after felling.

5.288 Natural regression should be recorded when the stock of forest and other wooded land reduces for natural reasons.

5.289 Monetary asset accounts for forest and other wooded land are not separately described but are covered as part of the monetary asset accounts for land in the next part.

5.6.5 Monetary asset accounts for land

5.290 The monetary asset account for land follows the structure outlined in Table 5.6.7. Changes in the overall value of land will relate primarily to the revaluation of land since the total area of land will remain largely unchanged. However, since at a more detailed level there will be changes in the purposes for which land is used (often due to purchases and sales of land between economic units), there are likely to be notable changes in the value of different types of land due to transactions and reclassifications.

5.291 Table 5.6.7 shows the value of land by type of land use. It may also be of interest to estimate the total value of land by institutional sector of ownership. In this case, transactions and reclassifications between sectors are likely to be important accounting entries.

Table 5.6.7 Monetary asset account for land (monetary unit)

		Type of land use							Total
	Agriculture	Forestry	Land used for aquaculture	Use of built up and related areas	Land used for maintenance & restoration of environmental functions	Other uses of land n.e.c.	Land not in use	Inland water	
Additions to stock									
Acquisitions of land									
Reclassifications									
Total additions to stock									
Reductions in stock									
Disposals of land									
Reclassifications									
Total reductions in stock									
Revaluations									
Closing value of stock of land									

Valuation of land

5.292 Unlike most environmental assets there is, in most countries, an active market in the purchase and sale of land of all types, including residential, industrial and agricultural land. However, determining the value of the land itself is a complex task.

5.293 Generally, the market values of land encompass the value of the location, the value of the physical attributes of the land and the produced assets that may be located on the land (e.g. buildings). Separating these different components may be difficult. Further, although there is a market in land, relatively little land changes hands in any year and thus observed prices may not be representative. Therefore, a comprehensive set of prices to cover all land types in all locations is seldom if ever available. Finally, 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 areas.

Composite assets

5.294 Several common situations in which assets are bundled with land need to be described and relevant accounting treatments defined.

5.295 Soil resources. Although land and soil are distinguished as separate environmental assets, in terms of valuation, land and soil are always considered jointly. Thus the value of all land, especially agricultural land, implicitly includes the value of any associated soil.

5.296 Buildings and structures. The opening and closing values of the stock of land should be recorded excluding the value of buildings and structures on the land.

5.297 For land underlying buildings, the market will, in some instances, furnish data directly on the value of the land. More typically however, such data are not available and a more usual method is to calculate ratios of the value of the site to the value of the structure (often using administrative data) and to deduce the value of the land from the replacement cost of the buildings or from the value on the market of the combined land and buildings. Another approach is to use estimates of the depreciated value of the stock of dwellings and other buildings and structures that is often compiled for the purposes of the core national accounts and deduct this amount from the value of the composite asset.

5.298 When the value of the land cannot be separated from the building or structure on it, the composite asset should be classified to the asset category representing the greater part of its value.

5.299 Land improvements. In addition to buildings and structures, there may be improvements to land due to activities such as land clearance, land contouring or the creation of wells and watering holes for agriculture that are integral to the land in question. These activities, collectively referred to as “land improvements” are characterised by the outcome that they lead to major improvements in the productivity of a given area of land, potentially through the prevention of a deterioration in the quality of land. In principle, the value of land improvements should be recorded as a separate produced asset distinct from the value of the land as it existed before improvement.

5.300 If the value of the land improvements cannot be separated from the value of land in its natural state, the value of the land may be allocated to one category or the other depending on which is assumed to represent the greater part of the value. (For details regarding the full accounting treatment for land improvements refer to the 2008 SNA.)

5.301 Biological resources. As with the treatment of buildings and structures the value of these environmental assets should, in principle, be separated from the land on which they are grown. For land under forests, the separation should be based on the value of the stock of timber resources (for details see section 5.8) For cultivated biological resources other than timber resources, the range of techniques for making this distinction outlined for buildings and structures are also relevant for these assets.

5.302 Land under roads and public land. In principle the land under roads, railways and other transportation routes should be valued in the same way as for other land. However, given the shared characteristics of these assets, determining appropriate valuations may be difficult.

5.303 It is recommended that the valuations adopted for the purposes of government finance statistics be used to value land under roads and public land more generally. The value of the roads and rail lines, etc should be determined separately, possibly on the basis of construction costs as required for the purposes of capital stock estimation in the national accounts.

5.304 Renewable energy sources. As described in Section 5.5, for some land and inland water the value may be influenced by the income generated from the generation of renewable energy. Examples include the value of land on which wind farms are based and the value of areas used for hydropower generation. The value arises due the scarcity of the sites used for energy generation. Where possible, the value of the land (including inland waters) should be partitioned to provide an estimate of the value of the land that is attributable to income arising from the generation of renewable energy.

Changes in value due to changes in the quality of land

5.305 Changes in the value of land may be due to many factors including changes in the quality of land. At times there may be catastrophic losses in land quality for example as a result of contamination by radioactive waste or major flooding. Changes in the quality of land that lead to changes in the value of the land should not be recorded as revaluations even though the area of land does not change. Rather, the changes in value should be recorded as reclassifications (where the land use changes), reappraisals (where the land use remains the same) or catastrophic losses as most appropriate.

5.306 It is also noted that changes in the quality of land implicitly reflect the capacity for a given area of land to provide ecosystem services and the associated values of land will take this capacity into account.

Accounting for transactions in land

5.307 Generally, all transactions in land are between resident economic units. In situations in which a non-resident purchases land, the accounting convention is to establish a notional resident unit that purchases the land and the non-resident is shown as having the full financial ownership of the notional unit. There are at times exceptions to this treatment such as when governments may purchase land from other countries. These should be recorded as acquisition and disposals between countries.

The treatment of costs of ownership transfer

5.308 Whenever land is sold, there are transaction costs involved, arising, typically, from the involvement of the lawyers registering the change of ownership of the land and of 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 the purchase of a fixed asset and they are written off over time by means of consumption of fixed capital.

5.309 In general, because they are treated as a separate asset the costs of ownership transfer on land are not included in the valuation of land in the asset account. However, some refinements on this general position need to be clarified. Where the transaction involves only land and land improvements (for example where the sale of buildings, forests, is not involved), the cost of ownership transfer are allocated to the produced asset land improvements. Where the transaction involves land and other fixed assets (such as buildings or cultivated biological resources) the costs are allocated to the specific fixed asset involved. In both of these situations the costs are also recorded against the opening and closing stock values for the relevant produced asset.

5.310 It is also noted that where the costs of ownership transfer relate to a non-produced asset other than land (such as when related to the sale of mineral and energy resources or natural timber resources) the costs are capitalised against the item "costs of ownership transfer on non-produced assets" but they are recorded on the balance sheet against the non-produced asset in question.

5.6.6 Links to ecosystem accounting

5.311 Ecosystem accounts are founded on consideration of the capacity of the environment to deliver ecosystem services as described in Chapter 2. Importantly, it is the interactions between different environmental assets within a given area that generates ecosystem services.

5.312 To the extent that meaningful groupings of land cover areas can be defined, these areas of land are effectively statistical units in the context of ecosystem accounts in the same way as establishments are statistical units in economic accounts. SEEA Experimental Ecosystem Accounts develops these ideas in detail to provide a framework for assessing the capacity of ecosystems to deliver ecosystem services.

5.7 Accounting for soil resources

5.7.1 Introduction

5.313 Soil resources are a fundamental part of the environment. They provide the physical base to support the production and cycling of biological resources, are the source of nutrients and water for agriculture and forestry systems, provide a habitat for diverse organisms, and fulfil a complex buffering role against environmental variability (ranging from dampening diurnal and seasonal change in temperature and water supply to the storage and binding of a range of chemical and biological agents).

5.314 Accounting for soil resources therefore has many dimensions. At one level, accounting for soil resources can provide information on the area and volume of soil resources lost due to soil erosion, or made unavailable by changes in land cover (e.g. soil covered by buildings or roads) and other causes (e.g. changes in soil structure due to compaction, acidity or salinity). More broadly, accounting for soil resources in terms of their types, nutrient content, carbon content and other characteristics is relevant for more detailed examination of the health of soil systems, and the connections between soil resources and production in agriculture and forestry.

5.315 The focus of asset accounting for soil resources in the SEEA is on the top layers (horizons) of soil that form a biological system. Thus, quantities of soil that are extracted for construction, land reclamation, engineering and similar purposes are not considered, except to the extent that such extraction reduces the area and volume of soil resources available to operate as a biological system. Quantities of soil extracted for landscaping and similar purposes where the soil continues to operate as a biological system are considered within the accounting framework.

5.316 Research into the quantity and quality of soil has been a longstanding undertaking in many countries. At an international level, there has been substantial effort to create harmonised systems for recording information on different soils and more recently there has been work to more completely record information on soils in all countries in recognition of the fundamental role that soil resources play in environmental and economic systems.[56]

5.317 At the same time, there have been few pieces of research that relate the changes in the physical volume and characteristics of soil to measures of economic activity using accounting frameworks like the SEEA. Work is advancing from a scientific perspective on considering changes in soil resources from a natural capital perspective[57] but until now this work has not been translated into the SEEA framework.

[56] See, for example, the *Harmonised World Soil Database* developed jointly by the Food and Agriculture Organisation of the UN, the International Institute for Applied Systems Analysis, ISRIC – World Soil Information, the Institute of Soil Science – Chinese Academy of Sciences and the Joint Research Centre of the European Commission - and, at finer scale, the GlobalSoilMap initiative overseen by a consortium of major soil information institutions (www.globalsoilmap.net)

[57] For material examining this issue from a soil science perspective see, for example, Dominati et al, 2010, "A framework for classifying and quantifying the natural capital and ecosystem services of soils", Ecological Economics, Vol 69.

5.318 Some aspects of accounting for soil resources fit easily into the broader asset accounting framework that is described in the Central Framework. Also, some of the physical flows associated with soil resources, for example, flows of nutrients, are within the framework of physical flows described in Chapter 3. More broadly, accounting for soil resources as a system providing multiple benefits is a part of the broader subject of ecosystem accounting and is described in SEEA Experimental Ecosystem Accounts.

5.319 This section presents a brief characterisation of soil resources and the associated information on soil. It then describes how the volume and area of soil resources can be accounted for within the asset accounts of the Central Framework. The final part of the section introduces the aspects of soil measurement that can be taken into consideration in other parts of the SEEA, including aspects such as nutrient balances and measuring soil resources as a system.

5.7.2 Characterisation of soil resources

5.320 Different types of soil are defined in reference to their components and properties. Soil components reflect the biogeochemical composition of the soil, the minerals, liquids, gases and organic matter that are present in the soil. Soil properties reflect the physical, chemical and biological characteristics of the soil – e.g. porosity, texture, pH level, microbial biomass.

5.321 Various soil types can be defined using information on different combinations of soil components and properties. It is these various soil types (groupings) that can provide the basis for a generalised accounting for soil resources not because soil types change, but because soils have different baselines and potentials. Soil types are necessary categories to understand the importance of measured change and the potential for improvement. The Harmonised World Soil Database describes 28 major soil groupings that can be used to categorise and map soils at a broad global scale. Various national and regional groupings of soil types may be appropriate for national and sub-national measurement.

5.322 Soil resources are measured through a series of inventory processes – known collectively as a soil survey. Typically, a soil survey produces maps of soil types, soil suitability for various purposes, hazard and degradation potential and, in some cases, maps of specific soil properties. Other important and complementary activities for soil resource accounting include site or area based measures of soil loss or erosion processes, and simulation modelling of the way in which soil types relate to various climate and land use settings.

5.323 Measures of soil quality or soil value can also be developed using a range of approaches. In most cases, the soil suitability for specific purposes is assessed through a standardised indexing procedure. Most countries and regions have similar procedures optimised for their approach to soil mapping and soil classification. Soils are generally ranked in terms of their productive capacity (e.g. for agriculture) and/or their tendency for degradation. Simulation models can then be used to extrapolate from well-studied sites across the landscape to produce quantitative measures of yield, runoff and soil erosion.

5.324 The availability of this suite of measurements varies between and within countries. Overall, while most soil information has not been placed into an accounting framework, there is a strong potential for aggregate accounting frameworks to be populated using the data available.

5.7.3 Accounting for the area and volume of soil resources

5.325 A first stage of accounting for soil resources is to measure the area of different soil types within a country. This type of accounting is an extension of the land accounts described in Section 5.6. An example of how an asset account for the area of soil resources can be structured in presented in Table 5.7.1. It shows the opening and closing stock of soil resources by type of soil and the additions and reductions in area of soil resources. In order to focus on soil resources that are available as a biological system the scope of this account should be restricted to land used for agriculture and forestry and also volumes of soil extracted to be used as a biological system. In certain circumstances there may be a focus on particular landscapes or land use systems that are under pressure.

5.326 In terms of accounting entries, the focus is on the area of different soil types at the beginning and end of an accounting period and on changes in the availability of different soil types. A distinction is made between changes in land cover (e.g. loss of soil resources for agriculture due to urban expansion – also known as soil alienation); and those due to changes in soil function (e.g. compaction or acidification) and the soil environment (e.g. due to desertification or land clearing). In practice distinguishing between these different types of changes may be difficult and the structure of the account should be based on highlighting the primary reasons and the changes of most environmental, economic or social interest.

Table 5.7.1 Physical asset account for area of soil resources (hectares)

		Type of soil resource				Total area
Opening stock of soil resources						
Additions to stock						
	Due to changes in land cover					
	Due to changes in soil function					
	Due to changes in soil environment					
	Total additions to stock					
Reductions in stock						
	Due to changes in land use					
	Due to changes in soil function					
	Due to changes in soil environment					
	Total reductions in stock					
Closing stock of soil resources						

5.327 In addition to an asset account such as in Table 5.7.1, there may be interest in tabulating types of soil resources by type of land use or land cover at a particular point time. Such information may help in analysis of whether various types of land use are being undertaken on high quality or marginal soil and hence provide a basis for assessment of alternative land uses. Considerable analytical benefits would also be gained through mapping information on soil types, land use and land cover using data that are spatially referenced.

5.328 A second stage in accounting for soil resources is to measure the volume of soil resources. Accounting for changing volumes of soil may enable assessment of the extent of erosion and the impact of major disasters such as flooding or drought, as well as providing information relevant to the assessment of soil depletion, i.e. the loss of soil resources due to economic activity.

5.329 An asset account for the volume of soil resources is shown in Table 5.7.2. It is structured to show the opening and closing volumes of soil and the changes in the volume of soil. Increases in the volume of soil by natural processes (soil formation) are assumed to be very slow and in this sense soil may be considered a non-renewable resource. However, the movement of soil through natural means (e.g. wind and water) may mean that soil lost from one area of a country may be deposited in another area or in another country, or in the sea and ocean. The deposition is often deleterious (e.g. covering infrastructure or polluting coral reefs) but there are situations where a region benefits from sediment movement. Where benefits from soil deposition can be established the flow should be considered part of the additions to stock while at the same time soil erosion is considered a reduction in stock.

5.330 The soil resources in Table 5.7.2 are classified by type of soil but it may also be meaningful to structure the changes in the volume of soil resources by geographic region or by type of land use or land cover. It is likely that different regions and land uses will have different impacts on and be differently impacted by soil erosion and soil deposition.

5.331 Changes in the volume of soil resources should also be recorded when soil are excavated and moved for various reasons. For example, soil may be excavated to build levies and dykes, for land reclamation, for road and other construction. Since the intent of the soil resources account is to recorded changes in the volume of soil resources that can operate as a biological system, the loss of the top layers of soil resource due to this extraction should be recorded as permanent reductions in soil resources unless the purpose is to create new biological soil systems in other locations. Losses in the accessibility of soil resources due to changing land cover (e.g. due to urban expansion or permanent flooding as is the case in the creation of artificial reservoirs) should be recorded as extractions.

Table 5.7.2 Physical asset account for volume of soil resources (cubic metres)

		Type of soil resource				
Opening stock of soil resources						
Additions to stock						
	Soil formation and deposition					
	Upwards reappraisals					
	Reclassifications					
	Total additions to stock					
Reductions in stock						
	Extractions					
	Soil erosion					
	Catastrophic losses					
	Downwards reappraisals					
	Reclassifications					
	Total reductions in stock					
Closing stock of soil resources						

5.332 Catastrophic losses of soil resources may take place in cases of major floods and other severe weather events. This may also lead to soil deposition depending on the quality of soil transferred. Reappraisals of soil volume should be recorded when additional information is available as for reappraisals of other environmental assets.

5.7.4 Other aspects in accounting for soil resources

5.333 In addition to the physical asset accounts proposed in this section, soil resources are accounted for in the physical supply and use tables (PSUT) described in Chapter 3. There are two main aspects to the PSUT entries for soil resources. First, the movement of soil resources for construction, land reclamation, landscaping and other such uses in the economy should be recorded as a natural resource input of soil resources from the environment to the economy. These entries should also record soil moved as part of dredging operations in rivers and ports and movements of contaminated soil for treatment or disposal.

5.334 Second, the flows of individual elements in the soil, such as soil carbon and soil nutrients (Nitrogen (N), Phosphorous (P) and Potassium (K)), can be recorded as part of material flow accounting. An introduction to net nutrient balances in the context of the SEEA is described in Section 3.6.

5.335 The recording of nutrient balances starts to consider issues related to the overall functioning of soil resources as a biological system and further, to the issue of valuing soil resources and associated measures of soil depletion and soil degradation. However, the accounting framework presented in the Central Framework does not fully describe the overall state or condition of soil resources, changes in the health of soil resources, or their capacity to continue to provide the benefits that soil resources generate.

5.336 In the Central Framework the value of soil resources is tied directly to the value of land as described in Section 5.6. In this context connections may be made between changes in the combined value of land and soil and changes in the associated income earned from use of the soil resources.

5.8 Asset accounts for timber resources

5.8.1 Introduction

5.337 Timber resources are important environmental assets in many countries. They provide inputs for construction and the production of paper and other products, they are a source of fuel and they are an important sink for carbon.

5.338 The compilation of timber resource asset accounts is one measurement tool in providing information to assess and manage changes in timber resources and the services they provide. For a complete assessment of timber resources it is also relevant to construct asset accounts regarding the stock of land associated with timber resources, primarily forest and other wooded land. The changes in the stock of forest and other wooded land due to afforestation and deforestation may be of particular interest. These asset accounts are described in Section 5.6: Asset accounts for land.

5.339 This section is structured to provide details on the definitions of timber resources and associated classification and boundary issues including the relationship between timber resources and forest and other wooded land. An important aspect is the delineation between cultivated and natural timber resources. The section then presents a physical asset account and a monetary asset account for timber resources. The final part of this section outlines a physical asset account for carbon in timber resources. This is a simple extension of the physical asset accounting for timber resources.

5.8.2 Scope and definition of timber resources

5.340 Timber resources may be found in a wide variety of places and may or may not be available to be felled and used as wood supply - i.e. to produce timber products or as fuelwood. Where timber resources are not available for wood supply this may be due to the trees being in areas in which logging operations are restricted or prohibited, the trees being in areas that are inaccessible or remote and hence logging is not economically viable or, from a biological perspective, the trees may not be commercially useful species.

5.341 While the timber resources that are not available for wood supply do not have an economic value, these timber resources remain in scope of timber resources in the SEEA in physical terms, as they fulfil the definition of environmental assets and may provide benefits. However, since these timber resources do not have an economic value, they are not recorded in the asset accounts for timber resources in monetary terms. Consequently, the volume of these timber resources in physical terms should be clearly identified such that appropriate alignment can occur between asset accounts in physical and monetary terms.

5.342 Most commonly timber resources are found in areas of forest land or other wooded land and the area of forest and other wooded land may often provide a good starting point for the compilation of data on timber resources. The areas that are classified as forest land and other wooded land for the purposes of measuring timber resources should be defined consistently with those same areas in the physical asset accounts for forest and other wooded land described in Section 5.6.4.

5.343 Timber resources are also found in other areas such as in orchards, rubber plantations, along roadsides and train tracks, and in city parks. Conceptually, the timber resources in all of these areas are also within the measurement scope of the SEEA. In practice, countries should determine the scope of their timber resource accounts depending on the relative importance of the types of areas that provide timber resources.

5.344 Within the relevant areas, ***timber resources are defined by the volume of trees, living or dead, and include all trees regardless of diameter, tops of stems, large branches and dead trees lying on the ground that can still be used for timber or fuel.*** The volume should be measured as the stem volume over bark at a minimum breast height from the ground level or stump height up to a top. Excluded are smaller branches, twigs, foliage, flowers, seeds and roots. [58]

5.345 The thresholds for minimum breast height, tops of stem and branches may vary across countries. This variation reflects the variety of species, growing conditions and forestry management and harvesting practices that take place in different parts of the world. For example, the precise specification of the volume of a tree will vary between a conifer in northern Europe and a teak tree in a tropical rainforest. The general principle that should be considered in determining the volume of timber resources is the volume that is commercially usable. All estimates of timber resources, including estimates of the monetary value of timber resources need to take into account country specific conditions and practices.

5.346 The volume of timber resources is often referred to as the volume of standing timber. This definition includes trees on the ground either because they have been felled, but not yet removed from the area, or because they have fallen through natural causes (e.g. disease or lightning strike) but are still useful for timber products or fuel. The volume of standing timber also includes dead trees that remaining standing. The volume of standing timber should be distinguished from the growing stock which relates to living trees and forms the basis for the calculation of the natural growth in timber resources over a period.

The boundary between cultivated and natural timber resources

5.347 The determination as to whether timber resources are cultivated or natural is important in the application of the appropriate accounting treatment. The growth in cultivated timber resources is considered to be a process under the direct control, responsibility and management of institutional units. Consequently, the growth is recorded as occurring within the production boundary on an ongoing basis as an increase in inventories of those establishments undertaking the cultivation. (The removal of cultivated timber resources is recorded as a decrease in inventories of timber resources and an equivalent amount of

[58] See Global Forest Resources Assessment 2010: Specification of National Reporting Tables for FRA 2010. Forestry Department, Food and Agriculture Organization of the United Nations. Forest Resources Assessment Programme Working paper 135, Rome 2007

sales.) The growth of natural timber resources, on the other hand, is not considered to take place within the production boundary and is recorded as entering the production boundary only at the time the tree is removed from the forest or other land area.

5.348 The treatment of timber resources as either cultivated or natural depends on the management practices applied to the areas in which timber resources are found. The key consideration is that the processes involved in cultivation must constitute a process of economic production. This is likely to include activities such as (a) control of regeneration, for example, seeding, planting of saplings, thinning of young stands; and (b) regular and frequent supervision of trees to remove weeds or parasites, or to attend to disease. The level of these types of activity should be significant relative to the value of the timber resources and should be directly connected with the growth of the timber resources in question.

5.349 In practice, a common starting point for the determination of whether timber resources are cultivated or natural is the type of land on which the timber resources are found. For example, for forest land, those timber resources within primary forests would generally be considered natural timber resources, whereas those timber resources in plantations are generally considered cultivated timber resources.

5.350 However, the rules by which different areas of forest land are differentiated may not align neatly to the production boundary of the SEEA or SNA. For example, when applying the definitions of different forest land as presented in Section 5.6.4, primary forest, as soon as it is logged for the first time, becomes other naturally regenerated forest and hence falls into a category of forest land that is likely to be a mixture of forest land that is under active management and control, and land in which human intervention is relatively infrequent. Also, in some countries there are large areas of planted forests that are not managed directly or frequently and the trees are left to grow until ready to harvest. These trees would be considered natural timber resources following the SEEA production boundary even though the term “planted forests” may immediately suggest a high level of economic activity.

5.351 Given the potential for forestry management practices to vary considerably across countries, it is recommended that countries determine the status of their timber resources as being either natural or cultivated based on application of the production boundary considerations listed above. This process is likely to require assessment by type of area in which timber resources are found, including forest land, other wooded land and other land with wood supply.

5.8.3 Physical asset accounts for timber resources

5.352 The physical asset account for timber resources records the volume of timber resources at the beginning and end of an accounting period and the change in this stock over the accounting period. Of particular interest is the analysis of the rate of natural growth of timber resources compared to the rate of removals.

5.353 A basic structure for a physical asset account for timber resources is presented in Table 5.8.2. The asset account should distinguish between the type of timber resource, most importantly between cultivated timber resources and natural timber resources. For natural timber resources a distinction should be made between those timber resources available for wood supply and those not available for wood supply to ensure that the different scope of the asset accounts in physical and monetary terms can be reconciled. Depending on the purpose of analysis and available data, accounts by species of tree may be compiled.

5.354 The focus of the asset accounts presented in the SEEA is on the timber resources found in areas of forest and other wooded land. There may be interest however, in developing estimates of the volume of timber resources in other areas depending on country circumstance.

Table 5.8.2 Physical asset account for timber resources (cubic metres over bark)

	Type of timber resource		
	Cultivated timber resources	Natural timber resources	
		Available for wood supply	Not available for wood supply
Opening stock of timber resources			
Additions to stock			
Natural growth			
Reclassifications			
Total additions to stock			
Reductions in stock			
Removals			
Natural losses			
Catastrophic losses			
Reclassification			
Total reductions in stock			
Closing stock of timber resources			
Supplementary information			
Fellings			
Felling residues			

Additions to the stock

5.355 The stock of timber resources will increase due to natural growth. This is measured in terms of the gross annual increment i.e. the volume of increment over the reference period of all trees with no minimum diameter.

5.356 The calculation of natural growth should be based on the timber resources available at the beginning of the accounting period. Increases in the area of forest land, other wooded land and other areas of land that lead to increases in the volume of available timber resources should not be considered as natural growth but instead should be recorded as reclassifications. Reclassifications may also occur due to changes in management practice that shifts timber resources from cultivated to natural or vice versa.

Reductions in the stock

5.357 The stock of standing timber will decrease over an accounting period through the removal of timber resources and natural losses. Removals are estimated as the volume of timber resources removed from forest land, other wooded land and other land areas during the accounting period. They include removals of trees felled in earlier periods and the removal of trees killed or damaged by natural causes. Removals may be recorded by type of product – e.g. industrial roundwood and fuelwood or by species of tree – eg coniferous, broadleaved.

5.358 Removals is the relevant variable for measuring the extraction of timber resources because the definition of the stock of timber resources includes trees that have been felled and are on the ground but not yet removed.

5.359 Natural losses are the losses to the growing stock (i.e. living, standing trees) during an accounting period due to mortality from causes other than felling. Examples include losses due to natural mortality, insect attack, fire, wind throw or other physical damages.

5.360 Natural losses should only include those losses that would reasonably be expected when considering the timber resources as a whole. Exceptional and significant losses due to natural causes should be accounted for as catastrophic losses.

5.361 The volume of natural losses and catastrophic losses should only be recorded against these categories when there is no possibility that the timber resource can be removed.

Depletion

5.362 Following the general definition of depletion, the depletion of natural timber resources is related to the sustainable yield of timber resources from the forest land, other wooded land and other land on which natural timber resources are found. More precisely, the sustainable yield of timber resources is the quantity of timber that can be harvested at the same rate into the future while ensuring that the productive potential is maintained. The sustainable yield will be a function of the structure of the growing stock and needs to take into account both the expected natural growth and the natural losses of trees. Various biological and forestry models will need to be taken into account in estimating sustainable yield.

5.363 Depletion of natural timber resources, in physical terms, is equal to extractions less sustainable yield. As explained in Section 5.4, some variation from year to year is to be expected in the relationship between estimates of sustainable yield and actual quantities of natural growth (less natural losses). Hence, depletion should only be recorded when extractions are beyond normal year on year variations in quantities of natural growth.

Fellings and felling residues

5.364 While these entries fully account for the change in the volume of timber resources over an accounting period there may be specific interest in the volume of trees felled during the period relative to the volume of timber resources removed. Annual fellings are equal to the volume of standing timber that is felled during an accounting period. Fellings include silvicultural and pre-commercial thinnings and cleanings.

5.365 In addition there may be interest in the volume of fellings that are not removed, i.e. felling residues. These residues arise because, at the time of felling, a certain volume of standing timber is rotten, damaged or excess in terms of the size requirements. Felling residues exclude small branches and other parts of the tree that are also excluded from the scope of standing timber. Estimates of felling residues may provide important information on the nature of forestry practice and for the compilation of carbon accounts (see Section 5.8.5).

5.366 Where available estimates of the volume of fellings and felling residues may be added as supplementary information in the physical asset account.

Timber resources as a renewable energy source

5.367 A broader discussion on renewable energy sources is presented in Section 5.5. It is noted that unlike other renewable energy sources, a stock of timber resources can be observed and measured. Thus, in concept the volume and value of timber resources will encompass all possible uses of the timber including its use as an energy source.

5.8.4 Monetary asset accounts for timber resources

5.368 Monetary asset accounts for timber resources consist of measuring the value of the opening and closing stock of timber resources and the changes in the value of the stock over an accounting period. The monetary asset account for timber resources is presented in Table 5.8.3.

5.369 Most of the changes in the stock relate directly to changes recorded in the physical asset account but there are also entries relating to the revaluation of timber resources which are recorded when the prices for timber change during an accounting period.

5.370 It may be that because of forest legislation and/or environmental and economic reasons not all timber resources are available for harvest. It is recommended that the volume of timber resources that cannot be harvested be separately identified and should not form a part of the overall calculations of the value of timber resources.

5.371 Estimates are made for the value of natural growth and the value of removals. For cultivated timber resources the natural growth is considered an increase in inventories and the removal of trees is treated as a decrease in inventories. Following the SNA only the change in inventories would normally be recorded but the entries are recorded on a gross basis in the SEEA.

5.372 For natural timber resources the natural growth is not considered an increase in inventories since the growth in the trees is not considered as part of a production process. The removal of the timber resources represents the point at which the timber resources enter the economy and output is recorded at that point.

Table 5.8.3 Monetary asset account for timber resources (monetary unit)

		Type of timber resource		
		Cultivated timber resources	Natural timber resources	Total
Opening stock of timber resources				
Additions to stock				
	Natural growth			
	Reclassification			
	Total additions to stock			
Reductions in stock				
	Removals			
	Natural losses			
	Catastrophic losses			
	Reclassification			
	Total reductions in stock			
Revaluations				
Closing stock of timber resources				

Valuing the stock of timber resources

5.373 In line with the general definition of resource rent (see Section 5.4), resource rent on timber resources is derived as the gross operating surplus from the harvest of timber resources less the value of the user cost of produced assets used in the harvesting process.

5.374 Defined in this way the resource rent will implicitly includes a share that should be attributed to the land on which the timber stands. This reflects the composite nature of the overall asset as discussed in section 5.6. In many cases due to the location of the land and the quality of the soil, the return to the land may not be large compared to the return to the timber resource but where relevant (for example, where the land may be potentially of value for other purposes) an estimate of the resource rent attributable to land should be deducted to derive the estimate of resource rent for timber resources.

5.375 Estimates of resource rent may be also be estimated more directly by using estimates of the stumpage price which is the amount paid per cubic metre of timber by the harvester to the owner of the forest. The stumpage price itself, may also be derived by deducting various harvesting costs from roadside pickup prices (also called wood-in-the-rough or raw wood prices). The costs should include costs of thinning (net of any receipts), other management costs and rent on land. For natural timber resources, these additional costs may be very low or even zero. Where timber resources are sold prior to felling, relevant contract prices may also be used, if available, with appropriate adjustments for the scope and coverage of the prices to align with the concept of resource rent.

5.376 Stumpage prices can then be multiplied by estimates of the volume of standing timber per hectare at the expected harvesting age to give estimates of future receipts. These receipts are then discounted to estimate a value per hectare for each age class and, in turn, 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. This approach should ensure that trees harvested after reaching maturity are separately accounted for.

5.377 A slightly simplified approach is to consider the current age structure and assume that each tree of a particular age grows to maturity and is harvested at maturity. Then the application of age specific prices generates an income flow for each age of tree that can be discounted back to the current period.

5.378 The primary difficulty in applying these NPV approaches is the extent to which information is available on the age structure of the trees and how these trees will mature into the future. Where the necessary detail is available these NPV approaches should be used taking into account modelling of future timber resources.

5.379 If detailed information on the future age structure is not available two methods are commonly applied. The stumpage value method requires information on an average stumpage price across all maturities of felling and an estimate of the current volume of timber. The consumption value method, requires information on the current age structure of the timber resources and stumpage prices for different maturities of standing timber.

5.380 While these two methods are variants of the basic NPV approaches, the assumptions underpinning them may be restrictive particularly in the case of a changing age structure of timber resources due to either overexploitation or active afforestation.

5.381 Other sources for the price of timber resources may also be available for comparison. For young forests, there may be good valuations for insurance purposes since at a young age there is a higher likelihood that forests are destroyed. Also, in some countries there are well developed markets in the acquisition and disposal of forests. In these situations pricing models have been established to provide appropriate valuations taking into account the location, type and age structure of the trees, etc. Care should be taken in using these pricing models for the purpose of valuing timber resources as the value of the forest may include estimates of the value of alternative land uses rather than only the future income stream from the timber resources.

Valuation of depletion, natural growth, removals and other flows

5.382 In general terms, the valuation of flows of timber resources should be undertaken using the same assumptions underlying the valuation of the opening and closing stock of timber resources. The relevant approaches are described in detail in Annex A5.1.

5.383 The value of removals is always given by the stumpage value of the timber removed from the forest. When the stumpage prices are not available, harvesting costs must be deducted from the value of the wood in the rough.

5.384 With respect to catastrophic losses, for example due to wind throw or forest fire, when a catastrophic event does not fully destroy the wood, it is necessary to take into account the value of the wood that will be salvaged. The stumpage value of the salvaged timber has to be accounted for in the value of the stock for the period until its removal from the forest, which, in some cases, may take a number of years.

5.385 It is noted that there may also be revaluation effects following large catastrophic events. Prices may rise following a destruction of timber resources due to fire or may fall if trees are killed but not destroyed in storms. The price changes will reflect the changes in the pattern of timber available to be supplied.

5.386 Other changes that affect the value of stocks of standing timber as a resource for the logging industry are changes in use or status, occurring, for example, when forests are protected and logging is prohibited. In this case, the value of the standing timber, in terms of income from the sale of timber resources, is reduced to zero.

5.8.5 Carbon accounts for timber resources

5.387 The assessment of carbon binding is an increasingly important consideration. Estimates of the amount of carbon bound in timber resources and the changes in these amounts over an accounting period can be derived from information on opening and closing volume of standing timber and the changes in volume by applying relevant average coefficients for both the relationship between the volume of standing timber and the total biomass (including above and below ground biomass) and the relationship between the biomass and the quantity of carbon. These coefficients will vary with the species of the tree and other factors.[59]

5.388 A carbon account for timber resources can be developed based on the structure of the physical asset account for timber resources (Table 5.8.2).

5.389 It is noted that references to reductions in the stock of carbon in timber resources, for example due to removals, does not imply that carbon has been released to the atmosphere. In general, carbon will remain bound in timber until the timber is burnt or decomposes naturally.

5.390 A complete articulation of carbon accounting, including for example carbon binding in soils, is beyond the scope of the central framework but will be discussed in SEEA Experimental Ecosystem Accounts. This is mainly because calculation methods are still

[59]See Intergovernmental Panel on Climate Change (IPCC): Good Practice Guidance for LULUCF and UNFCCC Guidelines on annual inventories.

developing and are not mature enough to provide sufficiently reliable information. At the same time it is noted that the underlying accounting models such as asset accounting and physical flow accounting are sufficiently well developed to be able to used for carbon accounting purposes.

5.9 Asset accounts for aquatic resources

5.9.1 Introduction

5.391 Aquatic resources are an important biological resource. They are subject to harvest for commercial reasons as well as part of recreational and subsistence fishing activities. The abundance and health of natural aquatic resources in inland and marine waters are also increasingly affected by water pollution and by the degradation of habitats through the damming and diversion of rivers, restricted water release from reservoirs to rivers, clearance of mangroves, sedimentation, coral mining, deforestation in the hinterland, urbanisation, 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.

5.392 In most parts of the world, fishing capacity has reached a level where unrestricted fishing will result in overexploitation and lead to smaller catches and economic benefits than would be possible if the catch was managed in a way to prevent overexploitation. In extreme cases, there is the risk of commercial extinction of some aquatic resources with attendant impacts on the aquatic ecosystem.

5.393 Asset accounts for aquatic resources aim to organise information on the stocks and changes in stocks of the quantity and value of aquatic resources within a country's economic territory including stocks within a country's EEZ or on the high seas over which the country holds ownership rights. In principle, all aquatic resources are in scope of the asset accounts in the Central Framework but, in practice, the scope is limited to those aquatic resources that are subject to commercial activity. Asset accounts cover both cultivated aquatic resources and natural aquatic resources thus enabling a comparison of trends in both resources.

5.394 The asset accounts presented in this section do not cover the assessment of general aquatic ecosystems that support the various resources and which provide a wide range of ecosystem services. The measurement of ecosystems is described in SEEA Experimental Ecosystem Accounts.

5.395 This section provides a definition and classification of aquatic resources including discussion of the boundary between cultivated and natural aquatic resources. Then a physical asset account is described with a particular focus on the measurement of resources of natural aquatic resources. Finally a monetary asset account is presented incorporating discussion on the role of quotas and licences in estimating the value of aquatic resources.

5.9.2 Definition and classification of aquatic resources

5.396 The aquatic resources for a given country comprise those resources that are considered to live within the Exclusive Economic Zone (EEZ) of a country throughout their lifecycles, both coastal and inland fisheries. Migrating and straddling fish stocks are considered to belong to a given country during the period when those stocks inhabit its EEZ.

5.397 When exploitation control over migrating and straddling fish stocks and fish stocks that complete their life cycle in international waters (high seas) has been established and the access rights of a country to them are defined in international agreements, the portion of agreed access rights of those aquatic resources can be considered to belong to the country.

5.398 In some cases, international agreements specify explicitly the share of total catches that should be allocated to each country. When this is the case, each country's share of the stock of the common aquatic resource can be determined on the same basis. In the absence of specific information about the share of the common aquatic resource, the realised catch by a given country can be used as an indicator of the country's share.

5.399 This measurement boundary is defined with reference to the United Nations Convention on the Law of the Sea (see United Nations, 1997a), in particular the Agreement for the Implementation of the Provision of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks (United Nations, 1998, sect. I; see also A/CONF.164/37) and the Code of Conduct for Responsible Fisheries of the FAO (ibid., sect. III). Together these agreements create a legal framework for international fisheries management.

Classification of aquatic resources

5.400 Aquatic resources include fish, crustaceans, molluscs, shellfish and other aquatic organisms such as sponges and seaweed, as well as aquatic mammals such as whales. The high level classification of aquatic resources is shown in Table 5.9.1.

Table 5.9.1 Classification of aquatic resources

	Aquatic resources		
		Cultivated aquatic resources	
			For harvest (inventories)
			For breeding (fixed assets)
		Natural aquatic resources	

5.401 The Food and Agriculture Organisation of the United Nations (FAO) and other fishery and aquaculture related institutions have collected capture and aquaculture production of aquatic resources, itemized at species level as much as possible. The data includes harvests of freshwater, brackish-water and marine species of fish, crustaceans, molluscs and other aquatic animals and plants, for all commercial, industrial, recreational and subsistence purposes.

5.402 The Aquatic Sciences and Fisheries Information System (ASFIS) list of species contains over 11,500 species, and is commonly used as the standard reference for fisheries production. It is linked to the FAO International Standard Classification for Aquatic Animals and Plants

(ISCAAP) which divides commercial species into 50 groups on the basis of their taxonomic, ecological and economic characteristics. [60]

5.403 Aquatic resources can be further grouped into the following nine divisions.

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
9. Aquatic plants.

5.404 Diadromous fish are either those that normally live in salt water and spawn in freshwater (for example, salmon) or those that normally live in freshwater and spawn in the sea (for example, eels). Miscellaneous aquatic animal products encompass pearls, mother-of-pearl, shells, corals and sponges.

Harvesting aquatic resources and the production boundary

5.405 Aquatic resources may be either cultivated or natural biological resources. The treatment depends on the degree to which the growth and regeneration of the biological resource is under the direct control, responsibility and management of an institutional unit.

5.406 The production boundary 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 aquatic resources, the growth of fish in fish farms and other aquaculture facilities is treated as a process of production.

5.407 Aquaculture is defined by 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 that are harvested by an individual or corporate body that has owned them throughout their rearing period contribute to aquaculture, while aquatic organisms that are exploitable by the public as a common property resource, with or without appropriate licences, are the harvest of the fisheries".

5.408 Following the FAO definition of aquaculture, all aquatic resources produced within aquaculture facilities are considered cultivated biological resources. All other aquatic resources harvested as part of capture production processes are considered natural biological resources.

[60] The ISCAAP is maintained by the Co-ordinating Working Party on Fisheries Statistics (CWP). Details on CWP and ASFIS are available at www.fao.org/fishery

In some cases the life cycle of aquatic resources may start in an aquaculture establishment before transfer to the wild. In other cases fish are captured in the wild for further growth in aquaculture facilities. Following standard methods, the proportion of growth in the wild and in aquaculture facilities should be separated and classified appropriately.

5.409 While all aquatic resources in aquaculture facilities are cultivated biological resources, not all aquaculture is undertaken in the same way. Some aquaculture is undertaken using netted areas in rivers or off-shore and there is an interaction between the fish and the aquatic environment in which it is situated. Other forms of aquaculture involve raising fish in tanks where the fish are entirely removed from the natural environment. Therefore, it may be the case that some cultivated aquatic resources should not be considered environmental assets following the principles outlined in Section 5.2. Information on this distinction between types of cultivated aquatic resources would be useful given that the interactions between the environment and the economy are likely to be quite different. In practice, it may not be possible to distinguish between cultivated aquatic resources on the basis of the farming practice.

5.9.3 Physical asset accounts for aquatic resources

5.410 A physical asset account for aquatic resources shows the total biomass of all species that are subject to harvesting activity or cultivated within the national boundary, including within its EEZ, and a portion of shared resources biomass to which a country has access rights either through traditional practice, international agreement or providing part of the distribution areas. Aquatic resources that exist within other countries' EEZ but are harvested by fishing operators that are resident in the reference country should not be included. The physical asset account also shows the changes due to harvest, normal loss, growth (in size and in number) and other changes.

5.411 A basic asset account for aquatic resources in physical terms is presented in Table 5.9.2

Table 5.9.2 Aquatic resources physical asset account (tonnes/numbers)

		Type of aquatic resource		
		Cultivated aquatic resources – fixed assets	Cultivated aquatic resources - inventories	Natural aquatic resources
Opening stock of aquatic resources				
Additions to stock				
	Growth in stock			
	Upwards reappraisals			
	Reclassifications			
	Total additions to stock			
Reductions in stock				
	Gross catch/Harvest			
	Normal losses			
	Catastrophic losses			
	Uncompensated seizure			
	Downwards reappraisals			
	Reclassifications			
	Total reductions in stock			
Closing stock of aquatic resources				

5.412 In all cases the units that are used to record the stock and changes in stock should be the same although the measurement unit may vary by type of aquatic resource. It may be necessary to convert some estimates of the mass into number and vice versa. Conversion factors by species and size are required for this purpose.

Cultivated aquatic resources

5.413 In the case of cultivated aquatic resources it is reasonable to assume that the stock and changes in the stock can be estimated by the operator or owner of the resource. Accounts should be structured by species as appropriate. Increases come from <u>growth in stock</u> (in both size and numbers) and decreases from harvesting and <u>normal losses</u>.

5.414 When natural aquatic resources are introduced either as seeds or breeding stock this should be recorded as a <u>reclassification</u> from natural to cultivated resources. In the case of ranching and enhancement of aquatic resources, cultured seeds released into the wild should be recorded as a reclassification from cultivated to natural resources. A risk for aquaculture undertaken in rivers and marine environments is that the fish may escape into the external environment. These escapes should also be considered a reclassification from cultivated to natural aquatic resources.

5.415 Unexpectedly large losses due to disease or natural catastrophic events should be considered <u>catastrophic losses</u>.

5.416 The majority of changes in the stock of cultivated aquatic resources should be accounted for as changes in inventories. However, there will be a proportion of the cultivated aquatic resources that are considered to be breeding stock. In principle, these resources should be considered as fixed assets rather than inventories and their growth should be recorded as gross fixed capital formation with associated entries for consumption of fixed capital.

Natural aquatic resources

Measuring stocks and changes in stocks of natural aquatic resources

5.417 Asset accounts for natural aquatic resources should be compiled separately for freshwater and marine aquatic resources within a country's EEZ and other aquatic resources over which the country has ownership rights. A distinction between freshwater and marine aquatic resources may also be compiled.

5.418 Fishery biologists define a "stock" as a group of individuals from the same species that constitute a unit in breeding new offspring. If mating between members of different groups occurs to the level required to modify their gene pools in the long term, those groups should be considered to belong to one stock. The resource management should be based on this concept of stock. The boundary of a stock in this sense does not correspond to national boundaries and when aquatic resources belonging to a stock move around multiple countries' boundaries, the international collaboration in management is needed and the national asset account of such stock can be defined as a proportion of share to access to the stock.

5.419 There are several definitions that can be used in measuring the size of the resources. The most important concept is to measure the sexually mature part of the stock (i.e. the spawning stock or parental biomass), as it is believed that the main purpose of fishery management is to maintain adequate level of spawning stock to be able to generate natural growth and to minimize the probability of collapse.

5.420 Another relevant concept is the exploitable stock size. This corresponds to the proportion of the stock that is subject to harvesting activity, that is, ignoring the cohorts that are younger than those being harvested about which little is known. In this regard, it is important to record separately catch of mature resources and the catch of immature resources within the same species. Similarly, in the case where stocking with cultured seeds is regularly conducted, as commonly observed in freshwater resources, it is important to include the amount of released seeds as a reclassification from cultivated aquatic resources in order to assess their potential impacts on wild ecosystems and gene pools.

5.421 Various methods can be used by fishery biologists to estimate the absolute size of the natural aquatic stocks including virtual population analysis (VPA), tag-recapture analysis, direct and indirect measurement with line-transect surveys or at randomly sampled areas (e.g. echo-sounder, trawl survey, sighting survey) according to the behaviour and distribution of the target species, the harvesting patterns and available data.

5.422 However, estimates of the absolute size of stocks can be imprecise. In practice, little can be done to estimate the variability in births and survivals before the recruitment to the stock, the effects of environmental factors affecting the growth of the individual fish, or the rate of natural death from accidents, sickness, age, predators and so on. Further, small modifications in such parameters within assessment models and equations may result in substantial differences in the estimated size of a stock. It is therefore important to record the impact of changes in model parameters as reappraisals in the asset accounts to distinguish these changes from other physical changes in the stock size.

5.423 When scientific assessment of the absolute stock size is not available, an alternative approach is to measure the gross catch for a certain harvesting operation in relation to the amount of effort required to obtain the catch for a given species e.g. days at sea, number and type of fishing gear, size and power of vessel, expenditure on catch effort (including wages and fuel), etc. The ratio of catch per unit effort (CPUE) can provide a good indicator of the relative change in stock size assuming that population density and population size are closely correlated and that CPUE is higher at higher population densities. Importantly, not all species have the same ratios between population structure and the associated CPUE and this needs to be taken into account in using this technique. Since the CPUE is derived based on information about activity over an accounting period, it provides an indicator of the stock at the mid-point of the accounting period.

5.424 Estimates may be available of stocks for individual species, since this is often the basis on which quotas are determined. However, it may be more applicable to focus on the size of the stock within a given area (or fishery) regardless of the number of species harvested in that area. Commonly, particularly in tropical areas, multiple species may be harvested at one time and accessing relevant indicators and models of the stock size that supports this harvest may be the most appropriate measurement approach.

Accounting for the harvest of natural aquatic resources

5.425 In physical terms, all aquatic resources harvested and all effort used to realize the harvest (e.g. in terms of fishing days multiplied by vessel power) should be recorded. Records should differentiate between species and the type of fishing/harvesting fleet (i.e. vessels operating in a similar way with similar gear). Further, the aquatic resources harvested in the open seas, coastal waters or inland waters by commercial or recreational fishing should be counted as production at the time they are harvested regardless of whether they are sold in the market or used for own consumption. This scope includes the activity of subsistence fishing.

5.426 The FAO has defined terms for the different stages of the catch from when fish encounter fishing gear to when they are landed. They are summarised here with a complete depiction of the relationships presented in a diagram in Annex A5.5.

i. *Gross removal.* The total live weight of fish caught or killed during fishing operations.
ii. *Gross catch.* The total live weight of fish caught (Gross removal less pre-catch losses)
iii. *Retained catch.* The total live weight of fish retained (Gross catch less discarded catch)
iv. *Landings.* The net weight of the quantities landed as recorded at the time of landing

v. *Nominal catch.* The live weight equivalent of the landings.

5.427 The most common catch concept used in practice is "landings" which are directly linked to the economic value of the product. However, this measure excludes the discards of incidentally caught organisms through harvesting activity (discarded catch) as well as the amount of the catch used for own-consumption. For the SEEA, the measurement of discarded catch is an important component in fully understanding the linkages between economic activity and the impact on aquatic resources. For this reason, it is recommended that the concept of "gross catch" be used to measure the extraction of fish resources.

5.428 Conceptually, "gross removal" is most appropriate concept to measure the impact on aquatic resources and the damage to aquatic ecosystems, e.g. to coral reefs, as a result of fishing activity. However, the measurement of gross removal is not possible in practice.

Depletion

5.429 In principle, depletion of natural aquatic resources is derived following the approach outlined in Section 5.4 and Annex A5.1, where depletion for renewable resources is equal to harvest less sustainable yield. Since the drivers for changes in populations of aquatic resources can only be modelled it may be difficult to obtain precise and consistent measures of sustainable yield over time. In these cases it is recommended that estimates from biological models be compared with indicators of stock size, such as CPUE, and also that estimation be carried out on an ongoing basis such that the dynamics of the various populations (natural growth, natural losses, etc) can be better understood.

5.430 With this information a level of sustainable yield may be established to which the level of harvest in any given period can be compared. As noted in Section 5.4, some year on year variation in the actual changes in the population must be accepted as part of the accounting and hence depletion should only be recorded when the extraction is beyond a normal level of natural growth (less natural losses).

Capture fishing by non-residents

5.431 Given the nature of aquatic resources and harvesting activity there will be capture fishing undertaken by non-residents within another country's EEZ. Following the principles of the SNA, the location of the aquatic resource is not the key determinant of the attribution of economic production. Rather production is allocated to the country of residence of the harvesting operation. On the other hand, the UNCLOS defines the exclusive sovereign right of exploring and exploiting resources within its EEZ to the coastal country.

5.432 Therefore, in the assessment of the change in the aquatic resources belonging to a country over an accounting period, it is not sufficient or accurate to focus only on the catch by operations of residents of that country. This estimate will exclude changes in the national aquatic resource due to catch by non-residents and will include catch by residents in other countries. For the purposes of accounting for the national aquatic resource the focus must be on the total catch from the country's aquatic resource, including any resources on the high seas over which ownership rights exist, regardless of the residency of the harvesting operation.

Illegal fishing

5.433 If a resident harvests aquatic resources beyond the scope of their licence, they are harvesting illegally. Nonetheless, following the principles of the SNA, this harvest should still be recorded as production with an income accruing to the fisherman.

5.434 In cases where non-residents harvest aquatic resources illegally, either without a licence or by taking catch in excess of their allocated quota, the physical removals should be recorded. These flows should be recorded as uncompensated seizures. In recording such flows care must be taken to exclude these flows from estimates of gross catch.

Other physical flows

5.435 It is unlikely to be the case that direct information can be separately obtained regarding the growth and normal loss in natural aquatic resources. Consequently, the estimates of growth and normal loss should be derived based on estimates of the opening and closing stock of aquatic resources and the extent of harvest when estimates of the absolute stock size are available. Otherwise, the change in CPUE over accounting periods should provide an indication as to whether the overall change (i.e. growth less gross catch less normal loss) is positive or negative.

5.436 It is also likely that reappraisals of the quantity of aquatic resources, both upwards and downwards, will occur; most commonly due to revisions in the parameters used in stock measurement models.

5.9.4 Monetary asset accounts for aquatic resources

5.437 A monetary asset account for aquatic resources records the opening and closing values of aquatic resources in an accounting period and the changes over the period in the form of additions to the stock, reductions in the stock and revaluations. Aside from revaluations all of the monetary flows in the asset account have a direct parallel with the physical flows recorded in the physical asset account.

5.438 A basic monetary asset account for aquatic resources is presented in Table 5.9.3.

Valuation of cultivated aquatic resources

5.439 Aquatic resources farmed in an aquaculture facility are produced assets, either inventories, or fixed assets in the case of breeding stocks. In most cases, market prices can be obtained and can be used to estimate the value of the resources and the value of the flows of resources over an accounting period.

Valuation of natural aquatic resources

5.440 Monetary valuation of natural aquatic resources is complex. There are two main options. One possibility is to value the aquatic resource via the value of long term 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 aquatic resources. Under the NPV approach there are two main approaches to estimating the resource rent – using information on annual licences or using information from the national accounts under the residual value method (see section 5.4 for details).

Table 5.9.3 Monetary asset account for aquatic resources (monetary units)

		Type of aquatic resource			
		Cultivated aquatic resources – fixed assets	Cultivated aquatic resources - inventories	Natural aquatic resources	**Total**
Opening stock of aquatic resources					
Additions to stock					
	Growth in stock				
	Upwards reappraisals				
	Reclassifications				
	Total additions to stock				
Reductions in stock					
	Gross catch/Harvest				
	Normal losses				
	Catastrophic losses				
	Uncompensated seizure				
	Downwards reappraisals				
	Reclassifications				
	Total reductions in stock				
Revaluations					
Closing stock of aquatic resources					

5.441 If there is a perfectly functioning market for licences, if these licences cover the whole stock, and if resource rent can be accurately estimated, then these different valuation approaches should give the same result. However, because of market imperfections and uncertainties in the statistical assumptions required for net present value calculations, this is unlikely to be exactly the case in practice.

Valuing natural aquatic resources using licence and quota information

5.442 In many countries, a licence issued by government is required in order to practise either fresh water or marine fishing. A licence may be issued for a right to fish in general; a right to fish with specific gear; or a right to catch specific species. 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.

5.443 An increasingly common approach to controlling marine aquatic resources so as to prevent overharvesting is to issue quotas. These are usually issued by government (which is also responsible for ensuring their enforcement) and may apply both to harvesting within the waters of the country's EEZ and to fishing on the high seas. Quotas typically apply to a particular species.

5.444 Quotas may be given away free to certain designated persons (for example, people in locations where fishing is the main source of livelihood) or sold. A quota may be valid for one year only or for a longer period, sometimes for the lifetime of the quota-holder. It may or may not be tradable to third parties. Even if not tradable, in certain circumstances it may still be transferable, say, from one generation to the next.

5.445 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 aquatic resources to which it relates.

5.446 When fishing/harvesting rights, evidenced by the existence of licences and quotas, are freely traded, it is possible to estimate the value of the aquatic resources 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 there is therefore 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) that 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 with prices of similar assets that do not encompass any such rights.

5.447 Two forms of individual transferable quota systems 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 that may itself be variable from year to year in accordance with, for example, international agreements.

5.448 In theory, the value of the quota represents the NPV of the owner's expected income using the quota over its period of validity. If the aquatic resource is managed with such quotas and the quotas are valid in perpetuity, then the value of all quotas, at the market price, should be equal to the value of the aquatic resource.

5.449 If the quotas are valid for a single year only, the total should give an approximation of the resource rent in that year. By forecasting the estimate of the value of a single year quota, applying an appropriate discount rate, and estimating the resource life, an overall value of the aquatic resource can be derived using the NPV approach.

5.450 However, in most of those cases where ITQs, ITSQs and similar arrangements are used to manage aquatic resources, the market in these quotas is far from perfect and so the access rights do not reflect the full value of the resource. Licences and quotas are often introduced when considerable excess capacity exists in the fishing/harvesting 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 level of income that maintains the aquatic resource intact. A total permissible catch resulting in earnings that are higher than this level will mean that some of those earnings should be regarded as depletion of the aquatic resources and not as income.

Valuing natural aquatic resources using the NPV of expected resource rents

Estimating resource rent

5.451 Following the approaches outlined in Section 5.4 and Annex A5.1, the operating surplus from harvesting natural aquatic resources can be used as a basis for the calculation of the resource rent of the resources. The total amount of gross operating surplus must be partitioned between that part representing the user costs of produced assets such as the ship, nets and other equipment used; and the part representing the resource rent of the aquatic resource.

5.452 There are a number of complications particular to the fishing industry that must be taken into account. One arises from the fact that artisanal fishing is very common, especially in developing countries. Here the generation of income account yields an item called "mixed income" as the balancing item rather than operating surplus. This item is so-named because it represents not only a return to the produced assets used and the natural aquatic resources but also an element of remuneration to the self-employed fisherman. In this situation an adjustment to remove this element of labour remuneration must be made.

5.453 It may also be difficult to separate harvesting and processing activities, both with respect to factory vessels and in cases where companies whose primary activity is land-based processing (that is, manufacturing) also have some harvesting operations. Although it is desirable to allocate the production and cost data to the relevant activity, this may be difficult in practice.

5.454 In addition, besides permitting harvest in excess of a sustainable level of catch, governments may sometimes subsidize fishing so that fishing continues even when the resource rent is negative.

Estimating the asset life

5.455 Estimating the asset life of aquatic resources presents a difficult measurement challenge. If the aquatic resource is to be preserved in perpetuity, harvest should not exceed the renewal rate of a stable population, i.e. the sustainable yield. In general, questions regarding the sustainable yield of an aquatic resource are answered using biological models (as described in Section 5.4) or through analysis of trends in relevant indicators such as gross catch, CPUE, and the species and size of the fish caught. In particular a declining trend in CPUE is a strong signal that the rate of harvest is exceeding the renewal rate of the fish stock. In this case the asset life may be estimated by extrapolating the declining pattern of the CPUE to the point where the population is zero.

Valuation of depletion and other changes in aquatic resources

5.456 The value of aquatic resources may change due to a wide range of factors. When it is not possible to identify separate reasons for changes in the size or value of stocks and to attribute the changes to natural causes or harvesting activity, it will only be possible to prepare a minimal asset account. For example, the physical asset accounts may consist of extractions (based on catch data) for a number of species but without corresponding stock estimates for all of the species.[61] Thus, it may not be possible to value the stocks of individual species, so that only a regional or national aggregate resource values will be produced.

5.457 Ideally, changes due to growth, normal loss, depletion and other changes could each be measured and valued directly. However, due to data limitations, these changes may often only be available as a composite entry either measured as the difference between the amount harvested and the change between opening and closing stocks or based on trends in CPUE.

[61] Further, many fishing operations harvest multiple species at the same time and it may not be possible to attribute CPUE to individual species.

5.10 Accounting for other biological resources

5.10.1 Introduction

5.458 Other biological resources are largely represented by cultivated animals and plants including livestock, annual crops such as wheat and rice, and perennial crops such as rubber plantations, orchards and vineyards. Together these biological resources form the basis of food production in all countries.

5.459 While the vast majority of other biological resources are cultivated, there is a range of natural biological resources that provide inputs to the economy and also form an important part of local bio-diversity. These resources may include wild berries, fungi, bacteria, fruits and other plant resources that are harvested for sale or own consumption. Alternatively they may relate to wild animals such as deer, boar or moose that are killed for sale or own consumption.

5.460 Since the majority of other biological resources are cultivated, estimates relating to the production and accumulation of these resources are an integral part of estimates of gross domestic product. The asset accounting for these resources is covered in detail in the SNA.

5.461 This section introduces asset accounting for natural biological resources. No tables are proposed because the compilation of accounts for these resources depends entirely on the resources of relevance in an individual country.

5.10.2 Accounting for natural biological resources

5.462 Natural biological resources are distinguished from cultivated biological resources because their natural growth and regeneration is not under the direct control, responsibility and management of an institutional unit.

5.463 As a consequence of not being under direct control of institutional units natural biological resources are not easily accounted for. Aside from wild fish and natural timber resources, most animals and plants that provide significant economic benefits have become cultivated. Thus while there are a range of animal and plant resources that are harvested that are not cultivated, there is typically only active measurement of the animals, plants and other biota for which access rights are controlled (e.g. through hunting licences) or for which there are other management or conservation arrangements in place. As well, many of the examples that might be considered pertain to use for own consumption or as part of subsistence farming.

5.464 At the same time there are particular species in certain countries where reasonably significant commercial operations operate, possibly illegally, and where there is significant extraction of animals and plants from the wild. Examples include the hunting of elephants for ivory and hunting of kangaroos for meat. There may therefore be interest in the organisation of data and other information on the quantity and value of the available resources, the extraction rates and the possible extent of loss in animal or plant populations due to over harvesting.

5.465 The structure and logic of the accounting for these resources is consistent with the accounting presented in sections 5.8 and 5.9 on timber resources and fish resources.

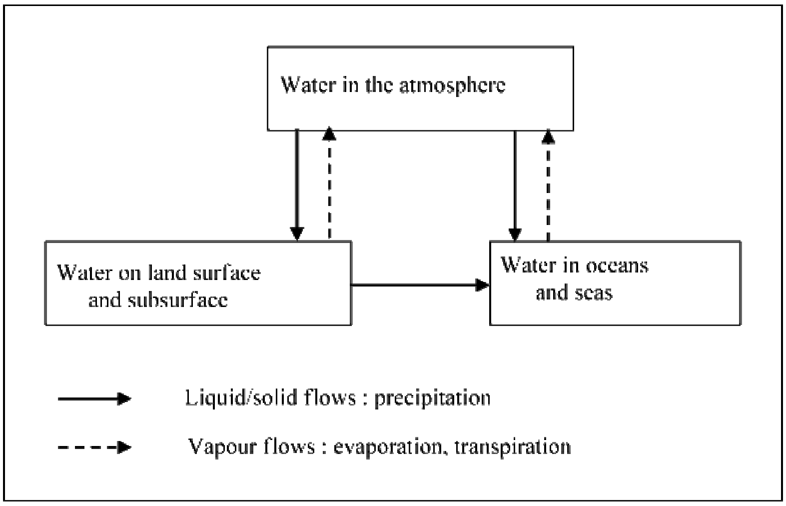
5.466 As natural biological resources may form an important part of bio-diversity and ecosystems in particular regions, there may be interest in compiling data on the availability and extraction of these resources at sub-national spatial levels. Further, information on these resources may be able to form an input into broader measures of ecosystem health that are discussed in SEEA Experimental Ecosystem Accounts.

5.11 Asset accounts for water resources

5.11.1 Introduction

5.467 Unlike other environmental assets, such as timber resources or mineral resources that are subject to slow natural changes, water is in continuous movement through the processes of evaporation, precipitation, sub-surface flows, river runoff and other flows. The natural cycle of water, the hydrological cycle, involves connections between the atmosphere, the oceans and land surface and sub-surface as shown in Figure 5.11.1.

Figure 5.11.1: Elements of the global hydrological system



5.468 Within the hydrological cycle, asset accounts for water resources focus on the inflows and outflows of water to and from the land surface and sub-surface, and on the destination of these flows. In conjunction with information on instream flows, seasonality and other factors, such a focus allows assessment of the availability of water to meet demands from the economy and to assess whether those demands are consistent with the longer term sustainability of water supply.

5.469 The asset accounts themselves present information on the stock of water at the beginning and end of an accounting period whether it is in artificial reservoirs, lakes or rivers or stored as ground or soil water. The accounts then record the flows of water as it is abstracted, is consumed, is added to through precipitation, or via flows to and from other countries and returned to the sea.

5.470 Water is included in two places in the central framework environmental asset classification – as part of "Land and other areas" and as part of "Water resources". As a component of land it is the in situ or passive use of water that is being considered, for example, in the provision of space for transportation and recreation. Consequently it is the area of water that is of interest. In the context of water resources, the focus is on the amount of water in the environment, its abstraction, and the use of water through the economy and hence it is the volume of water and the changes over time that are of interest.

5.471 This section defines water resources and the classes of water resources that are within scope of the asset accounts. It then presents the physical asset account for water resources and describes the relevant flows. A final part discusses related measurement issues such as the measurement of the value and quality of water resources.

5.11.2 Definition and classification of water resources

5.472 ***Water resources consist of fresh and brackish water in inland water bodies including groundwater and soil water.*** Inland water bodies are classified as shown in Table 5.11.1.

5.473 Freshwater is naturally occurring water having a low concentration of salt. Brackish water has salt concentrations between that of fresh and marine water. The definition of brackish and freshwater is not clear cut as the salinity levels used in the definition vary between countries.[62] Brackish water is included in the asset boundary on the grounds that this water is often used, with or without treatment, for some industrial purposes, for example, as cooling water, for desalination or irrigation of some crops. Countries may choose to present accounts by salinity levels or for freshwater only.

5.474 The definition of water resources excludes water in oceans, seas and atmosphere. At the same time, flows of water in oceans, seas and the atmosphere are recorded in the accounts in a number of places. For example, abstraction from the ocean and outflows to the ocean are recorded in the asset account and evaporation to the atmosphere from inland water resources is also recorded there. Flows to and from inland water resources are also recorded in the physical flow accounts for water (see Chapter 3).

Table 5.11.1 Classification of inland water bodies

Code		
	Surface water	
		Artificial reservoirs
		Lakes
		Rivers and streams
		Glaciers, snow and ice
	Groundwater	
	Soil water	

5.475 Surface water comprises all water that flows over or is stored on the ground surface regardless of its salinity levels. Surface water includes water in *artificial reservoirs,* which are purpose built reservoirs used for storage, regulation and control of water resources; *lakes* which are, in general, large bodies of standing water occupying a depression in the earth's surface; *rivers and streams* which are bodies of water flowing continuously or periodically in channels; *snow and ice* which include permanent and seasonal layers of snow and ice on the ground surface; and *glaciers* which are defined as an accumulation of ice of atmospheric origin,

[62] For further details see International Glossary of Hydrology, UNECSO/WMO, 2nd edition, 1992.

generally moving slowly on land over a long period.

5.476 Although artificial reservoirs are not natural components of the earth's surface, once in place, the stocks and flows of water are equivalent to the stocks and flows associated with natural stores of water, in particular natural lakes. Thus flows of precipitation, abstraction and evaporation affect artificial reservoirs in the same way as they affect natural lakes and hence artificial reservoirs form one part of the hydrological system. They are separately identified in the classification of inland water resources since, in many cases, the flows associated with artificial reservoirs, in particular evaporation, are of particular analytical interest.

5.477 Groundwater comprises water that collects in porous layers of underground formations known as aquifers. An aquifer is a geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs. It may be unconfined, by having a water table and an unsaturated zone, or may be confined when it is between two layers of impervious or almost impervious formations. Depending on the recharge rate of the aquifer, groundwater can be fossil (or non-renewable) in the sense that water is not replenished by nature in human life spans.[63]

5.478 Soil water consists of water suspended in the uppermost belt of soil, or in the zone of aeration near the ground surface. Soil water can be discharged into the atmosphere by evapotranspiration, be absorbed by plants, flow to groundwater or to rivers (run-off). In the SEEA, the measurement of soil water is limited to soil water in agricultural and forestry areas as defined by the area of land used for agriculture and forestry in the land use classification.

5.11.3 Physical asset accounts for water resources

5.479 Physical asset accounts for water resources should be compiled by type of water resource and should account for both the stock of water at beginning and end of the accounting period and the changes in the stock of water. The accounts are generally compiled in terms of millions of cubic metres of water.

5.480 Changes in the stock of water should consider additions to the stock, reductions in the stock and other changes in the stock. The structure of the physical asset account for water resources is shown in Table 5.11.2.

[63] Certain lakes may also be considered fossil water bodies.

Table 5.11.2 Physical asset account for water resources (cubic metres)

		Type of water resource		
		Surface water	Groundwater	Soil water
Opening stock of water resources				
Additions to stock				
	Returns			
	Precipitation		na	
	Inflows – from other territories			
	- from other national water resources			
	Discoveries of water in aquifers			
	Total additions to stock			
Reductions in stock				
	Abstraction			
	of which: for hydro power generation			
	for cooling water			
	Evaporation/Actual evapotranspiration			
	Outflows – to other territories			
	- to other national water resources			
	Total reductions in stock			
Closing stock of water resources				

Defining the stock of water

5.481 The concept of a stock of surface water is related to the quantity of water in a territory of reference measured at a specific point in time (usually the beginning or end of the accounting period). The stock level of a river is measured as the volume of the active riverbed determined on the basis of the geographic profile of the riverbed and the water level. This quantity is usually very small compared to the total stocks of water resources and the annual flows of rivers.

5.482 The stock of groundwater is the volume of water at a particular point in time, which has collected in porous and permeable underground layers known as aquifers that can yield significant quantities of water to wells and springs. An aquifer may be unconfined, that is it has a water table and an unsaturated zone immediately above the water table, or may be confined when it is between two layers of impermeable or nearly impermeable material.[64]

5.483 The stock of soil water is the volume of water suspended in the uppermost belt of soil, or in the zone of aeration near the ground surface, which can be discharged into the atmosphere by

[64] See *International Recommendations on Water Statistics*, paragraph 4.24

evaporation or taken up by the roots of plants and transpired. In countries where there is a consistent and regular hydrological year with a distinct dry period, the stock of soil water at the end of the hydrological year may be negligible in comparison to groundwater or surface water. While soil water can be distinguished from groundwater and surface water in theory, at present it may be difficult to measure it directly but it can be estimated indirectly using a variety of data.[65]

Additions to and reductions in the stock of water resources

5.484 Additions to the stock of water resources consist of the following flows.

i. Returns represent the total volume of water that is returned to the environment by economic units into surface, soil and groundwater during the accounting period. Returns can be disaggregated by type of water returned, for example, irrigation water, treated and untreated wastewater. In this case, the breakdown should mirror that used to disaggregate the returns in the physical supply and use tables in chapter 3.

ii. Precipitation consists of the volume of atmospheric wet precipitation (e.g. rain, snow, hail etc.) on the territory of reference during the accounting period before evapotranspiration takes place. The majority of precipitation falls on the soil but generally would be recorded as run-off to rivers, especially in cases of flooding. Most precipitation is therefore recorded as an addition to surface water although amounts retained in the soil should be recorded as additions to soil water. Some precipitation also falls directly into surface water bodies. It is assumed that water would reach aquifers after having passed through either the soil or surface water (e.g. rivers, lakes, etc.), thus no precipitation is shown in the asset accounts for groundwater. The infiltration of precipitation to groundwater is recorded in the accounts as an inflow from other water resources into groundwater.

iii. Inflows represent the amount of water that flows into water resources during the accounting period. The inflows are disaggregated according to their origin: (a) inflows from other territories/countries; and (b) from other water resources within the territory. Inflows from other territories occur with shared water resources. For example, in the case of a river that enters the territory of reference, the inflow is the total volume of water that flows into the territory at its entry point during the accounting period. If a river borders two countries without eventually 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. Inflows from other resources include transfers, both natural and man-made, between the resources within the territory. They include, for example, flows from desalination facilities and flows of infiltration and seepage.

iv. Discoveries of water in new aquifers. These flows should be recorded in terms of the quantity of water in the newly discovered aquifer as distinct from the overall capacity of the aquifer. Changes in the volume of water in an aquifer should be included as an inflow

[65] See *International Recommendations on Water Statistics*, paragraph 4.29

of water resources to groundwater.

5.485 Reductions in the stock of water resources consist of the following flows.

i. Abstraction represents the amount of water removed from any source, either permanently or temporarily, during the accounting period. The abstracted water may be directly returned to the environment or used for production activities (including the abstraction of water by households for own-consumption). Water used for hydroelectric power generation and as cooling water is considered part of water abstraction. Given the large volumes of water abstracted for hydroelectric power generation and for cooling purposes, it is advisable to separately identify the abstraction and returns of water for these purposes. Abstraction also includes the abstraction from soil water by plants in areas of rain-fed agriculture and cultivated timber resources. The water abstracted from soil water is either absorbed by the plants or returned to the environment through transpiration.

ii. Evaporation/Actual evapotranspiration is the amount of evaporation and actual evapotranspiration that occurs in the territory of reference during the accounting period, excluding amounts already recorded as abstracted from soil water (i.e. water transpired by cultivated plants). Note that evaporation refers to the amount of water evaporated from water bodies such as rivers, lakes, artificial reservoirs, etc. Evapotranspiration refers to the amount of water that is transferred from the soil to the atmosphere by evaporation and plant transpiration. Evapotranspiration can be "potential" or "actual" depending on the soil and vegetation conditions: potential evapotranspiration refers to the maximum quantity of water capable of being evaporated in a given climate from a continuous stretch of vegetation covering the whole ground and well supplied with water. Actual evapotranspiration, which is reported in the accounts, refers to the amount of water that evaporates from the land surface and is transpired by the existing vegetation/plants when the ground is at its natural moisture content that is determined by precipitation and the soil's properties. Note that actual evapo-transpiration will typically be estimated through modeling and may be a rough approximation.

iii. Outflows represent the amount of water that flows out of water resources during the accounting period. Outflows are disaggregated according to the destination of the flow, namely (a) to other water resources within the territory, (b) to other territories/countries and (c) to the sea/ocean. Outflows to other water resources within the territory represent water exchanges between water resources within the territory. In particular, they include the flows of water going out of a water body and reaching other water resources within the territory. Outflows to other territories represent the total volume of water that flows out of the territory of reference during the accounting period. Shared rivers are a typical example of water flowing from one upstream country to a downstream country. Outflows to the sea/oceans represent the volume of water that flows into the sea/oceans.

5.11.4 Other water resource measurement issues

Monetary asset accounts for water resources

5.486 The measurement of the stock of water in monetary terms is particularly difficult. The main problem is that, historically, water has often been made available free of charge as a public good supplied at less than the cost of production in order to support agricultural production; or supplied for a flat charge because it has been seen to be not subject to scarcity. The monetary prices, therefore, have tended to be related to the fixed infrastructure costs of collecting and transporting water to designated outlets rather than to actual volume of water used which may vary considerably.

5.487 Given this situation, the standard approaches to valuation of environmental assets, and in particular the net present value approach (described in Section 5.4), do not work because the resource rent that is derived following standard definitions is commonly negative. Estimates of negative resource rent arise when the income earned from the sale of abstracted water does not cover the costs of maintaining the produced assets required to distribute the water.

5.488 There is a trend towards water pricing to reflect the full costs of managing, abstracting and distributing water resources. Consequently, there may be some instances where approaches such as NPV can be applied. In these cases these values should be incorporated as part of the overall monetary value of environmental asset and as part of the value of economic assets.

5.489 Another approach to the valuation of water resources is to consider the value of water access entitlements which, in some countries, are traded in distinct markets. Often, the value of these entitlements may be closely connected to the value of the associated land and determining the relevant proportion of the total value of land that can be attributed to the access entitlements may be a way of determining the value of the associated water. These approaches to valuation are more likely to be most relevant in agricultural contexts where access to water by farmers is a significant consideration.

Spatial and temporal detail

5.490 Water statistics can provide data for water management at many geographic levels, from local levels, at the level of river basins and to the national and multinational levels. The choice of spatial reference for the compilation of water accounts ultimately depends on the data needed by users and the resources available to data producers. The choice of spatial scale is important as many countries have significant geographic variation in the availability of water (e.g. areas of very high or very low rainfall) and national aggregates may not accurately reflect the issues facing particular countries.

5.491 It is recognized internationally that a river basin is the most appropriate spatial reference for integrated water resource management (e.g., Agenda 21 (United Nations, 1992) and European Water Framework Directive, 2000). This is because the people and economic activities within a river basin will have an impact on the quantity and quality of water in the basin, and conversely the water available in a basin will affect the people and economic activities that rely on this water. In areas where groundwater is an important source of water, aquifers may also be appropriate spatial references for the compilation of water statistics.

5.492 Although data for specific spatial scales within a country are often more appropriate for the analysis of water resources, integration of physical data on water at relevant spatial levels, e.g. river basins, may not align with the available spatial detail for economic data (which are more commonly compiled based on administrative boundaries). In these situations, common areas of observation, accounting catchments, should be defined.[66]

5.493 When integrating or collecting water data, it is important that the reference periods for the different data items be aligned. In water and economic statistics, the calendar year is the recommended temporal reference. However, in practice water and economic data may not be available for calendar years. For example, for national accounts many countries use a financial year, while for water statistics, they may use a hydrological year. Financial and hydrological years may be the same as or different from calendar years. It is also noted that in some cases high seasonal variability in relationship between the demand and supply of water may mean that annual data (either on a financial or hydrological year) are insufficient and, instead, sub-annual data are required.

[66] For details see SEEA Water, paragraph 2.90.

Annex A5.1: The Net Present Value method for valuation of stocks and the measurement of depletion and revaluation for natural resources

Introduction

1. This annex explains, in some detail, the assumptions and computations needed to implement the net present value method (NPV) with a view to deriving valuations of the stock of natural resources and consistent flow measures of depletion, income, and revaluation. In particular, the latter element is often neglected in presentations of the NPV. Also, it must be accepted that the NPV is not applied under conditions of perfect foresight. Hence, revisions in the set of information available to the compiler over an accounting period need to be accounted for.

Defining the unit resource rent

2. Consider an enterprise that harvests and sells timber resources from an uncultivated, natural forest. The enterprise uses produced assets in the extraction process (e.g. lorries, saws, etc) as well as labour and intermediate inputs (e.g. fuel). The enterprise receives income from the sale of timber and pays input costs for labour, produced assets and intermediate inputs.
3. The enterprise must also pay for the timber resources to be extracted. This variable is best understood as the price per unit of timber resources extracted that the enterprise would be charged if the timber resources were owned by another unit (for example, the government). While *in principle* this amount is observable, often it is not available in practice, in particular when the extracting enterprise is itself the owner of the resource.
4. This amount is commonly referred to as the resource rent, RR_t and is equivalent to the total value of the natural resource input into the production process during an accounting period. It is comprised of two parts (i) the quantity of timber extracted, S_t, and (ii) the price per unit of timber extracted, P_{St}. The variable P_{St} is equivalent to the unit resource rent – i.e. the resource rent per extracted unit of timber resource.
5. Empirically, the resource rent can be measured *ex-post* (i.e. at the end of the accounting period) as a residual provided there is only one type of natural resource per enterprise or per industry. In this case, RR_t equals gross operating surplus plus the non-labor component of mixed income less the user costs of produced assets. Alternatively, RR_t may be observable from rent payments that extraction enterprises pay to the owners of a natural resource. (The various methods for estimating RRt are discussed in Section 5.4). Given RR_t and S_t, it is straightforward to compute the unit resource rent, P_{St}.
6. Having estimated the unit resource rent, two important tasks remain to be completed: first, the value of the stock of the natural resource needs to be established, and second, the period-to-period gross income attributed to the resource, RR_t needs to be split up into a part that represents the value of depletion and into a part that represents net income. These tasks are directly related and need to be addressed consistently.

Valuing the stock of a natural resource

7. To tackle the valuation of the stock of a natural resource, start with the fundamental asset market equilibrium condition or NPV that the value of an asset (the timber resources in this example) at the end of period t, V_t, equals the discounted flow of future resource rents $RR_{t+\tau}$ (τ=1,2,…N_t) over N_t periods. The estimate of the number of remaining periods of extraction may vary over time, therefore N_t depends on t. In the simplest case, and for a fixed finite period of exploitation, N_t declines by one period as t progresses. If the exploitation of a natural resource is judged to be sustainable, N_t will take an infinite value. It is assumed here that the resource rent accrues at the end of the accounting period.[67] The standard NPV condition is shown in equation (1).

$$V_t=\Sigma_{\tau=1}^{Nt} RR_{t+\tau}/(1+r_t)^{\tau} \qquad (1)$$

where r_t is a nominal discount rate valid at time t, but not necessarily constant over time.

8. $RR_{t+\tau}$ (τ=1,2,…N_t) is a nominal value of expected future resource rents and the projected time profile of the resource rent $\{RR_{t+1}, RR_{t+2}, \ldots\}$ may be non-constant. Note that the sequence of resource rents $\{RR_{t+1}, RR_{t+2} \ldots\}$ is an *expected* sequence and that the expectation is formed at the end of period t.

9. As time goes on, information may change and a different sequence of resource rents may be expected. Similarly, the value of the stock at the beginning of period t may be have been constructed with a different set of expectations about future resource rents or discount rates. Such a change in the set of information needs to be allowed for and will be addressed later.

10. V_t is the value of the stock at the end of period t. In concept, this value is composed of a price and a quantity component, call them P_t and X_t. Indeed without this price-quantity distinction, the meaning of 'V' would be unclear. In the timber example, if V_t is the value of the timber resource, P_t equals the price per cubic metre of the timber resources at the end of period t, and X_t is the cubic metres of timber resources at the end of period t. (In the case of an oil field, X_t would be the estimated quantity of oil in the ground.) Therefore, one has

$$V_t = P_tX_t \qquad (2)$$

11. To obtain an estimate of the price P_t and consequently of V_t, use the NPV condition from equation (1) together with the definition of the resource rent $RR_t=P_{st}S_t$:

$$V_t = P_tX_t = \Sigma_{\tau=1}^{Nt} P_{s,t+\tau}\, S_{t+\tau}/(1+r_t)^{\tau} \qquad (3)$$

12. Next, a hypothesis has to be formed concerning the future profile of extractions and the expected price change of P_{st}. One simple possibility is to assume that the most recent *quantity of extraction* is the best estimate of future extractions so that $S_{t+\tau}=S_t$ (τ=1,2,3,…N_t). This is only one possibility and different assumptions could be made, for instance if the extraction in year t was unusually large or small and unlikely to be occurring again in the future. Another possibility is to assume a constant *rate of extraction* such that

[67] Preferably, resource rent should be assumed to accrue to the mid-point of the accounting period. The assumption made here is used to simplify the explanation and the associated notation and has no impact on the underlying relationships described.

$S_{t+\tau}/X_{t+\tau}$ is constant for τ=1,2,3,…N_t. For the expositional purpose at hand, a constant quantity of extraction is assumed.

13. Similarly, a hypothesis needs to be formed regarding the evolution of the price P_{st} and the proposal here is consider the long-run trend in the unit resource rent or, even more straightforwardly, to assume that P_{st} evolves in line with an expected general rate of inflation, ρ_t.

14. Using these two hypotheses, the NPV condition can then be re-written as

$$V_t = P_tX_t \quad = \Sigma_{\tau=1}^{Nt} P_{s,t+1}\, S_{t+1}(1+\rho)^{\tau-1}/(1+r_t)^{\tau}$$

$$= P_{s,t}\, S_t\, \Sigma_{\tau=1}^{Nt} (1+\rho)^{\tau}/(1+r_t)^{\tau} = P_{s,t}\, S_t\Omega_t = RR_t\ \Omega_t \qquad (4)$$

$$\Omega_t \equiv \Sigma_{\tau=1}^{Nt} (1+\rho)^{\tau}/(1+r_t)^{\tau} \qquad (5)$$

15. Ω_t is a 'discount' factor that links future resource rents to the present value of the asset. Equation (4) provides the desired estimate for the value of the stock, V_t, as well as the price level for the unit value of the resource in/on the ground, $P_t=RR_t\ \Omega_t/X_t$. The above expression also shows the relationship between the unit resource rent P_{st} and the price of the asset in/on the ground P_t: the latter is the discounted value of the former, multiplied by the current extraction rate S_t/X_t.

$$P_t = P_{S,t}\Omega_tS_t/X_t \qquad (6)$$

16. One conclusion from this relationship is that it is incorrect to use the unit resource rent, P_{st} as the price of the asset, i.e., for valuation of the stock of the resource. It is also useful to note that with the simplifying hypotheses made above, the main element of Ω_t, $(1+r_t)/(1+\rho_t)$, is a real interest rate. In many countries, real interest rates tend to be relatively stable and should therefore not be too difficult to estimate.

17. The real interest formulation also relates to Hotelling's rule for non-renewable resources. Hotelling's rule states that under certain market conditions, non-renewable resource rents will rise at the rate of the nominal discount rate as the resource becomes scarce. Under these circumstances, the value of the resource stock can be calculated simply as the unit resource rent times the size of the stock. Because nominal resources rent rises over time at a rate that is exactly sufficient to offset the nominal discount rate, there is no need to discount future resource income. In terms of the notation at hand, this corresponds to a situation where $\rho_t=r_r$ so that $\Omega_t=1$ and $P_t=P_{st}S_t/X_t$, the unit resource rent. The application of Hotelling's rule is not recommended for the valuation of environmental assets in the SEEA.

Estimating the value of depletion, discoveries and losses for non-renewable natural resources

18. The next task consists of valuing the changes to the natural resource over the accounting period. In this section the flows associated with non-renewable natural resources are considered. The following section considers accounting for renewable natural resources.

19. As before, it is assumed that the quantity of natural resources at the end of period t, X_t is known and that there is a projected sequence of extractions, based on the information available at the end of period t. At the end of period t, the quantity at the end of the preceding period, X_{t-1} is also known. *Ex-post*, the difference between X_t and X_{t-1} can be decomposed into three components: depletion, discoveries and other additions (referred to in the following as "discoveries") and catastrophic losses and other reductions (referred to in the following as "catastrophic losses"). *Ex-ante*, i.e. based on the information at the end of the preceding period t-1, discoveries and catastrophic losses will not be known.

20. To operationalise the measurement of these three components, it is necessary to distinguish between the information available at the end of period t-1 and at the end of period t. The notation used for this purpose is such that X'_t relates to the quantity of the natural resource at the end of period t, given the information available at the end of period t-1. Thus, for example, using this notation $X'_{t-1}=X_{t-1}$ as no new information arises during period t about the stock at the end of period t-1. But in general it is *not* the case that $X'_t=X_t$ or $P'_t=P_t$.

21. With this notation it is now possible to define depletion, discoveries and catastrophic losses. Depletion, i.e. the regular and expected reductions from the stock of the asset, is defined as $X'_{t-1}-X'_t=S_t$ where S_t is the extraction during period t. (As we are dealing with a non-renewable resource, extraction equals depletion.) Thus, depletion is the difference between the quantity of resource at the end of period t-1 less the quantity of resource expected to be remaining in the ground at the end of period t.

22. Discoveries constitute an unexpected addition to the natural resource during the accounting period. The main body of the Chapter 5 describes, for each type of natural resource which types of discoveries should be recognized as such. Catastrophic losses relate to unexpected and significant reductions in the natural resource during the period. They constitute exceptional and significant losses. The combined effect of discoveries and catastrophic losses can now be measured as $X_t-X'_t$, i.e. the difference between expected and actual quantities at the end of the period.

23. To separately account for discoveries and catastrophic losses, let I_t be the physical amount of discoveries and let L_t the physical amount of catastrophic losses such that $X_t-X'_t= I_t-L_t$. Recall that $X'_{t-1}=X_{t-1}$ as no new information arises during period t about the natural resource at the end of period t-1. The same holds for prices and values of the asset: $P'_{t-1}=P_{t-1}$ and $V'_{t-1}=V_{t-1}$. With these remarks in mind, the total physical changes in the non-renewable resource between the beginning and the end of the accounting period are:

$$(X_t-X_{t-1}) = (X_t-X'_{t-1}) \equiv \Delta X_t = (X_t-X'_t + X'_t-X'_{t-1}) = I_t - L_t - S_t \qquad (7)$$

24. Using equations (2) and (7), the value of the natural resource between the beginning of period t, given the available information at that time, and the value of the natural resource at the end of the period, given the available information then, can be decomposed as follows:

$$(V_t-V_{t-1}) = (V_t-V'_{t-1}) = (P_tX_t-P_{t-1}X_{t-1}) = P_{t-1}\Delta X_t + X_t\Delta P_t \qquad (8)$$

25. In (8), the change in value of the natural resource (V_t-V_{t-1}) has been decomposed into a quantity effect and a revaluation effect. The quantity effect $P_{t-1}\Delta X_t$ measures the change in

the quantity of the resource valued at the price of the beginning of the period, the revaluation effect $X_t \Delta P_t = X_t(P_t-P_{t-1})$ captures the price change of the resource, multiplied by the quantity at the end of the period.

26. There is an alternative way to de-compose the term $(P_tX_t-P_{t-1}X_{t-1})$, namely with a quantity effect $P_t\Delta X_t$ and a revaluation effect $X_{t-1}\Delta P_t$. Neither is *a-priori* superior to the other, so an arithmetic average of the two effects can be employed:

$$\begin{aligned}(V_t-V_{t-1}) &= 0.5[(P_{t-1} + P_t)\, \Delta X_t + (X_{t-1} + X_t)\, \Delta P_t] \\ &= 0.5(P_{t-1} + P_t)(X_t-X'_t) + 0.5(P_{t-1} + P_t)(X'_t-X'_{t-1}) +(X_{t-1} + X_t)\, \Delta P_t \\ &= 0.5(P_{t-1} + P_t)(I_t - L_t) - 0.5(P_{t-1} + P_t)S_t +0.5(X_{t-1} + X_t)\, \Delta P_t \qquad (9)\end{aligned}$$

27. The final expression for the value of discoveries is then $0.5(P_{t-1} + P_t)I_t$, for the value of catastrophic losses is $0.5(P_{t-1} + P_t)L_t$, for the value of depletion is $0.5(P_{t-1}+ P_t)S_t$ and for revaluation is $0.5(X_{t-1} + X_t)\Delta P_t$. It is of note that the valuation of depletion with the average price of the period is consistent with the rules in the SNA for the valuation of consumption of fixed capital. Also, discoveries and catastrophic losses are valued with mid-period prices, implying an assumption about these events occurring mid-year on average. Finally, it should be pointed out that P_t when estimated by applying the NPV method (4) at the end of period t, takes into account any modifications in the expected extraction profile $\{S_{t+\tau}\}$ $(\tau=1,2,\ldots N_{t+1})$ that may have arisen as a consequence of discoveries or catastrophic losses during the accounting period. P_t thus constitutes the correct valuation of the balance sheet entry for the asset under consideration. P_t will also reflect any other informational changes, for example changes in the discount rate.

Estimating the value of depletion for a renewable asset

28. Unlike non-renewable resources, natural plant and natural animal resources have the potential to reproduce and grow over time and this natural growth enters as an additional flow that determines the evolution of the natural resource over the accounting period. Depletion, in physical terms is the decrease in the quantity of a natural resource that is due to the extraction of the resource occurring at a rate that will not permit the same amount of resource being extracted in all future periods. Depletion is thus determined as a relationship between extraction or harvest and sustainable yield, i.e. the largest amount that can be harvested for a given population size without reducing the long-term viability of the resource. In its simplest form, sustainable yield equals the natural growth of the asset. These issues are discussed in more detail in Section 5.4.

29. For the purpose of this annex, it is assumed that an estimate of sustainable yield can be made and hence an estimate of depletion in physical terms is available. In what follows, sustainable yield in period t will be called G_t. Physical depletion D_t is then estimated as $D_t=S_t-G_t$ and consequently $X'_t-X'_{t-1}=-S_t+G_t$, the (expected) change in the stock that is not due to discoveries or catastrophic losses. Note that the depletion for non-renewable resources can be seen as a special case where $G_t = 0$.

30. It is now possible to enhance expression (7) for the case of renewable natural resources:

$$(X_t-X_{t-1}) = (X_t-X'_{t-1}) \equiv \Delta X_t = (X_t-X'_t + X'_t-X'_{t-1}) = I_t - L_t - S_t + G_t \qquad (10)$$

31. Following the derivations for non-renewable natural resources, monetary depletion is physical depletion valued at average prices of the period, $0.5(P_{t-1} + P_t)D_t$.

32. In summary, the entries between the beginning and end of the accounting period, t, are as follows.

Closing balance sheet item of period t-1 based on information available at end of t-1:	$V'_{t-1}=P'_{t-1}X'_{t-1}$
+ Discoveries (and other additions):	$0.5(P_{t-1} + P_t)I_t$
- Depletion:	$- 0.5(P_{t-1} + P_t)(S_t-G_t)$
Of which due to natural growth	$0.5(P_{t-1} + P_t)G_t$
Of which due to extraction	$- 0.5(P_{t-1} + P_t)S_t$
- Catastrophic losses (and other reductions)	$-0.5(P_{t-1} + P_t)L_t$
+ Revaluation due to price changes:	$0.5(X_{t-1} + X_t)\Delta P_t$
Equals closing balance sheet item of period t based on information available at end of t:	$= V_t = P_tX_t$

Net income and depletion

33. As a final step, the value of depletion can be subtracted from the resource rent to yield an expression for the depletion-adjusted resource rent:

$$\text{Depletion-adjusted resource rent} = RR_t - 0.5(P_{t-1}+P_t)(S_t- G_t) \qquad (11)$$

34. The depletion-adjusted resource rent represents the net income generated by the natural resource. Putting aside any changes in expectations or differences between expected and realized variables, it corresponds to a return to capital or return to natural resources. This can be demonstrated as follows. Multiplying V'_{t-1} by $(1+r_t)$, subtracting V'_t (the expected value of the asset at the end of the period) and applying the NPV condition (1) yields

$$V'_{t-1}(1+r_t)-V'_t=RR'_t \qquad (12)$$

35. Note that all expressions are in terms of the information set at the end of period t-1 and, hence, discoveries and catastrophic losses are ignored. Combined with (9), one obtains

$$RR_t = r_tV'_{t-1}-(V'_t-V'_{t-1}) = r_tV'_{t-1} - 0.5(X'_{t-1}+X'_t)\Delta P'_t + 0.5(P'_{t-1}+P'_t)(S_t-G_t) \qquad (13)$$

36. The depletion-adjusted resource rent is then

$$RR_t - 0.5(P'_{t-1}+P'_t)(S_t- G_t) = r_tV'_{t-1} - 0.5(X'_{t-1}+X'_t)\Delta P'_t \qquad (14)$$

37. Thus, net income consists of the nominal return to capital, $r_tV'_{t-1}$ less (expected) revaluation of the asset. This does not imply that revaluation enters the measurement of income. It should be remembered that r relates to the returns that an investor or shareholder would *expect* from the use of an asset in production, i.e. it is a forward looking rate. Whether, ultimately, these returns come from normal business operations or from holding gains/losses is irrelevant to the (financial) investor. Hence, conceptually, the expected rate

of return r *includes* expected holding gains or losses. Therefore, to get to an income measure consistent with the definition of income in the national accounts[68], revaluations must be subtracted. After subtraction, expression (14) shows the return from 'normal business operations' excluding holding gains or losses.

38. The derivations above are valid for both renewable resources and the limiting case of non-renewable resources. When there is depletion, the term S_t - G_t will increase in absolute terms with a rising rate of depletion. In general, the quicker the resource is depleted, the higher will be the price change of the resource in the ground. When natural growth exceeds extraction, depletion should be recorded as zero and the excess amount added to additions of stock.

39. It should be noted that the specifications above leave no ambiguity about the valuation of stocks and flows:
    - The input of natural resources into production, the extractions, should be valued at the unit resource rent P_{st}.
    - The value of the stock of natural resources, and flows concerning depletion should be valued using the price of the asset *in situ*. (P_t)

Volume measures

40. With the price, quantity and value of the natural resource in situ in hand, it is fairly straight forward to compute a volume measure of the stock of natural resources. In the case of a single homogenous asset, the volume measure simply equals the evolution of the physical quantity in the ground, $\{X_t\}$. In the case of different types of natural resources, an aggregation procedure must be identified to construct a volume index across different types of natural assets.

41. The balance sheet entry for the value of natural resources at the end of year t-1 in end-year prices of t-1 is simply $\Sigma^z_{i=1} P^i_{t-1} X^i_{t-1}$ if there are z different types of assets. Assuming a chain Laspeyres index as is customary in the national accounts, the volume change between t-1 and t is then given by:

    $$\text{Volume change} = \Sigma^z_{i=1} P^i_{t-1} X^i_t / \Sigma^z_{i=1} P^i_{t-1} X^i_{t-1} \quad . \qquad (14)$$

[68] See OECD (2009) section 8.3.2 for a more detailed discussion in the context of produced assets.

Annex A5.2: Discount rates

<u>Introduction</u>

1. In the SEEA, a discount rate is a rate of interest used to adjust the value of a stream of future flows of revenue, costs or income such that the value of future flows can be compared with the value of flows in the current period.
2. Underpinning the use of discount rates is the concept that the value of money in the future is not the same as the value of money now. A common explanation of this concept is to consider how much money would be needed now to purchase a given amount of goods and services in one year's time.
3. This question may be answered by considering the interest rate at which a consumer should invest their money now in order to earn sufficient interest over one year to purchase the goods and services in one year's time. The consumer may then make a choice as to whether they consume the goods and services in the current period or wait, earn the interest from investing the money, and purchase the goods and services in one year's time. In making this choice the consumer indicates a time preference and the extent of the preference is given by the interest rate, or discount rate. A lower discount rate will apply if the consumer is relatively indifferent between receiving the benefits of consumption now or in one year's time. A higher discount rate will apply if the consumer has a stronger preference for consumption in the current period.
4. When time preferences are seen not from the perspective of an individual consumer but from the perspective of society, they entail comparisons of welfare across different generations. There is no immediate reason that the time preferences of individuals and society should coincide.
5. Discount rates are also affected by risk preferences and there is the question as to whether consumption foregone in the current period will induce more or less utility in future periods. Again, these two factors may be valued differently by individuals and society as a whole.
6. The application of the general concept of a discount rate to economic problems has generated much discussion (as yet unresolved) by many economists (e.g. Arrow, Nordhaus and Stiglitz, *et al.*). The choice of discount rate has become a feature of discussion in environmental economics because of the impact that the choice of discount rate has on models of economic outcomes over long periods of time and because of the ability to ascribe ethical underpinnings to the choice of discount rates and the nature of the assumed preferences.
7. This annex explains, in broad terms, the key aspects of the discussion on discount rates and the logic of the choice of discount rate that aligns with the SEEA's approach to valuation in monetary terms.

Types of discount rates

8. There are two broad types of discount rates: individual discount rates and social discount rates. They are quite distinct in concept. An individual discount rate considers preferences from the perspective of an individual consumer or firm and is directly related to the prices for goods, services and assets faced by the individual. In addition, the preferences are generally considered within the normal decision making timeframes of an individual consumer or firm. Finally, the discount rate relevant to an individual consumer or firm needs to take into account the likelihood of earning interest (or more generally a return) such that consumption can be undertaken in the future. Put differently, if an individual faces a smaller likelihood of making a return then they should seek a higher discount rate to compensate for this risk.

9. A social discount rate concerns the time and risk preferences of a society as a whole. Unlike individuals, societies must consider future generations to a greater extent and must also balance the benefits accruing to different sections of society in current and future periods (i.e. the distribution of income and consumption). In addition the risks of earning returns are far more dispersed and balanced at a societal level that for an individual and hence the compensation for risk will usually be lower for a society as a whole. Often, social discount rates are applied in a government context in relation to their decision making on behalf of a society.

10. A useful characterisation of the difference between individual and social discount rates is to consider that discount rates can take into account preferences in terms of both efficiency and equity. Generally speaking, individual discount rates take into account only aspects of efficiency in the allocation of resources over time from the perspective of an individual consumer or producer. On the other hand, social discount rates may consider only aspects of efficiency or may take into consideration aspects of both efficiency and equity between societies or between generations. Most discussion on discount rates revolves around the equity aspects – either due to the fact that they are not taken into account at all (e.g. in individual discount rates) or due to the philosophical basis for assumptions concerning equity that underlie a social discount rate.

11. Another characterisation of the difference between individual and social discount rates is in terms of descriptive and prescriptive discount rates. A discount rate determined on a descriptive basis is based only on prices faced by individuals and governments or other measureable factors; whereas a prescriptive discount rate incorporates assumptions regarding the preferences of individuals and societies particularly regarding equity between and within current and future generations.

Individual discount rates

12. The determination of discount rates for individuals focuses on information concerning the return needed by the individual consumer or firm to justify investment in the current period with the aim of receiving income or other benefits in the future. Relevant considerations are the expected returns an individual may earn by investing in different assets and the

degree of risk associated with different investments. Under pure market conditions it would be expected that the price of an asset (e.g. a building) would reflect the expected returns to the purchaser over the life of the asset and would take into account the likelihood of earning the income (i.e. the degree of risk). Thus there is a link between the choice of discount rates and the concept of market prices for assets.

13. In the SEEA, as in the SNA, the application of discount rates is in the valuation of assets not traded on markets. For these assets, market prices are not available and the technique of net present value (see Annex A5.1) can be used to estimate market prices. This technique requires the choice of a discount rate. The selection of a descriptive discount rate that considers only the prices faced by an individual consumer or firm, that relates to the expected returns, and accounts for the degree of risk associated with the investment, is the most appropriate discount rate in order to align with the market price valuation principle used in the SEEA.

14. For individual consumers and firms a relevant discount rate may be reflected in the cost of funds to the individual. Thus the interest rates needed to finance an investment either through loans, equity issues or the issue of corporate bonds may be appropriate discount rates that reflect the rate of return needed by the individual and also the degree of risk in the investment as assessed on the market. However, at the more aggregate level at which the SEEA operates, taking into account the variety of ways in which investment is financed and targeting the financing method to the valuation of specific non-traded assets makes the financing cost approach difficult to apply across individual firms within an industry, particularly if financial markets are not well developed within a country. It is also noted that returns to financial instruments, particularly equities, may be influenced by many external factors thus limiting their appropriateness in the valuation of non-traded assets.

15. The other approach to the estimation of a discount rate is to consider information on the actual returns accruing to specific activities, e.g. mining activity, where the related income streams all have similar risk profiles. This may be done by considering national accounts information on the operating surplus of relevant firms and the associated stock of produced assets. Underpinning this approach is the idea that the total operating surplus is the return to the firm for their use of a combination of produced assets, e.g. mining equipment, and non-traded natural resources.

16. Ideally, if the value of the relevant natural resources was known, the implied rate of return (total operating surplus divided by total value of assets) would apply to both produced assets and natural resources. However, since the value of the natural resources is unknown two alternatives must be considered. First, for a specific activity (e.g. coal mining) a rate of return equal to the total operating surplus divided by the value of the stock of produced assets can be calculated and the rate of return on natural resources and the discount rate can be set equal to this rate. By the manner of its construction this rate will overstate the rate of return since the denominator (the value of the stock of produced assets) excludes the value of natural resources. At the same time, this rate of return does take into account the returns accruing to the specific activity and hence the associated risks.

17. The second approach is to assume that the rate of return on produced assets should be equal to an external rate of return that the firm would have received if they had invested in alternative assets. This rate is then assumed to apply also to the natural resources. Since this rate of return takes into account investment in a broader range of assets across the economy, the industry specific risks of investment are less likely to be taken into account.

18. Although both of these relatively direct methods do not generate a discount rate that completely measures the desired concept, a comparison of both rates may yield useful information. In particular, a useful approach may be to use a general, external rate of return as a base rate and to adjust it using industry specific information to account for specific investment risk. Adjustments may be made on the basis of relative financing costs or the relative difference in the return to produced assets in the target industry compared to an economy wide return to produced assets.

19. It is noted that, in the valuation of assets owned by individual firms, the choice of external rate under the second approach should take into account some degree of risk, even if only general economy wide risks of investment. Often the use of relatively risk free rates of return is suggested, such as the rate of return on long-term government treasury bonds, but these rates take no account of individual risks that are faced in determining consumption and investment preferences.

Social discount rates

20. Social discount rates are used in the context of evaluating actions and assets that have value from the perspective of a society as a whole. Often this is applied in the assessment of government decisions and social discount rates are used to evaluate the costs and benefits of investment in public infrastructure since both the benefits and the costs are usually spread across many individuals and over long periods of time. However, social discount rates can also be used to provide social valuations of assets owned and operated by individuals and firms.

21. As noted above, both descriptive and prescriptive approaches may be taken to the determination of an appropriate social discount rate. A descriptive approach follows the same logic as for the determination of individual discount rates in that the rate is determined through a focus on the prices and returns relevant to the society rather than any explicit consideration of equity issues.

22. Prescriptive social discount rates that take into account equity considerations cannot be determined following the logic applied to individual discount rates. Rather, consideration must be given to the relative preferences of current and future generations and, ideally, to the relative preferences of different sections of society. A common approach by economists to determining prescriptive social discount rates is to apply the Ramsey growth model (Ramsey 1928) which takes specific account of consumption and saving choices for an economy as a whole. This model has underpinned many recent works on evaluating the impacts of environmental issues, in particular the 2006 Stern Review in the United Kingdom into the economic impacts of climate change. (Reference needed).

23. The formula for a prescriptive discount rate that emerges from the Ramsey model requires information or assumptions regarding (i) the "pure" rate of time preference, (ii) the rate of growth in per capita consumption and (iii) the extent to which the extra benefits to people from consumption decrease as their income increases (the marginal utility of income). The second and third terms are multiplied together and then added to the first term to derive the discount rate.

24. Much discussion on prescriptive social discount rates has focused on the first term which asks the question as to whether the preferences of current generations are more important than those of future generations. If the value of the first term is set to zero then the assumption is that all generations' preferences have equal weight. This assumption is distinctly at odds with the underlying premise of individual discount rates in which there is an underlying assumption that the present year (let alone the present generation) is always preferable (unless there is suitable return). The implications of choices for the pure rate of time preference are discussed in the next section of this annex.

25. A common misconception is that setting a zero "pure" rate of time preference implies a discount rate of zero. In fact, following the Ramsey model there are two other assumptions that need to be considered. Generally, it is understood that as income rises, the extra or marginal benefits that a person receives from spending additional income decline. Put differently, someone on a low income gains greater benefit from spending a dollar than someone on a higher income. When the same concept is considered over time, then if an individual in the future is assumed to have a higher level of income than someone today, it would be the case that they would get relatively lower benefit from spending that additional income compared to someone spending the same amount today. Thus even assuming all peoples' preferences are the same, there may still be an overall preference in consumption now because the marginal benefits from undertaking the same consumption in the future are lower (assuming growth in incomes). Different choices for the rates of growth in income and consumption and in the marginal utility of income will lead to different (non-zero) estimates of the social discount rate following the Ramsey model.

26. A different approach to taking into account the preferences of future generations is the use of declining discount rates. Different models may be used and there is mention in the literature of hyberbolic discount rates, gamma discounting and geometrically declining rates. Simple step functions have also been proposed whereby the discount rate is set at progressively lower levels as one moves away from the current period. The general aim of declining discount rates is to counter an impact of constant rate discounting that implicitly fixes the relationship of the preferences across generations. Declining rates effectively give relatively larger preferences to future generations than would otherwise be implied (although the preferences of future generations generally have less weight than those of current generations). The exact relationship depends on the function assumed for the pattern of decline.

Estimates of discount rates

27. In practice, the approaches to the selection of discount rates vary widely. Both prescriptive and descriptive approaches are often used and within both approaches a wide variety of solutions are adopted. It seems generally to be the case that those rates determined on a more prescriptive basis are lower than rates determined on a descriptive basis but this is not always the case.

28. An important consideration is whether the discount rate should be in real or nominal terms. A real discount rate is one that has been adjusted to remove the impact of inflation whereas a nominal discount rate has not had any such adjustment. The choice depends on the assumptions made in relation to the future flows. If the future flows, say of income, are measured in terms of the prices of the period to which they relate (e.g. an income flow for 2050 is in terms of 2050 prices), then the flow is said to be in nominal terms and a nominal discount rate should be used.

29. However, if the flows are expressed in terms of prices of the current period, then a real discount rate should be used. Since it is very difficult to project prices into the future, a common assumption is that the future flows are the same as the flows in the current period and, if this assumption is made then a real discount rate should be used.

30. The choice of discount rate – however determined – can have a significant impact on the value of an asset. Table A5.2.1 shows the differences in the value of an asset at different discount rates for a different length of asset life. Assuming that the income flow is \$100 per year, then over 10 years, the net present value (see Annex 5.1) can range from \$614 for a discount rate of 10% to a value of \$853 for a discount rate of 3%. Over 100 years the differences are even more stark, with the NPV of \$1000 for a discount rate of 10% but an NPV of \$3160 for a discount rate of 3%.

31. Of particular note is that for higher discount rates, increasing the asset life has little impact on the total current net present value of the asset. That is, there is relatively little difference in the NPV for an asset that has a life of 30 years or one of 100 years at higher discount rates.

Table A5.2.1: Net present value (\$) for constant income flow of \$100 over varying asset lives and at varying discount rates

		Asset life (years)			
		10	**30**	**50**	**100**
Discount rate	**3%**	853	1960	2573	3160
	5%	772	1537	1826	1985
	8%	671	1126	1223	1249
	10%	614	943	991	1000

Analytical implications of the choice of discount rate

32. The implications of the choice of a discount rate may be seen in a number of ways. First, the choice of approach to selecting a discount rate may provide an area of concern for users. The selection of a descriptive approach consistent with market valuations may generate concern that equity issues – especially those across generations – are not being adequately considered. At the same time, the selection of a prescriptive approach may raise concern about the role of statisticians in selecting implicit societal preferences.

33. Second, various interpretations may be made concerning the estimates derived based on particular discount rates. For example, there may be concerns about the use of relatively high discount rates (usually attributed to the use of market based approaches) since these give relatively lower values to long lived assets, such as many natural resources, and this may imply a preference for either immediate use of the resources or a preference for substitution with produced assets.

34. At the same time, the use of market based approaches to the determination of the discount rate permits a stronger parallel to be drawn with the valuation of produced assets and hence trade-offs between assets can be more consistently considered. In this regard the estimation of concepts such as national net worth can be consistently estimated across all asset types. Also, the use of a market-based descriptive approach does not necessarily ignore inter-generational and equity issues.

35. A general concern on the use of market based discount rates is that they tend to be relatively higher rates which in turn tend to provide relatively low values in absolute terms beyond normal planning timeframes, say 30 years. Thus for long lived and potentially everlasting resources, the use of relatively lower rates will tend to recognise values for these resources into the future to a greater extent. Independent of any implied societal preferences, lower discount rates may therefore better reflect the likely values of these resources. Also, especially for environmental resources, the recognition of values over a longer time period may assist in understanding the problem that while the benefits received from the environment tend to be received immediately, the costs to the environment may only be evidenced much later. The use of declining discount rates may be a way to deal with these issues.

Conclusions

36. For the purposes of the SEEA it is recommended that a discount rate be determined that is consistent with the general approach to valuation in the SEEA and the SNA, i.e. consistent with valuation at market prices. This suggests the choice of an individual discount rate which reflects the return needed by those undertaking an activity to justify investment in that activity. Consequently the relevant rate should be descriptive and, ideally, adjusted for any activity specific risks.

37. The derivation of an activity specific rate of return is difficult in the case of natural resources because the value of the natural resources is not known. Nonetheless, relevant

discount rates should be able to be determined on the basis of national accounts data and financial sector information.

38. Because judgements are required regarding societal preferences, it is not recommended that prescriptive approaches to the determination of discount rates be used for the purposes of official statistics.

39. Different discount rates can be selected under any approach to the determination of discount rates for valuing environmental assets. Given the significance of the choice of discount rate it is recommended that sensitivity analysis using different discount rates be undertaken in the compilation of valuations of environmental assets using the net present value approach. The varying estimates may be published to provide users with information on the impact of the choice of discount rate.

Annex A5.3: Description of the UN Framework Classification for Fossil Energy and Mineral Reserves and Resources 2009 (UNFC 2009)

1. The UNFC-2009 categorizes mineral and energy resources by looking at whether, and to what extent, projects for the extraction or exploration of the resources have been confirmed, developed or planned. Based on the maturity of the projects the underlying natural resources are classified. The UNFC-2009 is based on a breakdown of the resources according to three criteria affecting their extraction:
    - Economic and social viability (E)
    - Field project status and feasibility (F)
    - Geological knowledge (G)
2. The first criteria (E) designates the degree of favourability of economic and social conditions in establishing the commercial viability of the project. The second criteria (F) designates the maturity of studies and commitments necessary to implement mining plans or development projects. These extend from early exploration efforts before a deposit or accumulation has been confirmed to exist through to a project that is extracting and selling a product. The third criteria (G) designates the level of certainty in the geological knowledge and potential recoverability of the quantities.
3. Each criteria, E, F and G, is sub-divided into categories characterizing the projects for exploring and extracting the resource. The categories for the economic and social criteria are numbered from E1- E3.
    - The category E1 includes projects where extraction and sale is economically viable, i.e. the extraction is assumed to be economic on the basis of current market conditions and realistic assumptions of future market conditions. It includes considerations of prices, costs of the legal and fiscal framework, and various environmental, social and other non-technical factors that could directly impact the viability of a development project. The economic viability is not affected by short-term adverse market conditions provided that longer-term forecasts remain positive.
    - For projects falling into category E2, extraction and sale has not yet been confirmed to be economic but, on the basis of realistic assumptions of future market conditions, there are reasonable prospects for economic extraction and sale in the foreseeable future.
    - For E3 extraction and sale is not expected to become economically viable in the foreseeable future or evaluation is at too early a stage to determine economic viability.
4. The categories for project status and feasibility are numbered F1 – F4 with further sub-categories in some cases.
    - The category F1 includes projects where extraction is currently taking place (F1.1); or capital funds have been committed and implementation of the

development project or mining operation is underway (F1.2); or sufficiently detailed studies have been completed to demonstrate the feasibility of extraction by implementing a defined project or mining operation (F1.3).

- Both F2.1 and F.2.2 includes projects where the feasibility of extraction is subject to further evaluation. For F2.1 project activities are ongoing to justify development in the foreseeable future; and for F2.2 project activities are on hold and/or justification as commercial development may be subject to a significant delay. F2.3 indicates that there are no current plans to develop or to acquire additional data at the time due to limited potential.
- F3 indicates that the feasibility of extraction by a defined development project or mining operation cannot be evaluated due to limited technical data.
- F4 indicates that no development project or mining operation has been identified.

5. The categories for geologic knowledge are numbered G1-G4. Quantities associated with a high level of confidence (or low level of uncertainty) are classified as G1, quantities associated with a moderate level of confidence are classified as G2 and quantities associated with a low level of confidence as G3. Quantities associated with a potential deposit based primarily on indirect evidence are classified as G4.

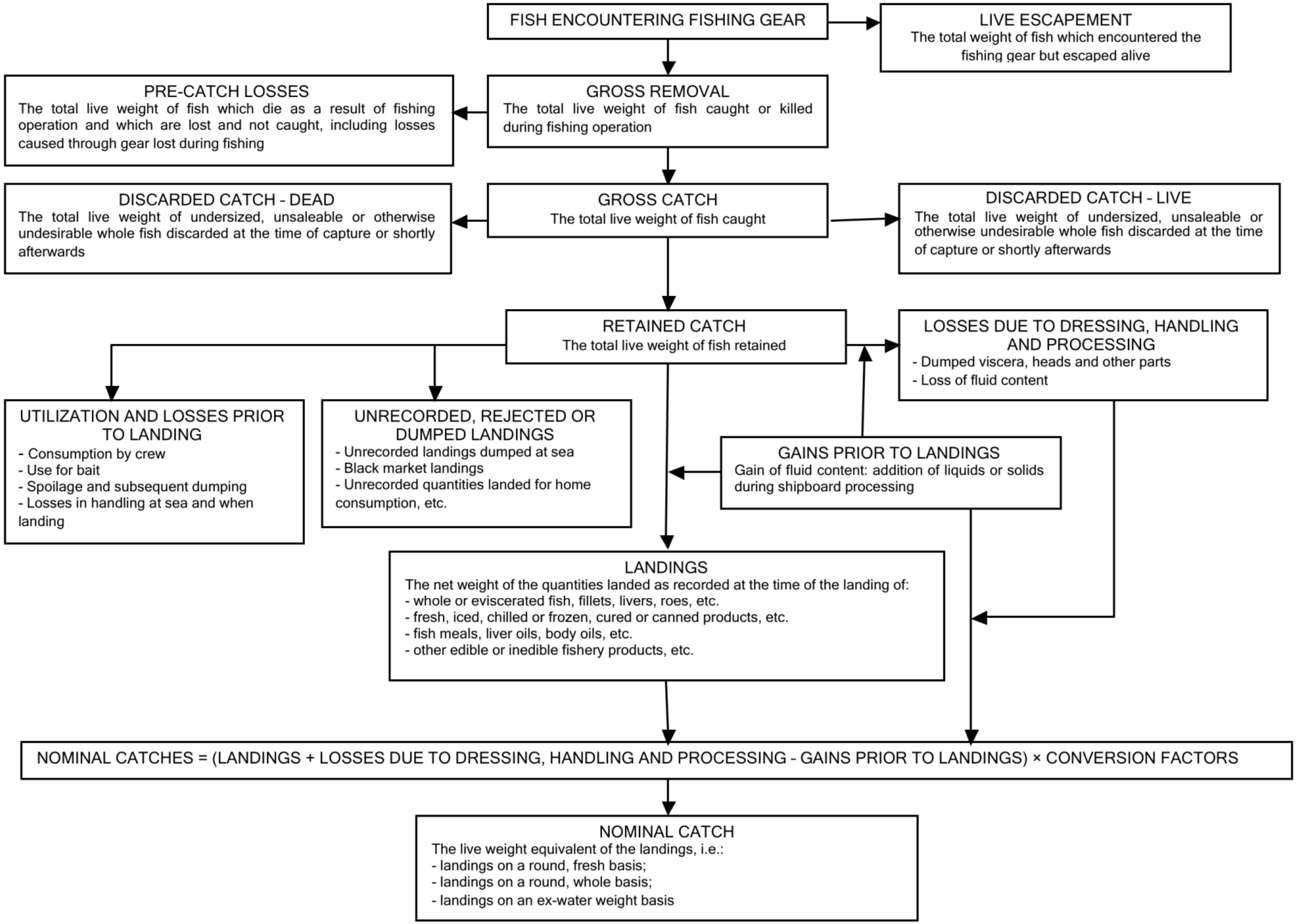
Annex A5.4 Land use classification

	LAND
	Agriculture
	Land under temporary crops
	Cereals
	Vegetables and melons
	Temporary oilseed crops
	Root/tuber crops with high starch or insulin content
	Temporary spice crops
	Leguminous crops
	Sugar crops
	Other temporary crops
	Land under temporary meadows and pastures
	Land with temporary fallow
	Land under permanent crops
	Fruit and nuts
	Permanent oilseed crops
	Beverage and permanent spice crops
	Other permanent crops
	Land under permanent meadows and pastures
	Cultivated permanent meadows and pastures
	Naturally grown permanent meadows and pastures
	Land under protective cover
	Forestry
	Forest land
	Primary regenerated forest
	Other naturally regenerated forest
	Planted forest
	Other wooded land
	Land used for aquaculture
	Land used for hatcheries
	Managed grow-out sites on land
	Use of built-up and related areas
	Mining and quarrying
	Construction
	Manufacturing
	Technical infrastructure
	Transport and storage
	Commercial, financial and public services
	Recreational facilities
	Residential
	Land used for maintenance and restoration of environmental functions
	Other uses of land n.e.c.
	Land not in use
	INLAND WATER
	Inland waters used for aquaculture or holding facilities
	Inland water used for maintenance and restoration of environmental functions
	Other uses of inland water n.e.c.
	Inland water not in use

Other Classes for extended measurement scope

	INTERNAL WATERS
	Internal waters used for aquaculture or holding facilities
	Internal waters used for maintenance and restoration of environmental functions
	Other uses of internal waters n.e.c.
	Internal waters not in use
	EXCLUSIVE ECONOMIC ZONE
	EEZ areas used for aquaculture or holding facilities
	EEZ areas used for maintenance and restoration of environmental functions
	Other uses of EEZ areas n.e.c.
	EEZ areas not in use

Annex A5.5 Catch concepts: Diagrammatic presentation (from Integrated Environmental and Economic Accounting for Fisheries, 2004)



REVISION OF THE SYSTEM OF ENVIRONMENTAL - ECONOMIC ACCOUNTS (SEEA)

United Nations Committee of Experts on Environmental Economic Accounting (UNCEEA)

Statistics Division / Department of Economic and Social Affairs, United Nations

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Chapter 6: Integrating and presenting the accounts

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6.1 Introduction

6.1 Environmental and economic information is important in the assessment of a range of contemporary environmental and economic policy and research questions. Beyond the provision of relevant information, a primary motivation of the SEEA is the effective integration of the vast amount of environmental and economic data. It also assists with the integration of social data, such as demographic and labour statistics.

6.2 This chapter shows the potential for information to be organised and integrated within the SEEA framework. The integration can take a number of forms. At a first level it can mean the presentation of information using common formats and classifications. At a second level, the framework can be used to provide a range of descriptive statistics and indicators of environmental pressures, states and responses. At a third level, data integrated using the SEEA framework can be used to construct analytical models for the analysis of consumption and production patterns, including for example, consumption footprint type indicators.

6.3 The focus in this chapter is on the first two levels of integration – the organisation of information, in particular the compilation of combined physical and monetary accounts, and the presentation of descriptive statistics and indicators. The accounts in the SEEA Central Framework are built in such a way as to fully support analytical uses. SEEA Extensions and Applications discusses the use of information from the SEEA framework to build analytical models and for other similar purposes in more detail.

6.4 It is not necessary to complete an exhaustive physical supply and use table for every material, or to compile asset accounts for every environmental asset. The intention of the SEEA is that supply and use tables, asset accounts and other parts of the SEEA are used as an organising framework, depending on the intended analysis and the availability of data. Therefore, for many applications it is legitimate to integrate a limited set of information.

6.5 At the same time, many environmental concerns involve many countries and hence the compilation of comparable data and accounts for common areas of concern is an important motivation for the development of this international standard.

6.6 In Section 6.2, the chapter commences with a description of the four key areas of integration within the SEEA framework: physical and monetary supply and use tables, asset accounts, the full sequence of economic accounts, and functional accounts.

6.7 Section 6.3 introduces the general concept of combining physical and monetary data within in the SEEA framework to form combined physical and monetary presentations or accounts. It then goes on to provide guidance on the basic organisation and presentation of environmental and economic information. In this regard, it is noted that one motivation for the organisation of information following the SEEA framework is for the improvement of data quality through data confrontation in an accounting framework. In particular, there can be benefits for data compilation through the confrontation of estimates measured in physical and monetary terms.

6.8 Section 6.4 provides guidance on the derivation of a range of descriptive statistics and environmental-economic indicators from information organised within the SEEA framework. The scope of the statistics and indicators covered in this section is limited to those that are either aggregates or totals within the core accounts and tables of the SEEA framework, or that are easily derived from different parts of the SEEA framework without the use of weighting or other complex assumptions. The statistics and indicators presented are not intended to reflect an exhaustive set since ultimately the selection of statistics and indicators is dependent upon policy or research questions.

6.9 The final section, Section 6.5, provides a general structure for combined presentations of physical and monetary data and then four examples of combined presentations, namely for energy products, water flows, air emissions, and forest products. These examples aim to provide an indication of the potential of the SEEA framework to provide information for analytical purposes.

6.10 This potential is further demonstrated in SEEA Extensions and Applications which provides introductory material on a number of different ways in which data from the SEEA framework can be used to support more detailed analytical techniques and specific thematic investigation. The areas covered in SEEA Extensions and Applications include input-output modelling, structural decompositions of environmental-economic information and the analysis of sustainable production and consumption patterns.

6.2 Integration within the SEEA framework

6.2.1 Introduction

6.11 The strength of the SEEA framework arises from the consistent application of accounting rules, principles, and boundaries in the organisation of environmental and economic information in both physical and monetary terms. Consequently, the SEEA accounts and tables can add considerable value to the underlying statistical information. The nature of the integration of the various components within the SEEA framework is outlined in summary terms in Chapter 2. This section provides additional detail on the integrated SEEA framework across the four key areas of integration within the SEEA framework.

6.12 The first key area of integration is the link between measures of flows of goods and services in physical and monetary terms as reflected in monetary and physical supply and use tables. An important part of this integration involves recording physical flows of natural inputs from the environment and flows of residuals generated through economic activity. The use of common product and industry classifications and consistent definitions and measurement boundaries is important in optimising the potential for analysis.

6.13 The second key area of integration is the link between changes in the stock of environmental assets over an accounting period and the use of extracted natural resources as an input to economic production, consumption and accumulation. The connection between asset accounts and supply and use tables is of interest in this area.

6.14 The third key area of integration is the connection between the measures of production, consumption and accumulation in monetary terms and measures of flows of income between different sectors. These sectoral flows of income are reflected in a sequence of economic accounts and balancing items such as value added and saving. Importantly, the SEEA adjusts these balancing items for depletion such that estimates of the monetary cost of using up natural resources can be deducted from conventional economic aggregates such as GDP and saving to form depletion adjusted aggregates.

6.15 The fourth key area of integration concerns the identification of economic activities undertaken with an environmental protection or resource management purpose in functional accounts. Generally, these activities are not clearly identified using conventional classifications of industries and products. By identifying these activities within the conventional national accounting framework the significance of environmental activities can be assessed in comparison to key economic aggregates such as GDP, value-added, capital formation, and employment.

6.2.2 Integration of supply and use tables in physical and monetary terms

6.16 The integration of supply and use tables in physical and monetary terms centres on the use of common classifications for the measurement of flows of products and the use of common boundaries between the economy and the environment. Consequently, flows recorded in monetary terms that focus on the exchanges of products between economic units are, in broad terms, the same set of flows of products measured in physical terms.

Physical flows of natural input and residuals are not available in monetary terms but since the measurement boundaries for these flows are aligned with measurement boundaries for product flows, the addition of natural input and residual flows in the SUT framework does not compromise the recording of flows relating to products.

6.17 As described in Chapter 3, there are some exceptions to the general consistency of the recording of flows in physical and monetary terms.

i. In cases where goods are sent abroad for processing, the monetary supply and use tables record transactions related to the service provided by the processing country. In physical terms the actual physical flows of the goods should be recorded.

ii. In some cases it may be of interest to record physical flows of materials, energy and water and their transformation into other products within an establishment. In monetary terms, only flows between establishments are recorded and hence the value of these intra-establishment flows are not shown in the monetary supply and use tables.

6.18 It is also noted that depending on the purpose and focus of the accounts being compiled, there may be interest in more fully describing flows associated with household production for own-use than would be the case in the compilation of supply and use tables in monetary terms for general economic analysis.

6.19 The alignment of supply and use tables in physical and monetary terms is shown in Table 6.2.1. This is an extension of the general physical supply and use table described in Chapter 3 (Table 3.2.1). The key areas of integration are the use of the same classifications for industries and products and the use of common groupings of economic units – enterprises represented by industries, households, and the rest of the world.

6.20 The integration of supply and use tables in physical and monetary terms is the basis for the compilation of extended supply and use and input-output tables that are often used in environmentally extended input output analysis.

Table 6.2.1 Supply and use tables in physical and monetary terms

SUPPLY in monetary terms							
	Production (incl. household production on own account)				**Flows from the Rest of the World**		**Total**
	Industries – classified by ISIC						
Products	Domestic production				Imports of products		
Total							
USE in monetary terms							
	Intermediate consumption	**Final consumption**		**Accumulation**	**Flows to the Rest of the World**		**Total**
	Industries – classified by ISIC	**Households**	**Government**				
Products	Intermediate consumption	Household final Consumption	Government final consumption	Gross Capital Formation	Exports of products		
Total							
SUPPLY in physical terms							
	Production; Generation of residuals			**Accumulation**	**Flows from the Rest of the World**	**Flows from the Environment**	**Total**
	Industries (including household production on own account) – classified by ISIC	**Generation of residuals by households**					
Natural inputs						Flows from environment	
Products	Domestic production				Imports of products		
Residuals	Residuals generated by industry Residuals generated following treatment	Residuals generated by household final consumption		Residuals from scrapping of produced assets Emissions from landfill sites	Residuals received from rest of the world	Residuals recovered from the environment	
Total							
USE in physical terms							
	Intermediate consumption; Use of natural inputs; Collection of residuals	**Final consumption**		**Accumulation**	**Rest of the World**	**Environment**	**Total**
	Industries – classified by ISIC						
Natural inputs	Extraction of natural inputs						
Products	Intermediate consumption	Household final consumption		Gross Capital Formation	Exports of products		
Residuals	Residuals received by waste mgt and other industries			Accumulation in controlled landfill sites	Residuals sent to the rest of the world	Residual flows direct to environment	
Total							

6.2.3 Integration of asset accounts and supply and use tables

6.21 The integration of information from asset accounts and supply and use tables is of particular relevance in the analysis of natural resources. For example, the assessment of the stock of fish resources will focus not only on extractions of fish relative to the available stock but also on the relationship between the extraction and other flows. Thus, there will be interest in so-called forward linkages that consider the extraction of fish in relation to the supply and use of fish products in the economy and associated international trade in fish products. And there will be interest in backward linkages to understanding the production processes associated with cultivated or natural fish resources, investment in boats and fishing gear by the fishing operators, and the extent of expenditure on resource management associated with fisheries. The integration of data from asset accounts and supply and use tables can structure information to consider these types of links and similar considerations are relevant in the analysis of other natural resources.

6.22 Asset accounts present information on the stock of environmental assets at the beginning and end of an accounting period and on the changes in the stock over the period. The changes may be of many types. They may be due to economic activity (e.g. extraction of natural resources) or due to natural flows (e.g. losses of environmental assets following natural disasters).

6.23 The relationship between these flows and the flows recorded in the supply and use tables are shown in Table 6.2.2. Changes due to economic activity are recorded consistently in both the asset accounts and the supply and use tables since extraction represents both a reduction in stock (an asset account entry) and a use of natural inputs (an entry in the physical supply and use table). For environmental assets this consistency is ensured by defining individual natural resources for the purposes of asset accounting in the same way as natural resource inputs in the physical supply and use table. This table is described further in Chapter 2 and the measurement issues associated with the individual flows are described in detail in Chapters 3 and 5.

Table 6.2.2 Connections between supply and use tables and asset accounts

						ASSET ACCOUNTS (Physical & Monetary terms)	
		Industries	**Household**	**Government**	**Rest of the world**	**Produced assets**	**Environmental assets**
						Opening stock	
MONETARY SUPPLY AND USE TABLE	**Product - supply**	Output			Imports		
	Product - use	Intermediate consumption	Final consumption	Final consumption	Exports	Gross Capital Formation	
PHYSICAL SUPPLY AND USE TABLE	**Natural inputs – supply**						Extracted natural resources
	Natural inputs – use	Extraction of natural resources					
	Product - supply	Output			Imports		
	Product - use	Intermediate consumption	Final consumption		Exports	Gross Capital Formation	
	Residuals - supply	Residuals generated by industry	Residuals generated by household final consumption			Residuals from scrapping and demolition of produced assets	
	Residuals - use	Collection & treatment of waste and other residuals				Accumulation of waste in controlled landfills	Residuals flowing to the environment**
						Other changes in assets (e.g. natural growth, discoveries, catastrophic losses, revaluations)	
						Closing stock	

* Note: Grey cells are null by definition. Blank cells may contain relevant flows. These flows are articulated in detail in Chapter 3.
** While these residual flows are not flows of environmental assets they may impact on the capacity of environmental assets to deliver benefits.

6.2.4 The full sequence of economic accounts

6.24 In monetary terms, monetary supply and use tables and asset accounts record much of the information of interest in the assessment of the interactions between the economy and the environment. However, there are a range of other monetary transactions and flows that are of interest such as payments of rent for the extraction of natural resources and subsidies and grants from government units to other economic units to support environmental protection activity.

6.25 The SNA records all of these flows in a presentation referred to as the full sequence of accounts. A particular feature of the sequence of accounts is the presentation of balancing items. Balancing items are calculated as the total value of all inflows to economic units grouped into institutional sectors less the total value of all outflows from the same group of economic units. The balancing items provide information in their own right but also link the sequence of accounts together. Key balancing items include value added, operating surplus, and saving. Economy wide aggregates can also be constructed such as gross domestic product and gross national income.

6.26 The articulation of the accounting framework of the SEEA is thus made complete in presenting a full sequence of accounts that presents information on all environmentally related transactions and flows. A key driver for the construction of the full sequence of SEEA accounts is that balancing items can be defined that take into account specific environmentally related flows, in particular the depletion of environmental assets. Thus, measures of depletion adjusted value added and depletion adjusted saving are defined as part of the full accounting framework.

6.27 The entries required at a sector level are basically the same as those at the national level except in situations in which an environmental asset is considered to be jointly owned by two sectors. This situation most commonly occurs in respect of mineral and energy resources where often the extractor has a long term lease over the resource from the government and both sectors share the resource rent attributable to the mineral and energy resources. The appropriate accounting for these situations is undertaken within the sequence of accounts framework and is described in Section 5.5: Asset accounts for mineral and energy resources.

6.28 Table 6.2.3 presents the SEEA sequence of accounts for institutional sectors based on the SNA. The primary differences from the SNA sequence of accounts are the adjustments for depletion made to the balancing items of value added, operating surplus, balance on primary incomes, disposable income, and saving. In other cases, the role of the sequence of accounts is to provide a logic for the recording of environmentally related transactions such as environmental taxes, environmental subsidies, and the payment of rent on natural resources.

Table 6.2.3 SEEA Full sequence of accounts

	Institutional sectors				
Accounting entry	Corporations	Households	General government	NPISH*	Total
Production account					
Output					
Less Intermediate consumption					
Gross Value Added					
Less Consumption of fixed capital					
Net Value Added					
Less Depletion of natural resources					
Depletion adjusted Value Added					
Generation of income account					
Gross value added					
Less Compensation of employees					
Less Environmental taxes on production					
Plus Environmental subsidies on production					
Less Other taxes less subsidies on production					
Gross operating surplus					
Less Consumption of fixed capital					
Less Depletion of natural resources					
Depletion adjusted Operating surplus					
Allocation of primary income account					
Depletion adjusted Operating surplus					
Plus Rent on natural resources					
Plus Other property income (interest, dividends)					
Depletion adjusted balance of primary income					
Distribution of secondary income account					
Depletion adjusted balance of primary income					
Plus Environmental current transfers (excl. Env subsidies on production)					
Plus Other current transfers					
Depletion adjusted disposable income					
Use of disposable income account					
Depletion adjusted disposable income					
Less Final consumption expenditure					
Depletion adjusted saving					
Capital account					
Depletion adjusted saving					
Less Gross fixed capital formation					
Less Changes in inventories					
Less Acquisitions less disposals of valuables					
Less Acquisition less disposals of natural resources and land					
Less Acquisition less disposals of other non-produced, non financial assets					
Plus Environmental capital transfers					
Plus Other capital transfers					
Add back Consumption of fixed capital					
Add back Depletion of natural resources					
Net Lending/Borrowing					

* Non-Profit Institutions Serving Households

Description of the sequence of accounts

6.29 Each step of production, income distribution, income 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 underlying sequence of accounts.

6.30 The balancing items link successive accounts as they are both the last entry in each account and the first entry in the following account in the sequence. The following description of the sequence of accounts focuses on the derivation of these balancing items.

Production account

6.31 The aggregate described in connection with the supply and use table is value added. In the sequence of accounts value added is also the balancing item of the production account and, as in the supply and use tables, represents the difference between output and intermediate consumption. Value added summed across all productive activities constitutes gross domestic product (GDP) at basic prices.

6.32 Value added (and other balancing items) may be shown before or after deduction of consumption of fixed capital which is the deduction made to reflect the using up of fixed capital in the production process. Where consumption of fixed capital is not deducted, the balancing item is prefaced by the term "gross". Where consumption of fixed capital has been deducted the preface used is "net". Differently from the SNA, the SEEA also accounts for own account environmental protection services (see Chapter 4). This leads to recording higher levels of output and intermediate consumption but value added and subsequent balancing items are not affected.

6.33 The key difference in the production account of the SNA and the production account of the SEEA is the deduction of depletion of environmental assets from gross value added to form depletion adjusted estimates of value added. In a manner analogous to consumption of fixed capital, the depletion adjustment reflects the using up of environmental assets that takes place as a consequence of production.

Generation of income account

6.34 The generation of income account shows how value added is allocated to the factors of production, i.e. labour and capital including both produced and non-produced assets. Amounts accruing to labour are shown as compensation of employees while amounts accruing to capital are shown as operating surplus. Operating surplus is also the balancing item in this account. Taxes less subsidies on production must be deducted from value added to derive operating surplus. In the SEEA environmental taxes and subsidies are explicitly identified from other taxes and subsidies. Also, as in the production account, depletion is deducted from operating surplus to reflect the using up of environmental assets in generating income from production.

Allocation of primary income account

6.35 Compensation of employees, taxes less subsidies on production, and operating surplus are three types of primary income. The final type of primary income is property income comprising flows of interest, dividends, and rent. Property income is received in exchange for putting financial assets and non-produced assets such as land and mineral and energy resources at the disposal of other economic units. At a sector level, the balancing item of all primary incomes is the balance of primary incomes.

6.36 At a national level the net impact of property income flows reflects the balance of these flows to and from the rest of the world. There may also be flows of compensation of employees to and from the rest of the world (recorded in the generation of income account). At a national level, the aggregate of the allocation of primary income account is national income.

6.37 A key flow in the SEEA allocation of primary income account is rent on environmental assets such as land and mineral and energy resources. This income reflects payments for the use of environmental assets between the extractor or user of the environmental assets and the legal owner. Usually, the rent on environmental assets represents one part of the income generated from extraction or use since, most commonly, the extractor/user will retain some operating surplus after the payment of rent to the legal owner. The details of the accounting treatment in these situations is outlined in Chapter 5, Section 5.5.

Distribution of secondary income account

6.38 The redistribution of primary income by means of transfers is shown in the distribution of secondary income account. These are payments made without a quid pro quo, or in other words, payments made that are not related to an exchange between economic units. The largest types of transfers are taxes on income, wealth, etc. and social benefits paid by government such as unemployment benefits and old-age pensions. The balancing item in the distribution of secondary income account is disposable income and shows the amount available for expenditure on final uses (consumption and capital formation).

6.39 For the SEEA the main flows to be identified here are payments of environmental subsidies and similar transfers, excluding environmental subsidies associated directly with production (recorded in the generation of income account) and environmental investment grants (recorded in the capital account). Typical payments recorded here are payments to households to support environmental protection activities, payments between levels of government to support environmental activities and donations to non-profit institutions involved in environmental protection and resource management activities.

Use of disposable income account

6.40 Disposable income can only be spent on current final consumption or saved. In the use of disposable income account the balancing item is saving derived by deducting consumption expenditure from disposable income. Most commonly, this balancing item is shown after the deduction of consumption of fixed capital, i.e. net saving.

6.41 As in the production and allocation of income accounts, the balancing item *net saving* is adjusted in the SEEA sequence of accounts to deduct depletion. Depletion adjusted saving has a particular interpretation in the SEEA framework. In general terms, saving represents the resources available for investment, while net saving represents the resources available to increase the overall asset base after accounting for the cost of replacing the fixed assets that have been used up over the accounting period.

6.42 Extending this concept in the SEEA, depletion adjusted saving represents the resources available to increase the asset base after accounting for replacing the fixed assets and "replacing" environmental assets that have been used up in the accounting period. Although non-renewable environmental assets cannot be replaced, adjusting saving for depletion can give an indication of the extent to which patterns of income and consumption are in alignment with changes in the overall asset base including produced and environmental assets.

Capital account

6.43 Income that is saved is used in a number of ways. It may be used for the acquisition of fixed capital, the acquisition of valuables, accounted for as a change in inventories, or it may be used to purchase financial assets (e.g. bank deposits) or reduce financial liabilities (e.g. home mortgages). The amount available for the acquisition of fixed capital and valuables may also be affected by capital transfers and the net flow of these transfers is also reflected in the capital account.

6.44 It is also important to show that amounts of consumption of fixed capital that were effectively set aside in the derivation of balancing items in earlier accounts are in fact amounts that are available for the acquisition of fixed capital since they are not an outlay in terms of current monetary expenditure. The same is essentially true of amounts of depletion, although the resources themselves cannot be "re-acquired" as is the case with fixed capital. Nonetheless the actual resources notionally set aside remain available for use, so consumption of fixed capital and depletion are added back in the capital account.

6.45 The balancing item of the capital account is net lending (if the account is in surplus) or net borrowing if the account is in deficit. These terms are used since any surplus must be lent to other units and any deficit is made up by borrowing from other units.

6.46 Net lending/borrowing is also the balancing item of the financial account which shows how the capital account surplus or deficit is financed. If a country records a deficit in its capital account then it must also show some amount of net borrowing from the rest of the world (either through an increase in financial liabilities or a decrease in financial assets) in the financial account that corresponds to the financing of that deficit.

6.2.5 Functional accounts

6.47 The fourth area of the integrated SEEA set of accounts concerns the identification of flows relating to environmental activity in monetary terms. These accounts are known as functional accounts as they focus on economic activity undertaken for a particular function or purpose. The purposes of interest in the SEEA Central Framework are environmental protection and resource management. The two functional accounts that are described in Chapter 4 are the Environmental Protection Expenditure Account (EPEA) and statistics on the Environmental Goods and Services Sector (EGSS).

6.48 The basic organisation of information for the SEEA functional accounts follows the structure of the core monetary supply and use tables and the full sequence of accounts. Within this basic structure the objective is to identify all transactions with a specific environmental purpose.

6.49 The integrated aspects of functional accounts come from the use of the core accounting structures, rules and principles of the national accounts. Consequently, information on environmental activities can be readily compared and contrasted with information on other activities within the economy. Further, environmental activities can be compared with other activities in relation to other economic variables such as employment.

6.50 While the focus of functional accounts and statistics such as EPEA and EGSS are on flows in monetary terms, it is also possible to align the monetary estimates with relevant physical flows. This can be done because the underlying accounting in these functional accounts is consistent in terms of the definition of economic units (enterprises represented by industries, households, governments) and the rest of the world and the scope of products. It is possible, for example, to relate expenditure for environmental protection purposes by industries and households with quantities of air emissions.

6.3 Combining physical and monetary data

6.3.1 Introduction

6.51 The presentation of information in a format that combines both physical and monetary data is one of the strongest features of the SEEA. This strength enables the SEEA to provide a wide range of information on specific themes, to compare related information across different themes, and to derive indicators that require the use of both physical and monetary data.

6.52 Given the integrated accounting structures for physical and monetary accounts and statistics, it is logical to use these structures and the common underlying accounting rules and principles to present both physical and monetary information. Such integrated formats are sometimes referred to as "hybrid" presentations or accounts because they contain data in different units. However, even though the units are different, the data sets are presented according to common classifications and definitions, and hence these presentations are referred to as combined physical and monetary presentations in the SEEA.

6.53 Different forms of combined physical and monetary presentations are possible and, indeed, there is no standard form for these presentations or accounts. Commonly, physical flow data is presented alongside information from monetary supply and use tables but even for this basic structure different combinations are possible. Ultimately, the structures of combined presentations of monetary and physical data are dependent on the availability of data and the question under investigation.

6.54 While no standard structure can be defined, compiling and contrasting monetary and physical data in meaningful ways is at the heart of the SEEA philosophy. This section provides general guidance on the compilation of combined physical and monetary presentations. More detailed presentations involving structures such as input-output tables, the full sequence of economic accounts or presentations that cover a particular theme or topic, for example fisheries, are considered in SEEA Extensions and Applications and in targeted thematic SEEA publications.

6.3.2 The concept of combining physical and monetary data

6.55 At the core of combining physical and monetary data is the logic of recording physical flows in a manner compatible with economic transactions as presented in the SNA. This linkage guarantees a consistent comparison of environmental burdens with economic benefits, or environmental benefits with economic costs. This linkage can be examined not only at the national level but also at disaggregated levels, for example, in relation to regions of the economy, or specific industries, or for the purpose of examining the flows associated with the extraction of a particular natural resource or the emissions of a particular material.

6.56 Because these presentations combine physical data that may be of more immediate use to scientists with monetary data familiar to economists, they also have the potential to form a bridge between these two schools of concern about the environment.

6.57 It is reinforced that it is legitimate to include only a limited set of variables, depending on the most urgent environmental concerns to be taken into consideration and that it is not necessary to complete an exhaustive physical supply and use table to be able to present combinations of physical and monetary data.

6.58 A combined physical and monetary presentation thus represents an analytical framework showing which parts of the economy are most relevant to specific indicators and how changes in the economic structure influences 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.

6.59 At finer levels of disaggregation, combined presentations can provide the research community with access to a structured database for further research into the role of these indicators in monitoring the overall environmental performance of national economies. In particular, datasets with combinations of physical and monetary data may be of direct use in the development of environmental-economic models.

6.3.3 Organisation of information

6.60 It is important that the information in the SEEA accounts can be effectively communicated to users and decision makers. This section highlights some general considerations in the presentation and organisation of data, especially with the view to aligning physical and monetary data for combined presentations.

Time series data

6.61 The tables in the Central Framework are designed to explain the accounting concepts and relationships of the SEEA and therefore feature data only for a single time period. In practice, time series of the aggregates that show the trends in economic and environmental variables are also of interest to users.

6.62 Some of the SEEA tables can be easily adapted to the presentation of data in time series fashion. For others that are in a matrix type format, for example supply and use tables, choices need to be made regarding which variables should be highlighted. The ability to release data in non-paper based format – for example in databases – permits a greater flexibility in the release of data.

6.63 Generally, time series should be compiled and presented over as long a period as possible with the periodicity determined based on the needs of users. Often in environmental and economic accounts, the length of time series may be short as the source data may have been collected infrequently or only in recent years.

6.64 One difficulty in the creation of time series of accounting data is the consistency with which source data are compiled over time. Changes in the classifications, coverage, and definitions used in source data can require significant re-working by accountants in order to prepare consistent time series. This may be especially problematic when the source data are compiled on an irregular or infrequent basis.

6.65 It is recommended that accountants place emphasis on maintaining a continuity of time series, in part by using the power of the accounting framework that requires meaningful balances and accounting identities to be upheld.

6.66 One consequence of compiling accounting data in time series fashion is that changes and additions to source data require the reassessment of data from previous accounting periods and hence revisions in the time series may need to be implemented. Although in principle a compiler can wait until all possible data are available before releasing the accounts for one period, generally, a balance must be found between the accuracy of the accounts and the timeliness of the information, and hence making revisions to the accounts should be considered standard practice.

6.67 At times, new information may not only highlight the need for revision to a specific time period but may also suggest the need to reassess surrounding time periods in order to retain the meaningfulness of the time series as a whole. The management of time series and the reassessment of models and assumptions is an important role for the compiler of SEEA based accounts.

6.68 Since revisions are important but difficult to predict, they should be considered and implemented in a way that is explicable to users and can be operationalised by compilers in a meaningful way. To this end, the best practice for formulating a revisions policy and for undertaking analysis of revisions has been summarised in *Guidelines on Revisions Policy and Analysis* (Organisation for Economic Co-operation and Development, 2008). Ideally, the revisions policies of national accounts and environmental accounts should be aligned.

6.69 It is important to ensure that the source data underpinning the physical and the monetary data relate to the same accounting period. Generally, monetary accounts will be compiled on a financial or calendar year basis. Physical data may be compiled on a basis that aligns more closely to natural environmental patterns and seasons. Where needed, adjustments to take these differences into account may need to be made.

6.70 Generally, the time frames considered in the SEEA are annual but in certain cases the compilation of sub-annual time series may be appropriate. This is particularly the case where the physical flows or economic activity are seasonal in nature, for example patterns of rainfall and electricity use. An understanding of required capacity in water and energy supply or in the thresholds for various environmental pressures will usually require knowledge of seasonal peaks and troughs rather than annual averages.

Institutional sector and sub-sector data

6.71 For some accounts and tables, the Central Framework describes the compilation of data by institutional sector. In principle, all accounts can be compiled at this level of detail although the data and accounting requirements may be quite extensive for a complete set of institutional sector accounts to be compiled.

6.72 At the same time, there may be particular instances where a broad focus on specific institutional sectors or sub-sectors is appropriate. For example, there may be particular interest in the environmental activities of government at different levels of government, i.e. at national, regional or local levels. To compile accounts of this type the flows between these different levels of government need to be recorded and balanced.

6.73 Another area of focus may be the household sector and in particular those parts of the household sector which are commonly not observed, for example the collection of water and fuelwood by households, subsistence farming and other informal household sector activities. While in concept these activities are part of the economy, often the lack of market transactions makes them difficult to observe and estimate. Given the close relationship between these non-observed activities and the local environments on which they depend, the preparation of accounts specifically for these types of units may be desirable.

6.74 Generally, consumption expenditure is only recorded for households and general government equal to the amount of consumption purchased by each sector. An alternative perspective on consumption is to recognise that often the consumption of households is supported by expenditure by governments on behalf of the households in an economy, for example, through the provision of education. Thus an aggregate of the "actual" consumption of households can be defined equal to household consumption expenditure plus the amount of government consumption expenditure that is classified as individual consumption. Individual consumption is distinguished from collective consumption, which is consumption that cannot be attributed to individuals or households such as defence services or the services of a legal and justice system.

6.75 The measurement of actual consumption is useful for cross country comparisons and long term comparisons within a country as it accounts for the way the provision of services to households is organised.

Data by geographic area

6.76 The initial consideration in the organisation of information on a geographic basis is the application of the residence principle within all SEEA datasets. Consistent with the SNA, the SEEA accounts and tables for a country are defined by the economic residence of the economic units rather than by the location of the activity of the units. The distinction between residence and territory principles of recording is described in Chapter 2.

6.77 The main focus of the accounting descriptions and explanations in the SEEA is on accounting for a country as a whole. This aligns with the intent of the SNA and with the general purpose of the SEEA to be a national accounting tool rather than used for accounting at the level of an economic unit. One of the motivations for retaining a higher level focus is that for the accounting principles to be applied at finer levels of geographic detail, there is a need to understand the flows in and out of the smaller regions and to understand the area of predominant economic interest for each economic unit. Often this type of information is difficult to establish at small geographic levels.

6.78 At the same time, there are likely to be both administrative boundaries within countries and different environmental and economic circumstances in different areas of a country that suggest the compilation of accounts by sub-national geographies is sensible. The geographic areas relevant for environmental and economic accounting may not be the same as the administrative breakdowns of regional areas.

6.79 In principle, all accounts can be compiled at these finer levels but compilers should be aware that in general additional assumptions will be required to complete the accounts, particularly regarding the location of economic units.

6.80 It may also be relevant to select specific variables – for example output, employment, or emissions and compile data relating to these variables at a regional level without compiling a full accounting framework. Provided the relationship between the variables is interpreted in the same way as in the broader accounting framework, then meaningful information concerning the pressures and drivers in particular regions might be established without the need to compile a full set of supply and use tables and other accounts.

Data in volume terms

6.81 For many environmental and economic indicators and statistics it is important and more useful to present monetary data in terms of the changes in the underlying volumes. Volumes represent changes in the value of stocks, transactions and other flows after the effect of price changes has been removed. Volume changes comprise changes in quantity and changes in quality. Adjusting for the effects of price changes is particularly important when presenting time series of data. Commonly, these estimates of volumes are termed estimates in “constant prices”.

6.82 A discussion on the approach to compiling monetary data in volume terms is in Chapter 2 and Chapter 5. From an integration perspective, compiling data in volume terms can be an important part of data confrontation. For the compilation of conventional national accounts estimates, it is increasingly common for countries to compile monetary supply and use tables in volume terms by removing the effects of price change from the supply and use tables reflecting transaction values. In concept, estimates in “volume” supply and use tables should bear a reasonable resemblance in structure to the flows of products in the physical supply and use tables.

6.83 It is not necessary to compile complete supply and use tables and asset accounts in volume terms in order to develop indicators that use variables expressed in volume terms. Ideally, an estimate of price change that is specific to the target variable should be used but, depending on the analytical purpose, it may be sufficient to divide a time series of monetary values by a general estimate of price change in an economy, for example a consumer price index.

Classifications

6.84 The monetary accounts in the SEEA are compiled using a consistent set of classifications of products and industries as used in the SNA. For physical data, different classifications are often used for different topics and themes that are specifically developed for analysis of those topics. For example, detailed classifications for water and energy in physical terms have been developed. While powerful for the purposes of measurement in physical terms, these specific classifications are not necessarily the most appropriate when compiling SEEA accounts and any differences in classification need to be resolved before combining physical and monetary data.

Accounting adjustments

6.85 The SEEA outlines two areas in which the compilation of physical accounts should record additional and different flows relative to the monetary accounts compiled following the SNA. These areas concern goods for processing overseas and own account production.

6.86 In both cases, the consistency between measures of output and intermediate consumption in physical and monetary terms is affected and the impact should be resolved before combining physical and monetary data.

6.4 SEEA Indicators

6.4.1 Introduction

6.87 The SEEA also lends itself to the derivation of important indicators and aggregates in the same way as the national accounts is best known by the important indicators that are derived from the accounting structure, particularly Gross Domestic Product (GDP) and Net National Income (NNI).

6.88 The breadth of the SEEA framework means that many indicators can be sourced from the SEEA. This section introduces the range of indicators that are either embedded in the framework or easily derived as the ratio between variables within the framework. Data from within the SEEA framework may also be used to compile more complex indicators that require a range of assumptions and weighting patterns for their derivation. These indicators are not discussed in this section.

6.4.2 Descriptive statistics

Totals and aggregates

6.89 The accounting framework of the SEEA contains a range of totals and aggregates that may be of interest in monitoring changes in environmental and economic activity.

i. From the physical flow accounts total physical flows such as total flows of water, energy, air emissions and solid waste for the economy as a whole or for individual industries and households can be obtained.

ii. From asset accounts, physical flows of natural resources including extraction and natural losses can be obtained as well as total values of natural resources and any associated depletion.

iii. From the sequence of accounts, the key aggregates from the perspective of the SEEA are the depletion adjusted balancing items such as depletion adjusted value added and depletion adjusted saving.

iv. From the functional accounts, EPEA and EGSS, totals such as national expenditure on environmental protection and total production, value added and employment of environmental goods and services may be obtained.

6.90 These various totals and aggregates are naturally obtained from the accounting structures that have been described in chapters 3, 4 and 5.

Structural statistics

6.91 Another type of descriptive statistic that can be obtained from the accounting structures is statistics on the structure of different physical and monetary flows and stocks. Because the accounting structures are complete in their coverage of economic units and geography, shares of different variables can be derived. For example, the share of total emissions by households and the share of water use by agriculture can be calculated in a straightforward manner from the relevant physical flow accounts.

6.92 Other examples of structural statistics include the share of environmental taxes in total taxes, the share of employment in the production of environmental goods and services in total employment, the share of energy supply from renewable energy sources and the structure of land cover and changes in land cover between points in time.

6.93 Specific mention is made of the ability to derive shares within functional accounts since the totals relating to expenditure and production can be directly related to conventional national accounts aggregates such as GDP and national income.

6.4.3 Environmental asset aggregates and indicators

6.94 Asset accounts in physical terms concerning individual environmental assets can provide indicators on the availability of these assets and changes in availability through the comparison of the amounts extracted with the remaining stock. Such information may be relevant in the management of demand and supply of environmental assets.

6.95 Asset accounts in monetary terms can be used to derive indicators for both individual environmental assets and for combinations of these assets since summation across assets is possible in monetary terms. A summation can provide estimates of environmental asset wealth which in turn can be compared to estimates of the value of other assets including produced and financial assets. Estimates of total national and institutional sector wealth can also be calculated.

6.96 The sequence of accounts can provide information on the depletion of environmental assets and also on the share of resource rent accruing to various sectors involved in the extraction of resources, particularly mineral and energy resources.

6.97 In combination with population statistics and descriptive statistics on households such as annual income, it is also possible to consider the use of resources on a per capita basis and the distribution and use of resources by different household types.

6.4.4 Indicators related to financing and cost recovery of economic activity related to the environment

6.98 Data contained in the sequence of accounts can provide important insights into the way in which economic activity related to the environment is financed and also the full cost of providing access to resources, particularly water and energy. The financing aspects can be considered through analysis of subsidies and other transfers for environmental purposes, particularly flows from government and the rest of the world. It may also be relevant to consider the collection of environmental taxes as a means of supporting economic activity related to the environment.

6.99 Estimates of the full cost of supplying resources must incorporate the general operating costs such as intermediate consumption of materials and compensation of employees and also other current and capital costs. These include payments of rent and interest as applicable and the costs of any relevant infrastructure and equipment. The estimation of capital costs should include both the consumption of fixed capital and the opportunity cost of investing in the assets which is equivalent to estimating a rate of return on the assets. The recognition of all costs is important in ensuring that investment decisions are taken with both short and long term costs in mind. All of the relevant variables for these estimates are contained in the SEEA sequence of accounts.

6.4.5 Environmental ratio indicators

6.100 The aggregates and indicators described in the preceding paragraphs emerge from accounts and tables in either physical or monetary terms. There are also important indicators of environmental pressures and responses that can be derived from combined physical and monetary presentations. They are generically referred to here as environmental ratio indicators. This sub-section describes three main types of these combined indicators.

Productivity and intensity type indicators

6.101 Productivity and intensity indicators are important indicators that can be derived from environmental and economic accounting data. Productivity indicators are formed as the ratio of an economic aggregate such as output or GDP to a physical flow such as the energy content of energy products used. Intensity indicators are formed the ratio of a physical flow to an economic aggregate, i.e. they are the inverse of productivity indicators. All of these indicators focus on the production process and changes in the extent to which environmental assets and other environmental inputs are being used by industries to produce goods and services.

6.102 In the derivation of these types of indicators, it is important that the economic aggregate being used is measured in volume terms if the intention is to measure changes over time. If not, a misleading picture of the degree of productivity or intensity may be obtained.

Decoupling type indicators

6.103 Decoupling indicators are aimed at showing the extent to which growth in income and consumption is occurring with a decreasing use of environmental resources e.g. decreased energy use, or reduced emissions. They are derived by dividing a relevant economic aggregate (e.g. household consumption or national income) by a relevant physical flow for example air emissions. These are essentially productivity indicators, but the focus is on the divergence of the environmental and economic aggregates. As for productivity type indicators, the economic aggregates should be measured in volume terms for time series purposes.

Polluter pays type indicators

6.104 Polluter pays type indicators relate physical information on emissions to payments, primarily environmental expenditures and environmental taxes, that are made in relation to those emissions. These indicators can help to show the extent to which environmental protection costs are internalised and taxation and other payment schemes are influencing the amount of emissions. An example of this type of indicator is the implicit tax rate for energy which is derived as energy taxes (as defined in Chapter 4) divided by joules of energy.

6.4.6 The SEEA and international indicator initiatives

6.105 For many years there has been interest in the development of sets of indicators that give insight into environmental and sustainable development issues. Examples of international indicator initiatives are those connected to the OECD Green Growth project, the UNEP Green Economy project, the Beyond GDP initiative of the European Union and the indicator work within the Convention of Biodiversity. Many of the indicators that are of interest in these indicator sets can be found within the SEEA framework.

6.106 Because of the strength of the underpinning accounting structure of the SEEA, particularly in terms of defining relationships between indicators and in providing a strong data compilation and confrontation framework, the SEEA can provide an important information base from which indicators can be chosen for use in populating different sets of indicators.

6.107 In addition, the strong connection between the SEEA and the SNA provides links to core macro-economic aggregates that allows environmentally focused indicators to be seen from a more economic perspective that is accessible to a broader audience. This strong connection also allows for modelling and forecasting.

6.108 It is recommended that in the development of sets of indicators that focus on environmental and sustainable development issues that the SEEA framework be used as the basis for compiling indicators wherever appropriate.

6.5 Examples of combined physical and monetary presentations

6.5.1 Introduction

6.109 As noted in Section 6.3, there is no standard structure for combining physical and monetary data as the logical structure varies depending on the topic or theme under investigation and the scope and availability of data in physical and monetary terms.

6.110 The capacity to develop different structures allows the combination of information from different core accounting structures – for example from supply and use tables, asset accounts, functional accounts and the sequence of accounts. This flexibility makes these presentations particularly appropriate for the organisation of information on particular topics or themes.

6.111 For example, the compilation of asset accounts for fish resources may provide useful information in both physical and monetary terms. However, in combination with information on the supply and use of fish resources through the economy, information on employment in the fishing industry, information on the emissions generated by aquaculture, and information on any payments made for fishing quotas; a far more complete view of the fishing industry and associated activity is likely to be presented. The breadth of the SEEA framework encompasses all of these types of information.

6.112 This section presents a general structure that may be adopted for combining physical and monetary data and follows with four examples of combined presentations for particular themes. The themes are energy, water, air emissions and forests. These examples should provide a sense of the potential of the SEEA framework to provide rich and integrated datasets for specific themes and also give a sense of the analytical potential that is supported by data from the SEEA framework. An extended discussion of the analytical potential of the SEEA is presented in SEEA Extensions and Applications.

6.5.2 General structure for combined presentations

6.113 Although there are no standard presentations of combined physical and monetary data there are some common areas that combined presentations will generally include. At a broad level these areas cover all of the content described in the Central Framework: Chapters 3, 4 and 5 with the selection of relevant variables and aggregates that best present the topic or theme of interest.

6.114 Table 6.5.1 a possible structure and some typical content for the presentation of combined physical and monetary data with four sections covering monetary flows, physical flows, stocks and flows of environmental and fixed assets and relevant indicators. None of these are mandatory fields and additional variables and levels of detail may be added as data and information requirements allow. An important feature of the structure is that the column headings remain the same for each of the four sections thus highlighting the ability to consider a range of different variables from the perspective of a consistent and commonly defined set of economic units.

6.115 The content presented in Table 6.5.1 and the examples of combined presentations in remainder of the section only relate to a single time period. Often it will be useful to present data over a longer time period and hence different structures will be required for presentational and publication purposes.

Table 6.5.1 Typical content for combined presentations

	Industries (by ISIC categories)					Households	Government	Accumulation	Flows with the rest of the world	Total
MONETARY SUPPLY AND USE FLOWS (currency units)										
Supply of products										
Intermediate consumption and final use of products										
Gross value added										
Depletion adjusted Gross value added										
Environmental taxes, subsidies and similar transfers										
Employment										
PHYSICAL SUPPLY AND USE FLOWS (physical units)										
Supply										
Products										
Residuals										
Use										
Natural inputs										
Products										
Residuals										
ASSET STOCKS AND FLOWS										
Closing stocks of fixed assets (currency units)										
Gross fixed capital formation (currency units)										
Closing stocks of environmental assets (currency units and physical units)										
Depletion (currency units and physical units)										
RELATED INDICATORS										

Note: Grey cells indicate zero entries by definition.

6.5.3 Combined presentations for energy data

6.116 Within energy accounts, there is particular interest in comparing the supply and use of energy products in both monetary terms and in terms of energy content. Therefore, a combined presentation of the supply and use of energy products in monetary and physical terms using the same industry and sector breakdowns may provide a useful comparison.

6.117 An example of combined accounts for energy products is shown in Table 6.5.2. This table shows the supply and use of energy products by type of energy product in monetary terms (measured in currency units) and in physical terms (measured in joules). It also extends to present related information on the relevant stocks of mineral and energy resources; on gross fixed capital formation for the extraction of energy resources and the supply of energy products; and on air emissions.

6.118 Broadly, each entry for the supply of energy products in physical terms has a corresponding entry in monetary terms. The exception concerns own-use of energy and losses of energy including those due to reinjection of natural gas and flaring and venting of natural gas at the well-head. These physical flows are included only in specific rows in the supply and use tables in physical terms as there are no associated monetary transactions.

6.119 Additional entries in the monetary supply table are required to convert estimates of supply measured in basic prices to estimates of supply in purchasers' prices. Monetary estimates in purchasers' prices are required as they are the basis of valuation in the use table.

6.120 For each industry the tables show the supply and use of energy products and include, in monetary terms only, a row for the total supply of products and the total intermediate consumption and final use of products, i.e. totals including energy and non-energy products. By including the supply and use of all products in these tables it is immediately possible to see the share of output of energy products in relation to the total output of products in the economy. Similarly, it is possible to see the role that energy plays in relation to other products in terms of intermediate consumption by industries, household and government consumption and exports.

6.121 For the full benefits of such a supply and use comparison the same classification of energy products should be used. Currently, there is not a clear relationship between categories of the Standard International Energy products Classification (SIEC), which is designed for classifying energy products in physical terms, and the Central Product Classification (CPC), which is generally used to classify product level data in monetary terms. Compilers must resolve these differences in classification, potentially by undertaking combined analysis at higher levels of aggregation that yield consistent commodity definitions.

Table 6.5.2 Combined presentation for energy data

	Industries (by ISIC categories)								Taxes less subsidies on products, trade and transport margins	Final consumption			
	ISIC 01	ISIC 02	ISIC 03	ISIC 04	ISIC 08	Other industries	Total industry	Rest of the world		Households	Government	Capital Formation	Total
1. Supply of energy products (Currency units)													
Coal													
Peat and peat products													
Oil shale/ oil sands													
Natural gas													
Oil													
Biofuels													
Waste													
Electricity													
Heat													
Nuclear fuels and other fuel nec													
2. Total supply of products(Currency units)													
3. Intermediate consumption and final use (Currency units)													
Energy products													
Total (energy and non-energy products)													
4. Gross value added (Currency units)													
5. Depletion of natural energy resources (currency units)													
Depletion adjusted value added													
6. Employment													
7. Supply of energy products (PJ)													
Coal													
Peat and peat products													
Oil shale/ oil sands													
Natural gas													
Oil													
Biofuels													
Waste													
Electricity													
Heat													
Nuclear fuels and other fuel nec													
8. End-use of energy products (PJ)													
Coal													
Peat and peat products													
Oil shale/ oil sands													
Natural gas													
Oil													
Biofuels													
Waste													
Electricity													
Heat													
Nuclear fuels and other fuel nec													
9. Closing stocks of natural energy resources (currency units / PJ)													
Oil resources													
Natural gas resources													
Coal and peat resources													
Uranium													
10. Depletion of natural energy resources (PJ)													
11. Gross fixed capital formation (currency units)													
For extraction of energy resources													
For supply of energy products													
12. Closing Stocks of fixed assets for extraction of energy resources (currency units)													

Note: Grey cells indicate zero entries by definition.

6.5.4 Combined presentations for water data

6.122 Within water accounting, the interest lies in linking the abstraction and use of water in physical terms with estimates of output and value added by industry and the total final consumption of households. The presentation of physical and monetary information in the same accounts allows for the derivation of consistent indicators for evaluating the impact on water resources of changes in the economy, e.g. changes in the economic structure, changes in interest rates, etc. Using combined accounts in economic models permits the analysis of possible trade-offs between alternative water policies and economic strategies.

6.123 A basic combined supply and use table for water is presented in Table 6.5.3. For the monetary part of the combined supply table, two water-related products are identified – natural water and sewerage services. Depending on data availability other products may be incorporated, for example relating to irrigation water. The monetary part also includes estimates of total supply of products (i.e. including the output of non-water products) for each industry thus providing an indication of the relative significance of the output of water related products as part of total industry output.

6.124 The monetary part of the combined table records additional entries to show the conversion of measures of output in basic prices to measures of output in purchasers' prices. This step enables an accounting balance to be maintained with the use table in monetary terms.

6.125 The physical flows in the combined supply table reflect volumes of water supplied between economic units including volumes of wastewater to sewerage (shown as an of which row), as well as total returns to the environment. The bulk of the supply of water appears in the columns corresponding to the Water collection, treatment and supply industry and the Sewerage industry. Flows relating to hydropower are shown explicitly due to the relative significance of these flows within the total physical flows of water.

6.126 The monetary part of the combined use table, shows the intermediate and final consumption of the two primary water related products, as per the combined supply table. Total intermediate consumption for each industry and total final consumption for households and government are also shown to provide an indication of the significance of the use of water as part of total consumption.

6.127 A distinction is also made between the final consumption expenditure by households and the actual final consumption of households. The difference reflects expenditure by governments to provide goods and services (in this case water supply) to households. Thus although these goods and services are purchased by governments the consumption is in fact that of households. This distinction allows an improved comparison of consumption over time and across countries as it is not dependent on the arrangements in place to manage and finance water supply.

6.128 It may be useful to add into the monetary part of the combined use table estimates of gross fixed capital formation (investment) for water supply and treatment operations. These entries are made for each relevant industry in additional rows in the table.

6.129 The physical part of the combined use table shows the volume of water abstracted from the environment including amounts retained for own use, and amounts received by economic units.

6.130 Depending on the purpose of analysis, additional information, for example concerning emissions to water by industry and household, or stocks of fixed assets used by water supply firms, can be included within the general combined supply and use table framework to provide a single reference point for relevant information. Additions such as these demonstrate the capacity of combined supply and use tables to incorporate additional information within a core structure.

Table 6.5.3 Combined presentation for water data

	Industries (by ISIC categories)								Rest of the world	Taxes less subsidies on products, trade and transport margins	Actual final consumption		Capital Formation	Total
	1-3	5-33, 41-43	35 Total	35 *of which*: Hydro	36	37	38,39, 45-99	Total industry			Households	Government		
1. Supply of water products (Currency units)														
Natural water														
Sewerage services														
2. Total supply of products														
3. Intermediate consumption and final use (Currency units)														
Natural water														
Sewerage services														
Other products														
4. Gross value added (Currency units)														
5. Employment														
6. Supply of water (Millions m3)														
Supply of water to other economic units														
Total returns														
7. Use of water (Millions m3)														
Total Abstraction														
of which: Abstraction for own use														
Use of water received from other economic units														
8. Gross fixed capital formation (Currency units)														
For water supply														
For water sanitation														
9. Closing Stocks of fixed assets for water supply (Currency units)														
10. Closing Stocks of fixed assets for water sanitation (Currency units)														
11. Water consumption (Millions m3)														

Note: Grey cells indicate zero entries by definition.

6.5.5 Combined presentations for forest products

6.131 The following presentation for forest products aims to give an example of the types of data that might be drawn together when considering flows related to environmental assets. Relevant flows include the physical flows of natural inputs and products, output and value added in monetary terms, stocks and flows of the relevant environmental assets, and stocks and flows associated with the extraction of natural resources.

6.132 Parts 1-6 of the combined presentation for forest products in Table 6.5.4 records the supply of forest products such as timber, fuelwood, and fodder. Within the supply and use structure the flows of the products can be followed through the economy. Imports of these products should be recorded in the column "Flows with the rest of the world". A separate column is included to record household own-account production of forest products which may include the collection of fuelwood, for example. In addition to flows of products, a more complete industry view of activity related to forests is obtained by including data relating to value added and employment.

6.133 Part 7 & 8 present information relating to the stock of timber resources – i.e. the area of land with timber resources (both cultivated and natural), the volume of standing timber, the extent of extraction and depletion and other data pertaining to the forest as an environmental asset. Although not included below information on the stock of forest animals or different food resources within forests areas might logically be included in this part. Data may be included in both monetary or physical terms.

6.134 Data on the stock of timber resources will generally be recorded in the far right columns of the table. In this presentation the area of land is broken down into that containing cultivated and natural timber resources but presentations by species or other distinctions may be appropriate. For some entries, it may also be relevant to record values in the columns for the forestry industry – for example, for removals.

6.135 The final parts of the table, Parts 9 & 10, present information on the assets used to extract forest products.

6.136 Overall, this presentation gives a sense of the breadth of information that can be combined from within the SEEA framework to help analyse and discuss themes relating to environmental assets.

Table 6.5.4 Combined presentation for forest products

	Industries (by ISIC categories)				Households	Accumulation	Flows with the rest of the world	Type of timber resources	
								Cultivated	Natural
1. Supply of forest products (currency units & physical units)									
Natural growth (cultivated timber)									
Timber logged									
Fuelwood									
Other goods (cork, gum, fodder, medicine, peat, etc)									
2. Total supply of products (currency units)									
3. Intermediate consumption and final use of forest products (currency units & physical units)									
Natural growth (cultivated timber)									
Timber logged									
Fuelwood									
Other goods (cork, gum, fodder, medicine, peat, etc)									
4. Total Intermediate consumption and final use (currency units)									
5. Gross Value Added (currency units)									
7. Employment									
7. Extraction and depletion of natural forest resources									
Removals (physical units)									
Felling residues (physical units)									
Depletion (currency units and physical units)									
Depletion adjusted value added (currency units)									
8. Closing stocks of timber resources (physical units)									
Area of land with timber resources (incl. forest and other wooded land)									
Volume of standing timber									
Carbon captured in forests									
9. Gross fixed capital formation for extraction of timber resources (currency units)									
10. Closing stock of fixed assets for extraction of timber resources (currency units)									

Note: Grey cells indicate zero entries by definition.

6.5.6 Combined presentations for air emissions

6.137 Within air emission accounts, the interest is in presenting a range of physical and monetary information for industries and households using common classifications. Thus a combined presentation can be constructed that allows comparison of air emissions by industry with the output and value added of those same industries measured in monetary terms. This combined presentation does not require compilation of a full supply and use table in physical terms. Rather, specific rows and columns within the full framework are selected.

6.138 A framework for a set of combined accounts for air emissions is presented in Table 6.5.5. In Parts 1-4 of the table, estimates of some key economic variables are included, classified by industry. Since all industries produce air emissions, all industries are in scope of the combined accounts although it may be of interest to focus on some specific industries, for example electricity generation, steel manufacturing or transport industries, as these industries are often large emitters.

6.139 The choice of economic variables could extend to the full set of supply and use variables. The main variables by industry suggested in this presentation are measures of output, intermediate consumption, gross value added and employment. Each of these variables give an indication of the relative size of each industry and hence assist in determining whether the associated emissions are significant factors for a specific industry and for the economy.

6.140 Part 1-4 also includes economic data on household final consumption expenditure (at the intersection of the row "Intermediate consumption and final use" and the column "Households"). The expenditure could be further classified to show the expenditure on products used for the purposes of transport and heating as these household activities are key sources of air emissions.

6.141 In Parts 5 & 6, economic data on expenditure for environmental protection purposes and on environmental taxes is included. These data can be compared to the levels of emissions and hence assess the effectiveness of industry, household and government responses to air emissions.

6.142 In Parts 7 & 8 of the table, estimates of total air emissions classified by type of substance are recorded. They are classified by industry and for households. The industry classification is identical to that used in the classification of the economic variables in Parts 1-6. Note that following SEEA accounting principles all emissions by government units are recorded against the relevant industry activity (e.g. public administration) rather than in the column labelled government (See Section 3.2 for details of this treatment).

6.143 A subset of total air emissions by industry relating to those due to transport activity is also shown in the table. Although transport activity will be most concentrated in the transport industry, all industries are likely to generate emissions through transport activity to some extent. The identification of transport emissions is important from a compilation perspective because adjustments are often needed to account for resident and non-resident emissions.

6.144 Overall, this combined accounts framework for air emissions shows the benefits of the use of the same classifications and structures for the organisation of different data. It permits the assessment of the relative importance of different air emissions, the derivation of relevant indicators for monitoring changes in air emissions; and the development of models based on the structured dataset.

Table 6.5.5 Combined presentation for air emissions

	Industries (by ISIC categories)								Households	Government	Total
1. Output by industry (currency units)											
2. Intermediate consumption and final use (currency units)											
3. Gross Value Added (currency units)											
4. Employment											
5. Environmental protection expenditure (currency units)											
Protection of ambient air and climate											
6. Environmental taxes (currency units)											
Carbon taxes											
7. Generation of air emissions (tonnes)											
Carbon dioxide											
Methane											
Dinitrogen oxide											
Nitrous oxides											
Hydroflourocarbons											
Non-methane volatile organic compounds											
Particulates (incl PM10, dust)											
8. Air emissions from transport activity (tonnes)											
Carbon dioxide											
Methane											
Dinitrogen oxide											
Nitrous oxides											
Hydroflourocarbons											
Non-methane volatile organic compounds											
Particulates (incl PM10, dust)											

Note: Grey cells indicate zero entries by definition.