Integrated Environmental and Economic Accounting for Water Resources

Draft For Discussion

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NOTE

Current status of the preparation of the handbook

The handbook *Integrated Environmental and Economic Accounting for Water Resources* has been undertaken in close cooperation with the London Group on Environmental Accounting. The handbook has been discussed and reviewed during several meetings of the London Group and drawn on the experience and contributions of members of the Subgroup of the London Group on Water Accounting.

This final draft has been prepared for discussion at the User-producer Conference: Water Accounting for Integrated Water Resource Management in Voorburg, the Netherlands, 22-24 May 2006. This version of the handbook will be reviewed one last time from the subgroup of the London Group and submitted for approval to the United Nations Committee of Experts on Environmental-Economic Accounting at its next meeting in 22 -23 June 2006 in New York.

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A. Introduction

1.1. Water is an essential element for life. It is a key element in growing food, generating energy, producing many industrial products as well as in ensuring the integrity of ecosystems and the goods and services they provide. Increasing competition for freshwater between agriculture, urban and industrial use as well as population growth result in unprecedented pressures on water resources, with many countries rapidly reaching conditions of water scarcity or facing limits to economic development. Moreover, water quality continues to worsen further limiting the availability of freshwater resources.

1.2. The integral role of water in development is widely recognized. It is not surprising that water is very high in the national and international development agenda, with several international agreements specifying targets on water supply and sanitation. The most notable is the Millennium Development Goals, which in Goal 7 – Improving Environmental Sustainability, Target 10 – Halve, by 2015, the proportion of people without sustainable access to safe drinking water and sanitation, cover two indicators, one on water and the other on sanitation.

1.3. Because water is critical and intimately linked with socio-economic development, it is necessary for countries to move away from sectoral development and management of water resources and to adopt an integrated overall approach to water management (WWDR 2006).

1.4. The purpose of this handbook is to provide a conceptual framework for organizing the hydrological and economic information in a coherent and consistent framework. The framework proposed in this handbook Integrated environmental-economic accounting for water resources, referred to as SEEAW, is an elaboration of the handbook of national accounting Integrated Environmental and Economic Accounting 2003, commonly referred to as SEEA-2003 (United Nations et al. 2003), which describes the interaction between the economy and the environment and covers the whole spectrum of natural resources and the environment. Both the SEEA and SEEAW are use as basic framework the 1993 System of National Accounts (1993 SNA), the standard system for the compilation of economic statistics and derivation of economic indicators, the most notable being gross domestic product (GDP).

1.5. This handbook complements the conceptual framework of the SEEAW with a set of standard tables focusing on hydrological and economic information as well as supplementary tables covering information on social aspects, which permit the analysis of the interaction between water and the economy. Standard tables constitute the minimum data set that all countries are encouraged to compile. Supplementary tables consist of items that should be considered by countries in which information would, in their particular cases, be of interest to analysts and policy makers or for which compilation is still experimental and not directly linked with the 1993 SNA. The set of tables, standard and supplementary, has been designed with the objective of facilitating the compilation of the accounts in countries and obtain information which is comparable across country and over time.

1.6. Only by integrating information on the economy, hydrology, other natural resources and social aspects can integrated policies be designed in an informed and integrated manner. Policy makers taking decisions on water need to be aware of the likely consequences for the economy. Those determining the development of industries making extensive use of water resources either as inputs in the production process or sinks for the discharge of wastewater need to be aware of the long-term consequences on water resources and the environment at large.

1.7. Section B of this chapter presents the main features of the SEEAW and discusses how the SEEAW relates to the 1993 SNA and the SEEA 2003 as well as the advantages of using the accounting framework to organize information on water resources.

1.8. Section C of this chapter introduces the concept of Integrated Water Resource Management (IWRM), the internationally agreed and recommended strategy for the management of water resources and discusses how the SEEAW can be seen as the information system in support for IWRM.

1.9. Section D provides an overview of the accounting structure and brief summary of each chapter. Section E looks at a number or issues related to implementing the system, including noting areas for future work.

B. Objective and features of the SEEAW

1.10. The SEEAW is part of a series of handbooks in support of the implementation of the Handbook of National Accounting Integrated Environmental and Economic Accounting 2003, commonly referred to as SEEA-2003. The SEEA-2003 provides a conceptual framework for economic and environmental information permitting a consistent analysis of the contribution of the environment to the economy and the impact of the economy on the environment. It is covers the whole environment and natural resources. Its scope is therefore very broad and, although the handbook is very extensive, it does not cover in detail all aspects of the environment. The SEEAW was developed in support of the SEEA-2003 by elaborating the concepts of the SEEA-2003 with special focus on water.

1.11. Both the SEEA-2003 and the SEEAW are satellite systems of the 1993 SNA, which is the statistical standard used for the compilation of economic statistics. As such, they have a similar structure to the 1993 SNA and share common definitions and classifications. They provide a set of aggregate indicators to monitor environmental-economic performance both at the sectoral and macroeconomic level, as well as a detailed set of statistics to guide resource managers toward policy decision-making.

1.12. There are two features that distinguish the SEEA and the SEEAW from other information systems about the environment. First, the SEEA and SEEAW directly link environmental and, in the case of SEEAW water, data to the economic accounts through a shared structure, set of definitions and classifications. The advantage of this database is that it provides a tool to integrate environmental-economic analysis and to overcome the tendency to divide issues along disciplinary lines, in which analyses of economic issues and of environmental issues are carried out independently of one another.

1.13. Second, the SEEA and the SEEAW cover all the important environmental-economic interactions, a feature that makes it ideal for addressing cross-sectoral issues such as integrated water resource management. It is not possible to promote IWRM from the narrow perspective of managing water resources; rather a broader approach that encompasses, economic, social and ecosystem aspects is needed. As a satellite accounts to the SNA, the SEEA and SEEAW are linked to full range of economic activities; with a comprehensive classification of environmental resources, the SEEA includes information about all critical environmental stocks and flows that may affect water resources and that may be affected by water policies.

1.14. While the SEEA-2003 reports best practices and, wherever possible, presents harmonised approaches, concepts and definitions, the SEEAW goes a step forward by providing a set of standard tables that countries are encouraged to compile using harmonized concepts, definitions and classifications. This is in line with the United Nations Statistical Commission decision, upon recommendation of the United Nations Committee of Experts on Environmental-Economic Accounting1, of elevating the SEEA-2003 to the level of a statistical standard by 2010 (UN, 2006c and 2006d).

1.15. The SEEAW includes as part of its standard presentation, stocks and flows of water resources within the environment; pressures of the economy on the environment in terms of water abstraction and emissions added to wastewater and released to the environment or removed from wastewater; the supply of water and the use of water as input in the production process and by households; the reuse of water within the economy; the costs of collection, purification, distribution and treatment of water as well as the service charges paid by the users; the financing of these costs, that is who is paying for the water supply and sanitation services; the payments of permits for access for abstraction or use it as sink for discharge of wastewater; the hydraulic stock in place as well as investments in hydraulic infrastructure during the accounting period. The SEEAW also presents quality accounts, which describe the water resources in terms of their quality. These accounts together with the economic valuation of water resources are included in the handbook for the sake of completeness, however, these modules are still experimental and they are presented in terms of issues in implementation illustrated by country practices, rather than providing guidelines on the compilation.

1.16. The SEEAW emphasizes the importance of deriving indicators from the accounting system rather than from individual sets of water statistics. Each chapter contains a section discussing the indicators that can be directly derived from the account. One chapter is dedicated to the uses of water accounting. The SEEAW provides policy makers (a) with indicators and descriptive statistics to monitor of the interaction between the environment and the economy, and progress toward meeting environment goals; and b) with a database for strategic planning and policy analysis to identify more sustainable development paths, and the appropriate policy instruments for achieving these paths.

1.17. Water resources and their management is very much linked to spatial considerations. The SEEAW takes into account the recommendation that the river basin is the internationally recognized unit of reference for Integrated Water Resource Management as called for Agenda 21 and the European Water Framework Directive (WFD) (European Parliament and Council, 2000). The water accounting framework in fact can be compiled at any level of spatial disaggregation – a river basin, an administrative region, a city. However, since the link between the economic accounts and hydrological information is at the heart of the SEEAW, one should consider that the economic accounts are generally not compiled at the river basin level but at the level of administrative regions. Ways of adjusting physical and economic information so that the water accounts can be compiled at the required level of disaggregation are discussed in the handbook and examples of how water accounts have been compiled at the subnational level, including at the level of river basin, are included. In particular, examples of countries that have used the SEEAW as the information system to report for the Water Framework Directive are presented.

Note on terminology

1.18. Agreed terminology on terms and definitions related to water accounting is used throughout the handbook and is presented in the glossary. Water accounting is multidisciplinary and spans across different fields such as hydrology, national accounting and environment statistics. Hydrologists,

[1] The United Nations Committee of Experts was created by the United Nations Statistical Commission at its Thirty-fifth session in March 2005 (UN 2005). More information about the UNCEEA is available on the UNSD website http://unstats.un.org/unsd/envaccounting/ceea/default.asp.

national accountants and environment statisticians need to be able to communicate using a common language. It is of great importance that a common language and terminology, which is consistent with the specific terminologies of each field, is agreed upon.

1.19. An Electronic Discussion Group (EDG)[2] on Terms and Definitions used in Water Accounting moderated by UNSD in cooperation with the United Nations Division for Sustainable Development agreed on terms and definitions relevant to water accounts. The result of the EDG served as input in this handbook and constitutes the basis of the glossary.

C. Integrated Water Resource Management (IWRM) and the SEEAW

1.20. Integrated water resources management is based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good, whose quantity and quality determine the nature of its utilization. To this end, water resources have to be protected, taking into account the functioning of aquatic ecosystems and the perenniality of the resource, in order to satisfy and reconcile needs for water in human activities. In developing and using water resources, priority has to be given to the satisfaction of basic needs and the safeguarding of ecosystems. Beyond these requirements, however, water users should be charged appropriately. (para 18.8. Agenda 21).

1.21. The IWRM calls for a sustainable management of water resources to ensure that there is enough water for future generations and water meets high quality standard. An IWRM approach promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems. This includes more coordinated development of (a) land and water; (b) surface and groundwater; (c) the river basin and its coastal and marine environment and (d) upstream and downstream interests (Global Water Partnership 2004).

1.22. For policy-making and planning, taking an IWRM approach requires that (a) policies and priorities take water resources implications into account, including the two-way relationship between macro-economic policies and water development, management and use; (b) there is cross-sectoral integration in policy development; (c) stakeholders are given a voice in water planning and management; (d) water-related decisions are made at local and river-basin levels are in-line with, or at least do not conflict with the achievement of broad national objectives; and (e) water planning and strategies are integrated into broader social, economic and environmental goals (Global Water Partnership, 2004).

1.23. The SEEAW is a useful tool in support of integrated water resource management by providing the information system to feed knowledge into the decision-making process. Because of its features outlined in the previous section, the SEEAW can assist policy makers in taking informed decisions on:

- *Allocating water resources efficiently*

  SEEAW shows the quantity of water used by various uses, including agriculture, mining, hydro-electric power generation, manufacturing as well as the quantity of wastewater and emissions generated as the result of production process. It also shows side by side with the physical information, information on the value added generated by the industries. This allows for the

[2] The EDG was based in particular on the review of the following glossaries: 2001 UNSD Questionnaire on Water Resources, 2002 Joint OECD/Eurostat Questionnaire on Water Resources, 2001 FAO/AQUASTAT Questionnaire, UNESCO/WMO International glossary of hydrology, 2nd edition, 1992, FAO/AQUASTAT On-line Glossary, Working copy of the Terminology of Water Management: Flood Protection TERMDAT, United Nations, 1997. Glossary of Environment Statistics. Studies in Methods, Series F, No. 67.

derivation of water efficiency and productivity indicators. The SEEAW becomes increasingly important to plan water resource development, allocation and management in the context of multiple uses. The SEEAW helps water managers take a more integrated approach that more accurately reflects the reality of water use.

- *Improving water efficiency*

Water efficiency can be improved from the demand as well as the supply side. On the demand side, policy makers are faced with the decision of which economic instruments to put in place in order to change the behaviour of the user. On the supply side, policy makers can encourage the efficiency of the water supply or irrigation system as well as the reuse of water. SEEAW provide information of the fees paid for the supply and sewerage services as well as payments for permits to access water resources either for abstracting water or for using water resources as sink. It also provides information on the quantity of water which is reused within the economy that is water that, after use, is supplied to another user for further use. The SEEAW provides policymakers with a database that can be used to analyse the impact throughout the economy and on water resources of the introduction of new regulations.

- *Understanding the impacts of water management on all users*

Policy makers are faced with decisions that have broader impacts than the water sector. It becomes increasingly important to plan water resources development, allocation and management in an integrated manner. SEEAW, since it is rooted in the 1993 SNA, provides the basic information system to evaluate tradeoffs of different policy options on all users.

- *Getting the most value for money from investment in infrastructure*

Investment in infrastructure has to be based on the evaluation of long-term costs and benefits. Policy makers need to have information on the economic implications of infrastructure maintenance, water services and potential cost-recovery. The water accounts provide the information of current costs to maintain existing infrastructure, the service charges paid by the users as well as the cost structure of the water supply and sewerage industry. They therefore can be used in economic models to evaluate potential costs and benefits of putting in place new infrastructures.

- *Linking water availability and its use*

Improving the efficiency in the use of water is particularly important in situation of water stress. For the management of water resources, it is important to link the use of water with the water available. The SEEAW clearly shows all users of water as well as available water resources.

- *Providing a standardized information system which harmonizes information from different sources, is accepted by the stakeholders and is used for the derivation of indicators*

Information on water is often generated, collected, analysed and disseminated by different government departments functioning in specific water-using sectors (e.g. irrigation, water supply, sanitation, etc.). The individual data sets are collected for different purposes and often use definitions and classifications which are not consistent resulting in overlaps in data collection. In a similar fashion, data collection may leave out important aspects of water resources, because not of direct interest to a specific government department.

The SEEAW brings together information from different sources in an integrated system with common concepts, definitions and classifications. This allows for the identification of inconsistencies in the data as well as data gaps. The implementation of such an integrated system ultimately leads to more efficient and consistent data collection systems. It aims for consistency across time, which is of the outmost importance in developing comparable time series estimates which are necessary in the policy process. Further, the accounting framework allows for the introduction of check and balances in the data, thus resulting in higher quality data.

Policy makers will find that the development of an integrated coherent and consistent information system will add value to individual sets of data collect to respond to sectoral policy needs. Further, the implementation of an integrated data system will allow for derivation of consistent indicators across countries and over time, which since they are derived from a common framework, will be accepted by all stakeholders.

- *Getting stakeholders involved in decision-making*

The SEEAW is a transparent information system. It should be used by the government to make informed decision, and interest groups and communities to argue their position on the basis of a sound information system.

1.24. As mentioned previously, the SEEAW focuses on the interaction between the economy and the environment, it may therefore be necessary to complement it with social indicators, which, to the extent possible, should be analysed in conjunction with the SEEAW information in order to facilitate the design of integrated policies.

D. An overview of the SEEAW accounting system

1.25. The SEEAW is a satellite system of the SNA and an elaboration of the SEEA framework. It comprises five categories of accounts. The first considers physical data relating to the flow of water and wastewater in terms of quantity as well as emissions and organizes them according to the accounting system (Chapters 3 and 4).

1.26. The second category of accounts takes the SNA supply and use tables and shows how the flows of data in physical and monetary terms can be combined to produce so-called "hybrid" flow accounts. The accounts in this category also explicitly identify those elements of the existing SNA which are relevant to water resource management. These include, for example, the cost of collection, purification and distribution of water as well as the fees paid by the users for the service received. These accounts are described in Chapter 5.

1.27. The third category of accounts in the SEEAW comprises accounts for water resource assets measured mostly in physical terms. These accounts show the opening and closing water stocks and the related changed over the course of an accounting period (Chapter 6).

1.28. The fourth category of accounts describes the stock of water in terms of its quality (Chapter 7). It should be noted that the quality accounts are still experimental and there is no agreement on a standard way of compiling them.

1.29. The final category of the SEEAW accounts comprises the valuation of water and water resources (Chapter 8). It should be noted that this category of accounts is still experimental and there is no agreement on a standard way of compiling them.

1. Category 1: Physical supply and use tables and emission accounts

1.30. Physical supply and use table provide information on the volumes of water exchanged between the environment and the economy (abstractions and returns) and within the economy (supply and use within the economy). Emission accounts provide information by industry and households on the amount of pollutants which are added to or removed from (by treatment processes) water during use.

1.31. This category of accounts brings together in a framework using definitions and classifications of the standard economic accounts of the SNA, hydrological data on the volume of water used and discharged back to the environment by the economy as well as the amount of pollutant added to the water. Bringing the physical information of water in the economic accounting system introduces checks and balances in the hydrological data and produces a consistent data system from individual sets of water statistics often collected by different line ministries responsible for designing targeted policies.

2. Category 2: Hybrid and economic accounts

1.32. Hybrid accounts align physical information already recorded in the physical supply and use tables with the economic accounts. Physical quantities can be compared with the matching economic flows by, for example, confronting use of water with information about the process of economic production and deriving indicators of water efficiency. The name “hybrid” results from the combination of different types of units of measures in the same category of accounts.

1.33. Monetary supply and use tables provide information on the costs associated with water use and supply such as water abstraction, purification, distribution, and wastewater treatment etc. They also provide information on financing that is on the extent users pay for the services of access to and treatment of water and on the extent these services are subsidized by the government and other units. They are particularly useful for cost-recovery policies and water-allocation policies. These accounts can also be compiled for activities aimed at the protection and management of water resources so as to obtain information on the national expenditure and financing by industries, households and the government.

3. Category 3: Asset accounts

1.34. Asset accounts measure stocks at the beginning and end of the accounting period and record the changes in stocks that occur during the period. They describe all increases and decreases of the stock due to natural causes (e.g. precipitation, evapo-transpiration, inflows and outflows) and human activities (e.g. abstraction and returns). They are particularly useful as they link water abstraction and return to the availability of water in the environment thus allowing measurements of physical water pressure induced by the economy.

4. Category 4: Quality accounts

1.35. Quality accounts are asset accounts that instead of describing water resources in terms of quantity, they describe them in terms of quality. They show stocks of water of a certain quality at the beginning and end of an accounting period. Since it is in general difficult to link changes in quality to the causes that affect it, quality accounts describe only the total change in an accounting period without further specifying the causes.

5. Category 5: Valuation of water resources

1.36. When natural resources are used in the production process, they are embodied in the final good or service produced. The price charged for the product contains an element of rent which implicitly reflects the value of the natural resource. Establishing this implicit element is at the heart of valuing the stock of the resource. In the case of water, however, which is often an open access resource, this implicit element, called the resource rent, is often zero. Increasingly water is being treated as an economic good, it is therefore expected that in the future the resource rent for water would be positive and thus value of the water stocks would be included in the balance sheets of a nation.

1.37. The valuation of water resources is included in the handbook because of its policy relevance, however, it is should be noted that this Chapter does not apply the 1993 SNA valuation concepts described in Chapter 5. As indicated above, the prices charged for water supply and sanitation are not considered adequate to cover the economic value of water (resource rent). Economists use several valuation techniques which go beyond the value of the market transactions recorded in the 1993 SNA. These techniques, their relationship to the concepts of the 1993 SNA as well as their advantages and disadvantages are discussed in Chapter 8.

E. Structure of the handbook

1.38. The handbook is structured in two parts. The first part (Chapters 2-6) presents those accounts for which there is considerable practical experience and consensus on best practices has emerged. The second part (Chapters 7-8) discusses those modules which are still experimental, that is for which either because of lack of practical experience, scientific knowledge, consistency with the 1993 SNA or a combination of those reasons, it was not possible to reach an agreement on concepts as well as on how to implement them. A chapter on policy uses and applications is the final chapter, Chapter 9.

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

Chapter 2: The water accounts framework

1.40. The SEEAW links the water resource system with the economy. The water resource system and the hydrological cycles as well as its relations with the economy are described in detail.

1.41. Since the SEEAW is rooted in the 1993 SNA, and this handbook is a statistical document, Chapter 2 provides and overview of the whole accounting system. It describe in great detail the classifications used throughout the handbook which form the backbone of the accounting framework. The overview of the SEEAW accounting structure and the interconnections between the different accounts are presented at the end of Chapter 2.

1.42. Since water resources present spatial and temporal characteristics, which are usually not addressed in standard accounts, the chapter describes how the SEEAW can be adapted to compiling information which is spatial and temporally disaggregated, without disrupting the accounting structure.

1.43. This chapter can be read either at the outset as a preliminary overview of what is to follow or finally as a synoptic review of the interconnections between the accounts and tables in different chapters.

Chapter 3: Physical water supply and use tables

1.44. Chapter 3 is the main chapter concerned with compiling water flow accounts in physical terms. It is designed to show how the use of water resources can be monitored in physical terms but using classifications and definitions consistent with the economic accounting structure of the 1993 SNA.

1.45. This chapter distinguishes different types of flows, namely flows from the environment to the economy, flows within the economy and flows from the economy back to the environment. Flows from the environment to the economy consist of water abstraction from the environment for production or consumption purposes.

1.46. Flows within the economy are the purview of the 1993 SNA. The SNA, in fact measures the flows of water and wastewater within the economy and shows water that is used to produce other goods and services (intermediate consumption), to satisfy current human wants (final consumption) and water that is exported (a small part since water is a bulky good). Flows from the economy to the environment consist of discharges of wastewater back to the environment.

1.47. Chapter 3 describes the supply and use tables for physical flows of water and provides simplified standard tables as well as more detailed tables for compilation. As an aid to understand the relationships among the various accounts, a fictitious but realistic database, SEEAW land, has been developed. The tables in the database related to physical flows are presented in Chapter 3.

1.48. The chapter also provides country examples in the compilation of physical supply and use tables both at the national as well as river basin level. It also considers indicators and analyses that can be derived from the accounts and discusses possible data sources for the compilation of the accounts.

Chapter 4: Emission accounts

1.49. Chapter 4 describes the impact of the economy in terms of the quality of water resources. Emission accounts describe the amount of pollutants which is added to wastewater as a result of production and consumption activities and is released to the environment. They also describe the amount of pollutants which is removed as part of treatment by the sewerage industry.

1.50. The chapter presents a set of standard tables to be compiled by countries. It also provides SEEAW land data set for emission accounts tables as well as examples of country practices in the implementation of these accounts both at the national as well as river basin level. It also considers indicators and analyses that can be derived from the accounts and discusses possible data sources for the compilation of the accounts.

Chapter 5: Hybrid and economic accounts for activities and products related to water

1.51. Chapter 5 describes the economy of water, that is it describes in monetary terms the use and supply of water related products, identify the costs associated with the production of these products, the income generated by them, the investments in hydraulic infrastructures and how much it costs to maintain them. Those flows are captured within the 1993 SNA and need to be separately identified.

1.52. Chapter 5 shows how a standard SNA supply and use table can be juxtaposed with the corresponding part of the physical table described in Chapter 3. The result is conventional national accounts presented together with physical information on water abstraction, use and supply within the economy, and discharges of water and pollutants into the environment. These accounts, which are referred to as "hybrid accounts", do not modify the basic structure of the conventional SNA accounts. The linkage between physical and monetary information provided by hybrid accounts is particularly useful for relating the abstraction of water resources and generation of wastewater to particular industries.

1.53. In addition to the water supply and sewerage industries, other industries and households may abstract water for own use or distribute it to other users or treat the wastewater they generate. In this chapter, the costs of production of these industries are separately identified from the costs of the main activity. This will provide information of the total the full extent of national expenditures on water.

1.54. Users of water and water related products do not always bear the entire costs associated with the use; they benefit from transfers from other economic units (generally the government) which bear part of the costs. Similarly investments in infrastructures can also be partly financed by different units. The chapter the financing of water and water related products. It also describes other monetary transactions connected with water, specifically those economic instruments increasingly being used to manage the use of water resources. These are imposition of taxes, the issuing of licences and permits to bestow property rights over water resources to designated users.

1.55. The chapter provides standard tables for compilation. It considers indicators and analyses that can be derived from the accounts and discusses possible data sources for the compilation of the accounts.

Chapter 6: The asset accounts

1.56. Chapter 6 looks at water assets and discusses how to account in physical terms for changes in these accounts as a result of natural process or human activities.

1.57. Since the asset accounts describe water in the environment, the chapter describes the hydrological cycle and how it is represented in the asset accounts. It describes the principles behind physical asset accounts; that is, getting from opening stock levels to closing stock levels by itemizing the flows within the accounting period. The chapter contains the classification of water resources and provides standard tables for compilation.

1.58. The chapter describes the compilation of asset accounts for transboundary water. It also considers indicators and analyses that can be derived from the accounts and discusses possible data sources for the compilation of the accounts.

Chapter 7: Quality accounts

1.59. Quality accounts do not have a direct link to the economic accounts, as changes in quality cannot be attributed to economic quantities using a linear relationship, as in the case of the water asset accounts, in volume terms. Nevertheless, since quality is an important characteristic of water ecosystem and limits its use, the SEEAW covers the quality accounts. Chapter 4 describes in qualitative terms the stock of water.

1.60. The chapter provides basic concepts on the measurement of quality and describes different approaches to defining quality classes and then in constructing quality accounts.

Chapter 8: Valuation of water resources

1.61. The need to treat water as an economic good has been widely recognized. The 1993 SNA records the value of transactions on water within the economy. The prices charged for water in the market often do not reflect the full economic value of water because of certain unique characteristics of water. Water is a collective good and heavily regulated, subject to multiple uses. The price charged often does not even reflect its cost of production; property rights are often absent. Economists have developed techniques for estimating the value of water which are non consistent with the 1993 SNA.

1.62. This chapter describes background concepts in the economic valuation of water and the valuation principles of the SNA. It provides an overview of different valuation techniques, their strength and weakness as well as their relevance to answer particular policy questions.

Chapter 9: Examples of policy uses and applications of water accounts

1.63. Water accounts are a relatively new tool for organizing water-related information. There is therefore a need to promote these accounts both among the users and producers of water information. This chapter links the accounts to its uses for water policy by showing how the accounts have been used in countries for the derivation of indicators to monitor and evaluate policies; and scenario-modeling to estimate, for example, the impact of water pricing reforms or projecting future demands.

1.64. Although the applications presented are derived from the techniques and tables presented in the previous chapters, chapter 9 is a stand-alone. It can be read at the outset as it provides an overview of the possible uses of the accounts and can assist in setting priorities in implementation: deciding on a set of priority indicators will lead to a set of tables to compile first. It can be read at the end as it shows how the information from different accounts is brought together and used to derive indicators and to provide a database, including water, for economic modelling.

1.65. The first part of the chapter describes the most common indicators used to evaluate patterns of water use and supply and pollution. It first presents indicators at the national-level and then more detailed indicators and statistics that shed light on sources of pressure on water resources, opportunity for reducing the pressure, contribution of economic incentives to the problem and possible solutions. This information sets the stage for more complex water policy issues that require economic models based on the water accounts.

1.66. The second part of the chapter describes the use of the accounts at the subnational and river-basin level and discusses the possibility of introducing more flexible temporal dimension. It then discusses the links between water accounts and other resource accounts in the SEEA in support to IWRM.

Annexes

1.67. The handbook contains three annexes. The first annex includes the standard tables which are presented and discussed in Chapters 3-6 of the handbook. The standard tables constitute the minimum data set that all countries are encouraged to compile. Annex II contains supplementary tables, which consist of items that should be considered by countries in which information would, in their particular cases, be of interest to analysts and policy makers or for which compilation is still experimental and not directly linked with the 1993 SNA.

1.68. Annex III links the waters accounts to indicators. In particular, Section 1 draws together the wide range of indicators developed in separate chapters of this handbook to show how, together, they provide a comprehensive set of water-related indicators. Section 2 links the indicators proposed in the World Water Development Report (United Nations and the World Water Assessment Programme, 2006) to the water accounts.

Glossary

1.69. The glossary provides agreed terminology on terms and definitions related to water accounting. It combines hydrological terms, which were agreed on by an electronic discussion group; environmental-economic accounting terms, which are drawn from the glossary of the SEEA-2003; and economic terms drawn from the glossary of the 1993 SNA. The hydrological terms were drawn from international questionnaires, international glossaries and selected country reports on water accounts.

1.70. The glossary is a major step forward in the harmonization of terms and definitions from the hydrological and the economic spheres. It is intended to facilitate the collection of consistent data on water based on existing international statistical standards, such as the 1993 SNA.

F. Implementation of the accounts

1.71. The modular structure of the water accounts allows for a step-by-step compilation. Countries may wish to start with the compilation of those modules of the accounts which are more relevant to their policy concerns and data availability.

1.72. Selected modules of the accounts have been compiled by approximately 25 countries including Australia, the Republic of Moldova, South Africa, Chile, Namibia, Botswana, Morocco and most of European countries. European countries have benefited from the support of Eurostat, which has developed and collected pilot standard tables compiled by many EU countries. The results of the pilot case studies have been published in *Water Accounts – Results of Pilot Studies* (Eurostat 2002c).

1.73. In general, countries have started the implementation of water accounts with those modules which are more related to their policy concerns and their data availability. For example, countries facing severe water scarcity often have started with the compilation of asset accounts and physical supply and use tables to identify sources of pressure on the environment and possibly design allocation strategy between competing uses of water. In contrast, resource based rich countries facing problems with water pollution have often started with emission accounts, monetary supply and use tables which allow for the formulation of policies aimed at reducing the emission to water resources and evaluate the costs for their reductions.

1.74. For analytical purposes, it is important to compile the accounts on a yearly base. Benchmark compilations are usually carried out every three to five years and coincide with detailed surveys on water use and supply. For intervening years, coefficients derived from information obtained during the benchmark compilation, are used to compile the water accounts.

1.75. An analysis of the consistency of the international questionnaires[3] on water resources and the water accounting standard tables was carried out (Di Matteo, Alfieri and Havinga 2005). The analysis concluded that concepts used in the questionnaires on water resources are in general consistent with those used in water accounts. This is mostly due to two parallel initiatives aimed at the reconciliation of the Questionnaires with water accounting. One was undertaken by Eurostat during the last revision of the OECD/Eurostat Questionnaire, and the other was undertaken by UNSD during the preparation of this handbook. The broad consistency of international data collection activities with the SEEAW is important result: physical information on water resources can be linked to the monetary accounts with minor additions/modifications to the existing international data collection activities.

G. Areas of future work in water accounts

1.76. Although many countries have implemented or are in the process of implementing water accounts, there is a need to promote the implementation of the SEEAW in new countries. Producers and users of water information have to become acquaint with the features of the SEEAW and the advantages of an integrated information system rooted in the 1993 SNA in support to integrated water resource management.

1.77. Although this handbook is a major step forwards in harmonizing concepts and methods in water accounting and related statistics, two topics are still considered experimental. They include the quality accounts and the valuation of water resources. Quality accounts have been implemented in relatively

[3] These include the UNSD/UNEP and the OECD/Eurostat questionnaires on water resources and the FAO-Aquastat questionnaire. The results of the analysis of the first two questionnaires are reported in the paper by Di Matteo, Alfieri, Havinga (2005).

few countries and there is not enough experience to draw conclusions on best practices. It is expected that with the future mandatory reporting for EU countries to the Water Framework Directive, which puts considerable emphasis on quality of water resources, more standardised methods for, for example, defining quality classes are likely to emerge.

1.78. Valuation of water resources is widely applied by resource economist, however rarely in the context of national accounts. Valuation of natural resources, which includes also valuation of water, has been placed in the research agenda for the update of the SEEA-2003. The research agenda has been established to meet the request of the UN Statistical Commission of elevating the SEEA-2003 to the level of a standard. Valuation of environmental goods and services remains one of the controversial issues and will in the next years be subject of further discussion.

1.79. With the recommendations of this handbook, to compile standard and supplementary tables on water in as many countries as possible, it emerges the need to develop a structure for assessing the quality of water statistics by comparing country practices with best practices, including internationally accepted methodologies such as the SEEAW. Data quality frameworks have been developed for several areas of statistics, including national accounts. The data quality framework for water accounts could be an elaboration of the national accounts structure.

Chapter 2 The water accounting framework

A. Introduction

2.1. Integrated environmental and economic accounting for water resources (SEEAW) provides a systematic framework for the organization of water information to study the interaction between the economy and the environment. It is a further elaboration of the Integrated Environmental and Economic Accounting (SEEA) framework focusing exclusively on water resources. As the SEEA, the SEEAW expands the System of National Accounts (SNA) by separately identifying information related to water in the conventional accounts and linking physical information on water with economic accounts. The purpose of this chapter is to describe the accounting framework for water.

2.2. Section B provides a description of the interactions between the hydrological system and the economy in a diagrammatic form. It describes in a non-technical way the hydrological system, the economic system as measured by the 1993 System of National Accounts (SNA) (CEC et al. 1993) and their interactions.

2.3. Section C introduces the SEEAW framework as a satellite system of the 1993 SNA and describes how the SEEAW expands the 1993 SNA in order to address water related concerns. Section D presents the accounting framework in more detail: it describes the various accounts in the SEEAW framework, and presents the concepts, definitions and classifications that are used in the SEEAW. Section E introduces two cross-cutting issues in the compilation of water accounts: namely the identification of the temporal and spatial reference.

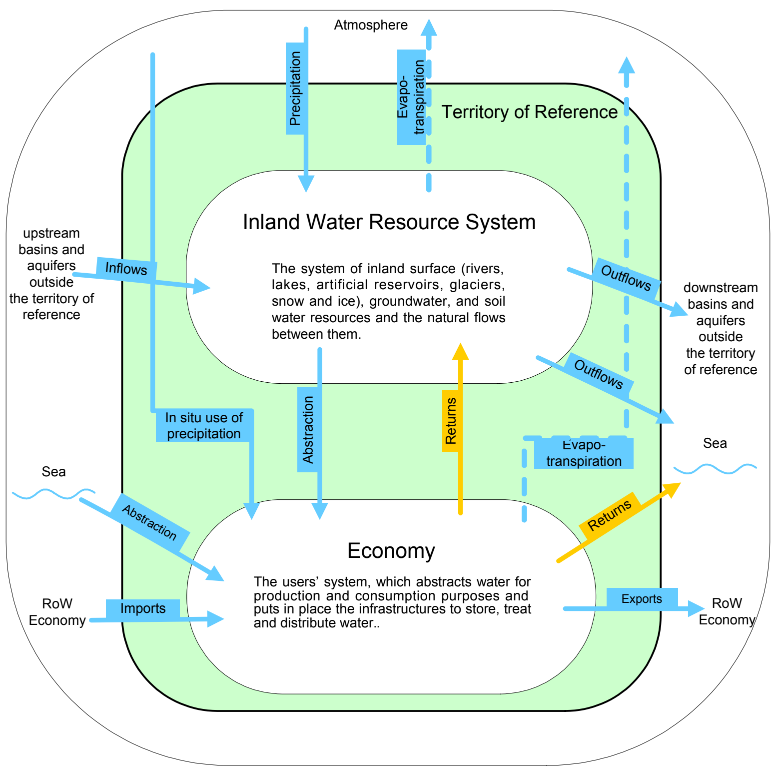
B. Water resource system and the economy

2.4. Water is needed in all aspects of life: it is essential for basic human needs, for socio-economic development and for the integrity and survival of ecosystems. Water resources provide several services to the economy, as well as to mankind outside the economy and to other living beings, namely they provide (a) material input into production and consumption activities; (b) sink functions for waste material (such as wastewater discharged into water resources); and (c) habitat for all living beings including mankind. This handbook focuses on water as material input into production and consumption activities and as a 'sink' for waste. Accounts for water as a provider of ecosystem habitat are only discussed in this handbook in terms of the quality of water and its link to the various uses.

2.5. The SEEAW provide an integrated information system to study the interaction between the environment and the economy. At present, the integration with the social dimension which is particularly important for the management of water resources is not systematically included in the SEEAW framework. Information on some crucial social aspects of water, such as access to safe drinking water and sanitation, are included in supplementary tables to facilitate the analysis of water policies in their social impacts. Other social aspects of water can be made explicit in the SEEAW, for example, by disaggregating the household sector by specific characteristics (e.g., by income, rural versus urban etc.). At this stage, the SEEAW framework only focuses on the interactions between the environment and the economy. Further methodological research and practical experience is needed to extend the framework to the social dimension.

2.6. The framework of the SEEAW can be presented in a simplified diagrammatic form presented in Figure 2.1. The figure presents in a simplified diagram the economy, the system of water resources and their interactions. The economy and the inland water resource system of a territory – referred to as 'territory of reference' - are represented in the figure in two separate boxes. The inland water resource system of a territory is composed of all water resources in the territory (surface water, groundwater and soil water) and the natural flows between them. The economy of a territory consists of resident[4] water users who abstract water for production and consumption purposes and put in place the infrastructures to store, treat, distribute and discharge water. The boxes of the inland water system and the economy are also presented in further detail in Figure 2.2 in order to describe the main flows within each system and the interactions between the two systems.

Figure 2.1: Flows between the economy and the environment



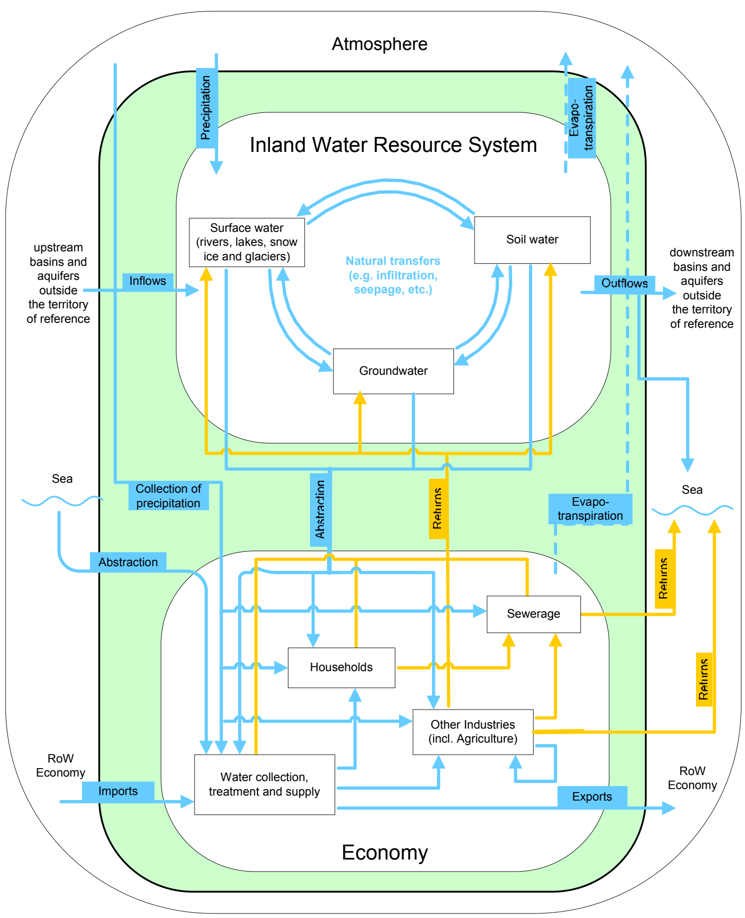
2.7. The inland water resource system and the economy of a given territory, which can be a country, an administrative region or river basin, can exchange water with those of other territories through imports/exports of water (exchanges of water between economies) and through inflows from upstream territories (exchanges of water between inland water systems). Figure 2.1 also shows exchanges with the sea and the atmosphere which are considered outside the inland water resource system but within the territory of reference. These flows are also captured in the SEEAW accounting framework.

[4] The concept of residence follows that of the 1993 SNA according to which "an institutional unit is resident in a country when it has a centre of economic interest in the economic territory of that country" (SNA para 4.15). This concept can be applied also to geographical boundaries other than the national ones.

2.8. The economy uses water in different ways. It can physically remove water from the environment for production and consumption activities or use water without physically removing it from the environment. In the first case, the economy abstracts water from the inland water bodies or the sea, uses the precipitation (in-situ use of precipitation in Figure 2.1) through rain-fed agriculture or water harvesting, and uses water for hydroelectric power generation. In the second case, the economy uses water for recreational and navigational purposes, fishing and other uses, which rely on the physical presence of water (in-situ uses) and, often, also on the quality of water. Even though these uses may have a negative impact on the quality of the water bodies, they are not directly considered in water resource accounting as they do not involve a displacement of water. However, in defining the sustainable water use for a given territory, considerations are made so as to guarantee the availability of water for other uses including in-situ uses.

2.9. In addition to abstracting water, the economy returns water into the environment. As shown in Figure 2.1, returns can be either to the inland water system or directly into the sea. Usually, return flows have a negative impact on the environment in terms of quality, as the quality of this water is often lower than that of abstracted water. Although returns to the water resource system alter the quality of the receiving body, they represent an input in the water system as returned water becomes then available for other uses.

Figure 2.2: Main flows within the inland water resource system and the economy



2.10. Figure 2.2 expands the boxes describing the inland water resource system and the economy to show in more detail the water flows captured by the accounts. It should be noted that, in order to keep the figure as simple as possible, only the main flows within the inland water resource system and within the economy are depicted in the figure. For example, direct abstraction of sea water by industries for cooling purposes is not explicitly shown in the figure even though it is recorded in the accounts.

1. The inland water resource system

2.11. Water is in continuous movement: because of solar radiation and gravity water keeps moving from lands and oceans into the atmosphere in the form of vapour (evapotranspiration) falling back again on land and oceans through precipitation. The inland water resource system is composed of: (a) all inland water resources from which water is or can be abstracted (i.e. rivers, lakes, artificial reservoirs, snow, ice, glaciers, groundwater and soil water); (b) water exchanges between water resources within the territory of reference (e.g. infiltration, runoff, percolation etc.); and (c) water exchanges with water resources of other territories (i.e. inflows, outflows). Exchanges of water between the water resources are referred to as natural transfers.

2.12. The water resources considered in the inland water resource system are rivers, lakes, artificial reservoirs, snow, ice, glaciers, groundwater and soil-water within the territory of reference. These resources form the water asset classification presented in chapter 6. The main natural inputs of water for these resources are precipitation and inflows from other territories and from other resources within the territory. The main natural flows that decrease the stocks of water are evapotranspiration, outflows to other water resources within the territory and to other territories. Human activities decrease and increase the water stocks through abstraction and returns.

2.13. The asset accounts module of the SEEAW describes the inland water resource system in terms of stocks and flows: it provides information on the stocks of water resources at the beginning and end of the accounting period and changes therein. These changes are described in terms of flows brought about by the economy and by natural processes. Asset accounts can be thought of as a description in accounting terms of the hydrological water balance.

2. The users' system – the economy

2.14. As mentioned in earlier paragraphs, water resources provide several functions not only to mankind which use water for survival, production and consumption activities, but also to other forms of life which are sustained by water. The economy is one of many water users. The focus of water accounting is on the interactions between water resources and the economy where the economy is thought of as the system which abstracts water for consumption and production activities, and puts in place the infrastructure to mobilize, store, treat, distribute and return water into the environment.

2.15. In Figure 2.2 the box representing the economy is expanded to show the main economic agents related to water. In particular, the following are identified:

- the industry primarily involved in the collection, treatment and supply of water to households, industries and the rest of the world;
- the industry primarily involved in the collection, treatment and discharge of sewage;
- other industries which use water as an input in their production processes;
- households which use water to satisfy their needs or wants.

2.16. Note that households are separately identified only as final consumers of water. If water is used by households as an input in the production, for example, of agricultural products, water should be considered as an input in the production process and the activity should be classified according to the relevant category of the classification of economic activities.

2.17. The box representing the economy in Figure 2.2 describes, in a simplified format, the physical exchanges of water represented by arrows between economic units (represented by boxes). Additional information to the one presented in the box of the economy is integral part of the SEEAW. It includes:

- the monetary transactions related to water exchanges including: (a) costs of collection, treatment and supply of water and costs of sanitation services; (b) fees and taxes paid for water and sanitation services; (c) payments for access to the resource (e.g. water rights) as well as for discharging wastewater; and (d) the financing of these services.
- the costs for environmental protection and resource management. They describe the economy's effort to prevent environmental degradation or eliminate part or all of the effects after degradation has taken place. They include actual expenses incurred by industries, households and the government;
- the investments in infrastructure. They describe (a) the costs of new investment; (b) the depreciation of old investment; (c) the costs of maintaining the water-related infrastructure; and (d) the financing of these investments;
- the emissions of pollutants into the environment. They allow for the identification of pressure on the environment by the various economic agents, namely industries, households and the government.

2.18. Sources of water for the whole economy of a given territory include: inland water resources in the environment of the territory of reference, precipitation which is either collected or used directly (e.g. rain-fed agriculture), sea water, and imports of water from other economies (the rest of the world). Once water enters the economy, it is used, returned back to the environment (to inland water resources and to the sea) or supplied to other economies (exports). In addition, during use or transportation water can be lost through leakages or processes of evaporation and evapotranspiration.

2.19. Each economic unit either abstracts water directly from the environment or receives it from other industries. Once water is used, it can either be discharged directly into the environment, be supplied to other industries for further use (reused water), or be supplied to a treatment facility which in Figure 2.2 is denoted by the box "Sewerage".

2.20. During use, some water may be retained in the products produced by the industry or evapotranspired during use (note that most of the industrial activities lose water mainly due to evaporation as opposed to agriculture which consumes water mainly due to evaporation and transpiration by plants and crops). In these cases, water is considered "consumed" by the industry. The term consumption has often different meanings depending on the context. In this handbook, the term *consumption* refers to the quantity mentioned above that is water which after use is not returned back to the environment (inland and sea water). It is different from *water use* that is the water that is received by an industry or households. The term "water consumption" is used in the hydrological sense and may create confusion among national accountants who tend to use the terms "consumption" and "use" as synonymous.

2.21. Note that Figure 2.1 and Figure 2.2 aim at showing in a simple way situations that are more complex in reality, and therefore they do not contain all the flows that occur in reality and are recorded in the accounts. For example, in Figure 2.2 flows of water lost during distribution are not explicitly shown, but they often occur, at times even in significant quantities. Although not explicitly shown in the figures, these losses are recorded in water accounts.

C. The SEEAW and SNA framework

2.22. The SEEAW has been designed to link the economic information with hydrological information in order to provide the users with a tool for integrated analysis. The SEEAW takes the perspective of the economy and looks at the interaction of the economy with the hydrological system. It has been developed as a satellite account of the SNA in the sense that it expands the analytical capacity of national accounts by addressing water related concerns without overburdening or disrupting the central system. As a satellite accounts of the SNA, the SEEAW has a similar structure to the SNA as it uses concepts, definitions and classifications consistent with the conventional accounts while not violating the fundamental concepts and laws of hydrology. The SEEAW expands the central accounting framework by:

- Expanding the 1993 SNA asset boundary to include all water assets and their quality and produced assets used for mobilizing water resources.

  The 1993 SNA includes only "aquifers and groundwater resources to the extent that their scarcity leads to the enforcement of ownership and/or use rights, market valuation and some measure of economic control" (SNA 1993, Annex of Chapter XIII). The SEEAW expands the SNA asset boundary by including all water resources, surface, groundwater and soil water, found in the territory. The water asset accounts in physical terms are an elaboration of the hydrological water balance, and they describe the changes in stocks due to natural causes and human activities.

  Water resources are also described in the SEEAW in terms of their quality as often the degradation of the quality of water resources is a limiting factor in the use of water. Quality accounts describe the quality of the stocks of water at the beginning and end of the accounting period. Quality can be defined in terms of one pollutant, a combination of them, or in terms of physical characteristics (e.g. salinity level) of water.

  Asset accounts for infrastructure (e.g. pumps, dams, etc.) related to water and sanitation are already included in the SNA, however, they are often lumped together with other produced assets. The SEEAW allows for the explicit identification of those assets related to water and sanitation. This type of information has great analytical value as it provides information on the ability of a country to mobilize water.

- Expanding the SNA by juxtaposing physical information to the monetary accounts.

  In the SNA stocks or assets used in the production process and flows of products are measured only in monetary terms, even if underlying physical information may be used in the compilation of monetary accounts. The SEEAW allows for the compilation of the accounts in physical terms. In the case of water, physical flows include the quantity of water used for production and consumption activities and the quantity of water reused within the economy and returned to the environment (treated or untreated). Monetary flows include the current and capital expenditures for abstraction, transportation, treatment and distribution of water resources as well as water- and wastewater- related taxes paid and subsidies received by industries and households.

- Introducing information on the relationship between the economy and the environment in terms of abstraction, returns and emissions thus allowing for the analysis of the impact on natural assets caused by production and consumption activities of industries, households and government.

Production and consumption activities affect both the quality and quantity of water resources. By introducing information on abstraction and discharge of water by industry, households and government as well as information on the emission of pollutants into water resources, the SEEAW allows for the study of the impacts of these activities both in terms of quantity and quality of water resources.

- Separately identifying expenditures for the protection of water resources and their management.

The SNA already includes implicitly expenditures for environmental protection and resources management. The SEEAW reorganizes this information in order to make it more explicit thus allowing for the separate identification of the expenditures for the protection and management of water as well as the identification of taxes, subsidises and the financing mechanisms.

2.23. The strengths of using the national accounting framework to describe the interactions between the environment and the economy are manifold. First, the SNA is an international standard for compiling economic statistics. It provides a set of internationally agreed concepts, definitions and classifications which ensures the quality of the statistics produced. The SNA is the main source of information for internationally comparable economic indicators and for economic analysis and modelling. The integration of environmental information into this framework requires using concepts, definitions and classifications consistent with those of the SNA. This ensures the consistency of environmental and economic statistics and facilitate and improve the analysis of the interrelations between the environment and economy

2.24. Second, the accounting framework contains a series of identities (for example, that involving supply and use), which can be used to check the consistency of data. Organizing environmental and economic information into an accounting framework has the advantage of improving basic statistics.

2.25. In addition, the accounting structure allows for the calculation of a number of indicators which are precisely defined, consistent and interlinked with each other because they are derived from a fully consistent data system. Compared to the use of loose sets of indicators, using indicators that are derived from the accounts has the advantage of enabling further analyses of interlinkages and of causes for changes, completed by scenarios and prognoses on the basis of scientific macro-economic models.

2.26. In short, the existence of an underlying integrated data system is essential for integrated economic and environmental analyses: it allows for cost-effectiveness, scenario modelling, economic and environmental forecast and evaluation of trade-offs by no longer viewing sectoral policies isolation but in a comprehensive economic and environmental context.

D. The SEEAW framework

2.27. The SEEAW framework is based on the SEEA-2003 (UN et al. 2003). This handbook is divided in two parts. The first part describes the accounts for which there is experience in countries and agreement on how to compile the accounts. It expands what is presented in the SEEA-2003 by (a) focusing on definitions and classifications related to water; (b) providing standard compilation tables; and (c) discussing data issues and suggesting indicators that can be derived from the accounts. The second part describes modules that are more experimental and for which not enough country experience exists. Part II of the SEEAW includes the quality accounts and valuation of water which are discussed in Chapters 7 and 8. These chapters discuss issues in the compilation of those accounts and illustrate those issues by presenting country experiences. As opposed to part one, there is no recommendation on how to compile those modules of the accounts. The SEEAW framework consists of the following accounts.

Part I

Flow accounts

2.28. The central framework of the SNA contains detailed supply and use tables (SUT) in the form of matrices that record how supplies of goods and services originate from domestic industries and imports, and how these supplies are allocated between intermediate or final uses, including exports. Flow accounts provide information on the contribution of water to the economy and the pressure exerted by the economy on the environment in terms of abstraction and emissions.

Physical supply and use tables

2.29. The SEEAW allows for the compilation of physical accounts for the supply and use of water. The physical supply table is divided into two parts: one which describes the flows of water within the economy (e.g. distribution of water from one industry to another or to households) and with the rest of the world), the other which describes flows from the economy to the environment (e.g. discharges of water in the environment).

2.30. The physical use table is also divided into two parts: one which describes flows from the environment to the economy (e.g. water abstraction by industry and households); and the other which describes flows within the economy (e.g. water received from other industries, households and the rest of the world). Physical supply and use tables are presented in chapter 3 of this handbook.

Emission accounts

2.31. Emission accounts provide information by industry, households and government on the amount of pollutants added to wastewater which is either discharged into the environment (with or without self-treatment) or discharged into a sewage network. Emission accounts are presented in chapter 4.

Hybrid and economic accounts

2.32. Hybrid accounts present, in a consistent manner, physical and monetary information on the supply and use of water by juxtaposing the standard (monetary) 1993 SNA supply and use tables with the corresponding physical tables. The monetary supply and use tables explicitly identify water-related products and water-related industries.

2.33. For analytical purposes, it is useful to identify the government expenditures on the management of water supply and sanitation. Further, it is also interesting to assess the contribution of water-related activities to the economy, linked to the physical flows of water, in particular to understand the financing of these activities and products. Monetary accounts for government expenditure on water-related activities as well as hybrid accounts for the collection, treatment and supply of water carried out as secondary and ancillary activity and as principal activity provide this kind of information which coincides with the environmental protection and resource management expenditure for water resources.

2.34. One outcome of the compilation of economic accounts for water is the construction of the financing table, which allows for the identification of the units which bear the costs of production of water supply and sanitation services and those which receive transfers from other economic units, government or other countries.

2.35. These accounts are presented in chapter 5 together with other economic transactions related to water, namely taxes/subsidies and water rights.

Asset accounts

2.36. Asset accounts measure stocks at the beginning and end of the accounting period and record the changes in stocks that occur during the period. Two types of assets are related to water: produced assets which are used for the abstraction, mobilization and treatment of water and natural assets of water resources.

Produced assets

2.37. Produced assets related to water include infrastructure put in place to abstract, distribute, treat and discharge water. They are included in the SNA asset boundary as fixed assets; hence they are implicitly included as part of the core SNA accounts compiled in monetary terms. This information, however, is generally available in conventional national accounts in an aggregated manner and special surveys may be necessary to separately identify economic assets related to water. Often these assets are owned either by water companies or water authorities. Changes in the value of these stocks during the accounting period are explained by changes due to transactions (gross fixed capital formation), consumption of fixed capital, changes in the volume of the asset that are not due to transactions (e.g. changes in classification, natural disasters etc.), and revaluation (due to changes in prices) (1993 SNA para. 13.92). These accounts provide information on the ability of an economy to mobilise and treat water including information on investments on infrastructure and its depreciation. Accounts for these assets are not dealt with explicitly in this handbook as these accounts follow the structure of the conventional accounts. Interested readers should refer to chapter XIII of the 1993 SNA.

Water resources

2.38. The asset accounts describe the volume of water resources, in the various asset categories, at the beginning and end of the accounting period and all the changes therein due to natural causes (precipitation, evapotranspiration, outflows etc.) and human intervention (i.e. abstraction and returns).

2.39. The SEEA asset boundary of water resources is very broad to include, in principle, all inland water bodies, namely surface water (rivers, lakes, artificial reservoirs, glaciers, snow and ice), groundwater and soil water. In practice, it is very difficult to compile asset accounts for all water resources in the SEEAW asset boundary. Nevertheless, they are included in the asset classification for the sake of completeness and are important in particular, when measuring exchanges between water resources (flows within the environment).

2.40. A small part of water resources is already included in the SNA asset boundary: the category AN.214, Water Resources, includes aquifers and groundwater resources to the extent that their scarcity leads to the enforcement of ownership and/or use rights, market valuation and some measure of economic control.

2.41. Asset accounts for water resources could also be compiled in monetary terms, but in practice, it is more common to compile them only in physical units: very rarely water has a positive economic value as it is often provided free of charge or at prices that do not reflect the costs of providing the services. Physical assets accounts are presented in chapter 6.

Part II

Quality accounts

2.42. Asset accounts can also be compiled on the basis of water quality. They describe stocks of water of a certain quality at the beginning and end of an accounting period. Since it is in general difficult to link changes in quality to the causes that affect it, quality accounts describe only the total change in quality in an accounting period without further specifying the causes. Quality accounts are presented in chapter 7.

Valuation of non-market flows

2.43. This component presents non-market valuation techniques and their applicability in answering specific policy questions. Since the valuation of water resources and consequently their depletion remain controversial because of the fundamental importance of the resource for basic human needs and the lack of a real market for water, this handbook does not discuss the calculation of macroeconomic aggregates adjusted for depletion and degradation costs, which are nevertheless discussed in the SEEA-2003. Chapter 8 of this handbook presents a review of the valuation techniques that are used for water resources and discusses their consistency with the SNA valuation.

1. Classifications of economic activities and products

2.44. The economy is comprised of five sectors: the non-financial corporation sector, the financial corporation sector, the general government sector, the non-profit institutions serving households sectors, and the households sector. These sectors are themselves comprised of resident institutional units which are economic entities that are capable, in their own right, of owning assets, incurring liabilities and engaging in economic activities and in transactions with other entities (SNA paragraph 4.2).

2.45. When looking at the institutional units in their capacity as producers, they are referred to as enterprises. They can be involved in a various range of productive activities which may be very different from each other with respect to the type of production processes carried out and also the goods and services produced. Therefore to study production, it is more useful to work with groups of producers who are engaged in essentially the same kind of production. These are called establishments and are institutional units disaggregated into smaller and more homogeneous units. The SNA defines industries as groups of establishments. The production accounts and generation of income accounts are compiled for industries as well as sectors.

2.46. The classification of industrial economic activities used in the SEEAW is the same as that used in the SNA, that is the International Standard Industrial Classification of All Economic Activities (ISIC).

2.47. ISIC is a classification according to the kind of economic activity (and not a classification of industries, goods and services). The activity carried out by a unit is the type of production in which it engages. This is the characteristics of the unit according to which it is grouped with other units to form industries. An industry is defined as the set of all production units engaged primarily in the same or similar kinds of productive economic activity (see also para. 5.41, 1993 SNA).

2.48. ISIC does not draw distinction according to kind of ownership, type of legal organization or mode of operation because such criteria do not relate to the characteristics of the activity itself. Units engaged in the same kind of economic activity are classified in the same category of ISIC irrespective of whether they are (part of) incorporated enterprises, individual proprietors or government, and whether or not the parent enterprise consists of more than one establishment. Also ISIC does not distinguish between formal and informal, legal and illegal production or market and non-market activity.

2.49. Since an establishment, the statistical unit for industrial or production statistics, may often engage in a number of activities, it is useful to distinguish between principal, secondary and ancillary activities. The output of principal and secondary activities, which are consequently principal and secondary products, is produced for sale on the market, for provision free of charge or for other uses that are not prescribed in advance: for example they may be stocked for future sale or further processing. The principal activity of an economic entity is the activity that contributes most to the value of the entity, or the activity the value added of which exceeds that of any other activity of the entity. A secondary activity is each separate activity that produces products eventually for third parties and that is not a principal activity of the entity in question. Finally, an ancillary activity is an activity undertaken in order to facilitate the principal or secondary activities of an entity: the output is always intended for intermediate consumption within the same entity, often the enterprise.

2.50. Secondary and ancillary activities are generally not explicitly identified in the conventional accounts. However, these activities may be particularly important to understand the interactions between the economy and the environment. Thus environmental and economic accounts explicitly identify secondary and ancillary activities in the accounts (see chapter 5 for further detail on the externalisation of ancillary activities related to water). In the case of water, for example, a number of industries abstract water directly to use in their production processes (in this case, abstraction is an ancillary activity). Aggregating this information with the principal production of a unit would produce partial information on the water use of the economy.

2.51. In the conventional accounts, the activity classification of each unit (establishment) is determined by the ISIC class in which the principal activity, or range of activities, of the unit is included. There are, however, cases in which the production of secondary activities within an establishment is as important, or nearly as important, as the production of the principal activity. In these cases, the establishment should be subdivided so that the secondary activity is treated as taking place within an establishment separate from that in which the principal activity takes place and classified accordingly. In the SEEAW accounts, ancillary and secondary activities are also classified according to the kind of production and are allocated to the ISIC class of the establishment.

2.52. Box 2.1 provides a schematic summary of the economic activities, classified according to ISIC Rev. 4 (United Nations, 2006), which are primarily related to water in the sense that they either provide water or water related services. Note that structural changes were introduced since the previous version of ISIC, namely ISIC Rev. 3.1 (United Nations 2004). In particular, for activities related to water, two major changed have been introduced in ISIC Rev. 4:

(i) In order to reflect the fact that often activities of abstraction, purification and distribution of water are carried out in the same enterprise as activities of wastewater treatment and disposal, ISIC Rev. 4 combines into the same section all these activities which were classified in different sections in ISIC Rev. 3.1.

(ii) Given the importance of activities aimed at the decontamination of water resources and wastewater management, a division is introduced in ISIC Rev. 4 to explicitly identify these activities.

2.53. The correspondence of codes of ISIC Rev. 4 and Rev. 3.1 is presented in this chapter together with a detailed description of the classes relevant to water accounting. In the rest of this handbook, reference to a particular class is made according to ISIC Rev. 4. As it can be seen from the code correspondence, countries implementing ISIC Rev. 3.1 will not be substantially affected by the change introduced by ISIC Rev. 4. The main activities related to water are described below.

2.54. Activities of **operation of agricultural irrigation systems** in support of crop production include, among various support activities for crop production, all water mobilisation activities corresponding to agricultural uses including groundwater abstraction, construction of dams, catchments for surface flows, etc., and the operation of irrigation equipment. The operation of irrigation systems is recorded under class **0161** of ISIC Rev. 4 and it corresponds to the class 0140 of ISIC Rev. 3.1. This does not include the provision of water in ISIC 36 Rev. 4 or any construction involved in the provision of this service. Note, however, that special surveys are often necessary to disaggregate information on class 0161, ISIC Rev. 4 in order to explicitly identify activities for the operation on irrigation system.

2.55. Activities for the **collection, treatment and supply of water** (ISIC Rev. 4 class 3600), include: collection of water from various sources (abstraction from rivers, lakes, wells etc. and collection of rain water); purification of water for supply purposes; and distribution of water through mains, by trucks or other means for domestic and industrial needs. This class also includes activities of desalting of sea or ground water in order to produce water. The operation of irrigation canals is also included; however, the provision of irrigation services through sprinklers, and similar agricultural support services, are classified under the class 0161 of ISIC Rev 4. ISIC Rev. 4 class 3600 corresponds to ISIC Rev. 3.1 class 4100.

2.56. Note that activities of abstraction and purification are an example of the importance of externalising as much as possible secondary and ancillary activities. In fact, abstraction and purification are often carried out either as secondary or ancillary activities: direct water abstraction by an industry for their own use is an example of an ancillary activity. Similarly, an industry, which after having used water in the production of some goods, sells it to another industry instead of discharging it into the environment is an example of a secondary activity. Ignoring these activities by aggregating information with the economic unit's principal activity would underestimate the volumes of water involved as well as the cost associated with these activities.

2.57. Activities of **sewerage** (ISIC Rev. 4 class 3700) include: the operation of sewer systems or sewer treatment facilities; the collection and transportation of (human and industrial) wastewater from one or several users, as well as urban runoff by means of sewerage networks, collectors, tanks and other means of transport (sewage vehicles etc.); the treatment of wastewater by means of physical, chemical and biological processes like dilution, screening, filtering, sedimentation etc.; the emptying and cleaning of cesspools and septic tanks, sinks and pits from sewage; and servicing of chemical toilets. This class also includes activities of maintenance and cleaning of sewers and drains. Note that an economic unit engaged in the collection and treatment of wastewater, ISIC 3700 Rev. 4, can also distribute (waste)water to specific users for further use.

2.58. Class 3700 of ISIC Rev. 4 corresponds to part of the activities classified in class 9000 of ISIC Rev. 3. The rest of the activities classified in class 9000 of ISIC Rev. 3 relate to remediation activities and are explicitly identified in ISIC Rev. 4 in class 3800 and 3900. ISIC rev. 4 class 3800 is waste collection, treatment and disposal activities and materials recovery. The activities of class 3800 refer to solid waste and therefore are not discussed further in this handbook.

2.59. **Remediation activities and other waste management services**. These activities are coded under class 3900 of ISIC Rev. 4 and they include the provision of remediation services, i.e. the cleanup of contaminated buildings and sites, soil, surface or ground water. Only part of these activities are related to water: they include (a) decontamination of soils and groundwater at the place of pollution, either in situ or ex situ, using e.g. mechanical, chemical or biological methods; (b) decontamination and cleaning up of surface water following accidental pollution, e.g. through collection of pollutants or through application of chemicals; (c) cleaning up of oil spills and other pollutions on land, in surface water, in ocean and seas, including coastal areas.

2.60. These activities are particularly useful in assessing environmental protection expenditures. Class 3900 of ISIC Rev. 4 corresponds to part of class 9000 of ISIC Rev. 3.1.

2.61. Activities aimed at the **administration and regulation of programmes related to water** such as potable water supply programmes, waste collection and disposal operations and environmental protection programmes (part of ISIC Rev. 4 class 8412) are classified together with the administration of a number of other programmes in health, education, sport etc. Thus when compiling water accounts, the interest is only in the information on the part of class 8412, ISIC Rev. 4, which is relevant to water which has to be identified through special surveys. Class 8412, ISIC Rev. 4 corresponds to class 7512 of ISIC Rev. 3.1.

Box 2.1: Main activities related to water in the economy

ISIC 0161 **Support activities for crop production** [corresponds to class 0140, ISIC Rev. 3.1] This class includes among various support activities for crop production: - operation of agricultural irrigation equipment.
ISIC 3600 **Water collection, treatment and supply** [corresponds to class 4100, ISIC Rev. 3.1] This class includes water collection, treatment and distribution activities for domestic and industrial needs. Collection of water from various sources, as well as distribution by various means is included. The operation of irrigation canals is also included; however the provision of irrigation services through sprinklers, and similar agricultural support services, is not included. This class includes: - collection of water from rivers, lakes, wells etc. - collection of rain water - purification of water for water supply purposes - desalting of sea or ground water to produce water as the principal product of interest - distribution of water through mains, by trucks or other means - operation of irrigation canals *This class excludes: operation of irrigation equipment for agricultural purposes, see 0161; treatment of waste water in order to prevent pollution, see 3700; (long-distance) transport of water via pipelines, see 4930.*
ISIC 3700 **Sewerage** [part of class 9000, ISIC Rev. 3] This class include: - the operation of sewer systems or sewer treatment facilities - collecting and transporting of human waste water from one or several users, as well as rain water by means of sewerage networks, collectors, tanks and other means of transport (sewage vehicles etc.) - emptying and cleaning of cesspools and septic tanks, sinks and pits from sewage; servicing of chemical toilets - treatment of waste water by means of physical, chemical and biological processes like dilution, screening, filtering, sedimentation etc. - treatment of waste water in order to prevent pollution, e.g. from swimming pools, industry - maintenance and cleaning of sewers and drains - sewer cleaning and rodding.
ISIC 3900 **Remediation activities and other waste management services** [part of class 9000, ISIC Rev. 3] This class includes: - decontamination of soils and groundwater at the place of pollution, either in situ or ex situ, using e.g. mechanical, chemical or biological methods - decontamination of industrial plants or sites, including nuclear plants and sites - decontamination and cleaning up of surface water following accidental pollution, e.g. through collection of pollutants or through application of chemicals - cleaning up of oil spills and other pollutions on land, in surface water, in ocean and seas, including coastal areas - asbestos, lead paint, and other toxic material abatement - other specialized pollution-control activities *This class excludes: treatment and disposal of non-hazardous waste, see 3821; treatment and disposal of hazardous waste, see 3822; outdoor sweeping and watering of streets etc., see 8129.*
ISIC 8412 **Regulation of the activities of providing health care, education, cultural services and other social services, excluding social security** [corresponds to class 7512, ISIC Rev. 3.1] This class also includes: - administration of potable water supply programmes - administration of waste collection and disposal operations - administration of environmental protection programmes.

2.62. Note that division 84 of ISIC Rev. 4 includes activities normally carried out by the public administration. However, the legal or institutional status is not, in itself, the determining factor as ISIC does not make any distinction regarding the institutional sector to which a statistical unit belongs. Activities carried out by government units that are specifically attributable to other areas of ISIC should be classified in the appropriate class of ISIC and not in division 84, ISIC Rev. 4. Often there is the tendency of allocating to class 8412 of ISIC Rev. 4 activities for collection, purification and distribution of water (class 3600 of ISIC Rev. 4) and for the sewage, refuse disposal and sanitation (class 3700 of ISIC Rev. 4) when they are owned by the government. This can occur, for example, when the local government accounts are not detailed enough to separate water supply or sewage collection from other activities. Division 84 of ISIC Rev. 4 includes the administration of programmes related to a variety of services, enabling the community to function properly, but it does not include the actual operation of facilities, such as water works. Some activities in this division may be carried out by non-government units.

2.63. Monetary supply and use tables are constructed for the products associated with the industries in Box 2.1 and provide information on the value of the output produced (supplied) and its uses as intermediate, final consumption and exports. In the SNA, products are classified according to the Central Product Classification (CPC) Ver. 2.0 (United Nations, 2006). The CPC constitutes a comprehensive classification of all goods and services and classifies products based on the physical properties and the intrinsic nature of the products as well as on the principle of industrial origin. The CPC and the ISIC are both general-purpose classifications, with the ISIC representing the activity side and the CPC the product side of these two interrelated classifications. Note, however, that a one to one correspondence between the CPC and the ISIC is not always possible as the output of an industry, no matter how narrowly defined, will tend to include more than a single product. Similarly, a product can be produced by industries classified in different classes. In general, however, each subclass of the CPC consists of goods or services that are predominantly produced in a specific class or classes of the ISIC, Rev. 4.

2.64. The main products related to water which are identified in the CPC Version 2.0 are described in Box 2.2 together with a reference to the ISIC, Rev. 4 industry or industries in which most of the goods or services in question are generally produced.

2.65. Although the term natural water seems to describe water in the natural environment, the CPC class “Natural water” is very broad and covers all types of water: water in the environment, water supplied and used within the economy and also water discharged back into the environment. The exact boundaries of this class are usually determined by the statistical framework that uses the CPC. To reflect these different types of water flows, water accounts disaggregate the CPC class of natural water firstly in terms of the type of flow (from the economy to the environment, within the economy and from the economy to the environment), secondly in terms of the type of water: for example, water supplied to other economic units is further disaggregated to identify, for example, if it consist of wastewater supplied for further use. This is often very important as some water conservation policies encourage the reuse of water. Examples of relevant categories of water in the physical supply and use tables are presented in Chapter 3.

2.66. Physical supply and use tables record the amount of water that is exchanged between an economic unit and the environment (abstraction and return flow) and between economic units. However, monetary supply and use tables may report the value of the service associated with the water exchange as well as the value of the water exchanged. This is because the output of the supplying industry is generally a service (and the monetary SUT records the value of the service). For example, the water supply industry, which collects, treats and supply water, generally charges only for the service of collection, treatment and supply and not for water as a good.

Box 2.2: Main products related to water according to CPC Version 2.0

Product code	ISIC reference
Hydroelectric energy which is part of the class CPC 1710 - Electrical energy. Note that the class CPC 1710 contains electrical energy produced under different processes such as thermal, nuclear, hydroelectric, gas turbine etc. Only the part relevant for water – the part generated by hydroelectric power plants - is reported in the table. This is referred to as hydroelectric energy.	ISIC 35 - Electricity, gas, steam and air conditioning supply
Natural water - CPC 18000	ISIC 3600 – Collection, treatment and supply of water
Operation of irrigation systems for agricultural purposes which is part of CPC 86110 - Services incidental to crop production. The class CPC 86110 includes a number of activities necessary for agricultural production ranging from the preparation of fields to harvesting. The supply and use table only report the part of this class that is relevant for water.	ISIC 0161 - Support activities for crop production
Water related administrative services which are part of CPC 91123 - Administrative housing and community amenity services. The class CPC 91123 covers a number of services, the part that is relevant for water include: (i) public administrative services for water supply, (iii) services provided by offices, bureaux, departments and programme units involved in developing and administering regulations concerning water supply; and (iii) public administrative services related to refuse collection and disposal, sewage system operation and street cleaning.	ISIC 8412 - Regulation of the activities of providing health care, education, cultural services and other social services, excluding social security
Sewerage, sewage treatment and septic tank cleaning services - CPC 941. This group includes: (i) Sewerage and sewage treatment services (CPC 9411) and (ii) Septic tank emptying and cleaning services (CPC 9412).	ISIC 37 - Sewerage
Site remediation and clean-up services, surface water – CPC 94412. This subclass includes services involved in implementing approved plans for the remediation of surface water on a contaminated site, that meet requirements specified by legislation or regulation *Site remediation and clean-up services, soil and groundwater* – CPC 94413. This subclass includes: (i) services involved in implementing approved plans for the remediation of soil and groundwater on a contaminated site, that meet requirements specified by legislation or regulation, (ii) maintenance and closure of landfills and other disposal sites; and (iii) operation, maintenance, closure of hazardous waste disposal facilities.	ISIC 3900 Remediation activities and other waste management services

Note: main products related to water as identified in the CPC Version 2.0 are presented together with the reference to the industry, ISIC Rev. 4, which most of the goods or services in question are generally produced.

2. Main identities of the SNA accounting framework

2.67. The conventional economic accounts consist of an integrated sequence of accounts which describe the behaviour of the economy from the production of goods and services – generation of income – to how this income is made available to various units in the economy and how it is used by these units. The SNA has identities within each account and between accounts that ensure the consistency and the integration of the system. The identities that are used in this handbook more frequently are described below.

2.68. A particularly useful identity for the SEEA involves the total supply and total use of products. In a given economy a product can be the result of domestic production (output) or production in another territory (imports). Hence

Total Supply = Output + Imports.

2.69. On the other side (use), the good and services produced can be used in various ways. They can be used by: (a) industries to produce other goods and services (intermediate consumption); (b) households and government to satisfy their needs or wants (final consumption); (c) they can be acquired by industries for future use in the production of other goods and services (capital formation); and finally they can be used by the economy of another territory (exports). Therefore

Total Use = Intermediate Consumption + Final Consumption +

+ Gross Capital Formation + Exports.

Total supply and total use as defined above have to be equal. In the SNA this identity is expressed only in monetary terms, but in the SEEA it holds also when the accounts are compiled in physical terms.

2.70. Another identity of the SNA involves the generation of value added. Gross value added is the value of output less the value of the goods and services, excluding fixed assets, consumed as inputs by a process of production, (intermediate consumption); and is a measure of the contribution to Gross Domestic Product (GDP) made by an individual producer, industry or sector. When we take into account also the reduction in the value of the fixed assets used in production during the accounting period resulting from physical deterioration, normal obsolescence or normal accidental damage (consumption of fixed capital), we then obtain net value added:

Gross Value Added = Output – Intermediate Consumption

Net Value Added = Output – Intermediate Consumption – Consumption of Fixed Capital.

2.71. Once the value added is generated, it is decomposed in the primary generation of income accounts in compensation of employees, taxes and subsidies on production and operating surplus:

(Gross) Value added = (Gross) Operating Surplus + Compensation of Employees + Taxes – Subsidies

2.72. Another identity of the SNA particularly useful in the SEEA involves assets and links them with flows. This identity describes the stocks of assets at the beginning and end of an accounting period and their changes. Changes are the result of transactions on the asset (gross fixed capital formation), consumption of fixed capital, changes in the volume of the asset that are not due to transactions (e.g. changes in classification, discoveries, natural disasters etc.), changes in their prices (holding gains/losses on assets):

Closing Stocks = Opening Stocks + Gross Fixed Capital Formation – Consumption of Fixed Capital

+ Other Changes in Volume of Asset + Holding gains/losses on assets.

3. The water accounting framework

2.73. Figure 2.3 gives a simplified representation of the SEEAW accounting framework and links supply and use tables (SUT) with the asset accounts. The framework of the SEEAW is the same as the one of the SEEA-2003, only it focuses specifically on water. The unshaded boxes represent monetary accounts that are already part, explicitly or implicitly, of the SNA. The grey boxes represent accounts that are introduced in the SEEAW and are not covered in the SNA. They are measured in physical and monetary units. The various types of accounts are described next.

2.74. The monetary SUT are shown in Figure 2.3 with unshaded boxes. While the SNA supply table in monetary terms remains unchanged in the SEEAW framework, the use table in the SEEAW contains a more detailed breakdown of the costs for water use, which are not usually explicitly available in the SNA. Monetary supply and use tables for water are presented in chapter 5.

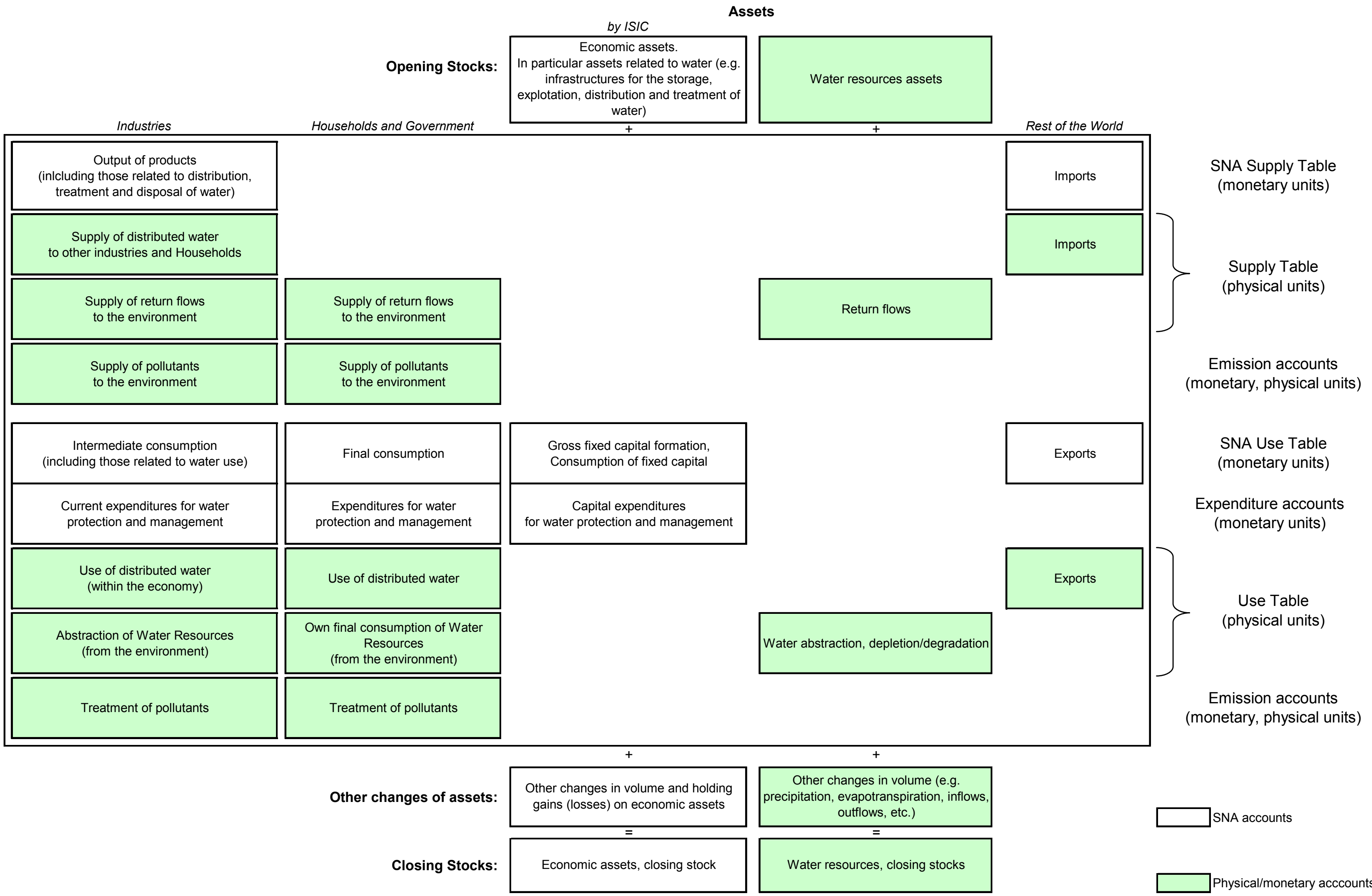
2.75. Expenditure accounts are also shown in the figure with unshaded boxes. This is because the information on expenditures for water protection and management are also part of the conventional accounts even though the information is generally aggregated and special surveys are necessary to disaggregate these expenditures from others. Water protection and management accounts are also presented in chapter 5.

2.76. Physical SUT describe the water flows from abstraction, use and supply within the economy and returns into the environment and are shown in the figure with shaded boxes as they are not part of the core national accounts. The SEEAW also introduces SUT for pollutants (emission accounts) which describe the flow of pollutants, in physical and possibly in monetary terms, generated by the economy and supplied to the environment.

2.77. The asset accounts are obtained in Figure 2.3 by combining the opening and closing stocks of assets with the part of the SUT which affects the stocks. In particular, Figure 2.3 distinguishes assets related to water which are within the asset boundary (unshaded box) which includes infrastructures for the storage, mobilization and use of water, as well as assets of water which include mainly water in the environment. Note that part of the assets of water is already included in the SNA (e.g. groundwater) but they are not shown separately for two reasons: one is that these assets represent a minimal part of all water assets; second, that the valuation of those assets, even if theoretically possible, remains in practise a difficult exercise and it is often embedded in the value of land.

2.78. The framework in Figure 2.3 can also be presented in a matrix form. The matrix presentation is commonly referred to as National Accounting Matrix including Water Accounts (NAMWA). NAMWA and more in general National Accounting Matrix including Environmental Accounts (NAMEA) have been developed by Statistics Netherlands (CBS) (see Box 2.3) and adopted by Eurostat. It should be noted that NAMWA is not a different framework rather an alternative presentation of the information contained in the supply and use tables presented in Figure 2.3.

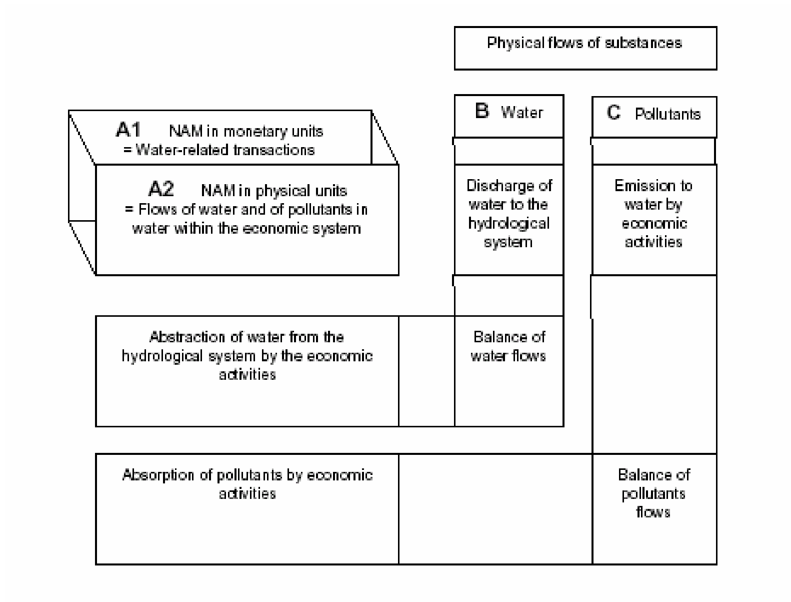
Figure 2.3: Framework for Integrated Environmental Economic Accounting for Water Resources



Box 2.3: NAMWA representation of the water accounting framework

NAMWA extends the matrix presentation of national accounts (NAM) with supplementary rows and columns where flows of substances (water and pollutants) are recorded in physical units and presented in parallel with economic transactions. In the matrix presentation each account is represented by a row and column pair. The convention is that incomings or resources are shown in the rows, and outgoings or uses are shown in the columns. Table 2.1 shows how the different accounts are organized in NAMWA.

Table 2.1: NAMWA



Source: Eurostat, 2002c.

NAMWA consists of three parts:

A. Description of flows within the economy (monetary and physical units)
B. Description of flows of water between the environment and the economy (physical units)
C. Description of flows of pollutants between the environment and the economy (physical units)

Flows within the economy. In NAMWA, flows within the economy are described in boxes A1 and A2 of table 2.1. Box A1 represents the national accounting matrix with focus on water related transactions: it presents more detailed transactions on water-related products (for example, water supplied by an economic activity, sewage services etc.), detailed production accounts of water-related activities (for example, ISIC 3600 and ISIC 3700), expenditures for ancillary activities related to water within other activities (parts of the production accounts of non-water-related activities), taxes linked to water and to water-related activities (abstraction taxes, pollution taxes, etc.), subsidies in relation to water use, etc. Box A2 in table 2.1 translates into physical units some of the transactions reported in box A1, more precisely, those to which physical flows can be connected: flows of water and pollutants transported in water.

Flows of water between the economy and the environment. These flows, described in part B of table 2.1, include detailed information in physical units on water abstraction and water returns by economic activities. In particular, abstraction and returns are disaggregated according to the type of natural resource water is abstracted from and returned to (e.g. groundwater, surface water, sea water etc.).

Flows of pollutants between the environment and the economy. These flows, described in part C of table 2.1, include detailed information in physical units on the generation and absorption of pollutants by economic activities. The absorption of pollutants is the removal of pollutants from abstracted water and it occurs during purification/treatment processes.

The basic NAMWA presentation can be extended to describe the contributions of pollutants to environmental themes such as eutrophication and dispersion of heavy metals (which is compiled by Statistics Netherlands – see chapter 4 for more details) and water exchanges within the environment such as flows between different water resources in the environment and stocks and changes in stocks.

E. Spatial and temporal issues in water accounting

2.79. Water resources are not evenly distributed in time and space. Major spatial variability at the global level can be seen in the difference between arid regions where almost no precipitation falls and humid regions where several metres of rain can fall yearly. Even at a smaller spatial scale, there can be a great variability in the availability of water: within the same river basin there can be areas subject to water scarcity while others are subject to flooding. The temporal distribution of water resources depends on the characteristics of the water cycle. There is in fact a rain cycle for which periods of high rainfall alternate with dry periods, for example, on a yearly basis, dry summer months are followed by wet winter months. The frequency of the water cycle varies with climatic regions and the inter-annual variability can be significant.

2.80. Since water accounts consist of integrating hydrological information with economic information which is compiled according to the SNA and uses as spatial reference the country or administrative regions, and as a temporal reference the accounting year and in some cases smaller temporal references (such as quarterly accounts), some issues in the reconciliation of the temporal and spatial reference of the two sets of data arise.

2.81. Therefore, some considerations on the choice of the spatial and temporal reference for the compilation of water accounts are presented next. In general, priority should be given to the spatial and temporal reference of the conventional economic accounts. The main reason being that it is easier to adapt the reference of hydrologic information to that of the conventional economic accounts, as hydrological data are often available at a more disaggregated spatial and temporal level than economic data. As a second principle, in order to allow for meaningful comparisons through time, the spatial and temporal references of the accounts should not be changed

Spatial dimension

2.82. The choice of the spatial reference for the compilation of the accounts ultimately depends on the objectives of the analysis. As mentioned above, the compilation of national water accounts is important for designing and evaluating macro-economic water policy. However, to reflect better spatial differences in the water use, supply, pressure on water resources and to make decision on water allocation between different users, it is often more appropriate to use a finer spatial reference.

2.83. The water accounting framework can in principle be compiled at any level of geographical disaggregation of a territory. The options are usually to compile the accounts either at the level of administrative regions, river basins or accounting catchments.

2.84. An **administrative region** is a geographic area designated by the provincial government for administrative purposes. Administrative regions are usually responsible for certain economic policies within their jurisdiction and regional economic accounts are usually compiled for administrative regions.

2.85. A **river basin** is a naturally defined region which is drained by a river or stream. It is internationally recognized that the river basin is the most appropriate unit of reference for Integrated Water Resource Management: Agenda 21 (UNCED) and the European Water Framework Directive (WFD) call for the adoption of water management plans at river basin level. Water management can in fact be more effectively pursued at the river basin level since all water resources, including groundwater, within a river basin are inextricably linked to each others both in terms of quantity and quality. In this way, managers are able to gain a more complete understanding of overall conditions in an area and the factors which affect those conditions. For example, emissions from a sewage treatment plant might be reduced significantly, and yet the local river and groundwater may still suffer if other factors in the river basin, such as polluted runoff from upstream emissions, go unaddressed.

2.86. As there are often large spatial differences in terms of availability and use of water resources between different river basins of a country, especially in "water stressed" countries, the use of national averages is not always sufficient for sound policy decisions at the local level. Policy analyses for each main national "basin area" (a homogeneous basin area formed by the association of contiguous river-basins) are generally required. In addition, the compilation of the accounts by local basin data providers for their water management needs is generally essential to sustain their involvement in the water accounting process.

2.87. River basin agencies have been increasingly established in countries. They are usually independent agencies endowed with own resources and entrusted with all issues (economic, hydrological and social) related to water. They are often responsible - within a clear legal and participatory framework - to collect taxes and fees on water abstraction and discharges and to make decisions on water allocation. To support their decision, they often collect physical and monetary data related to water resources. In the Netherlands, for example, wastewater treatment is mainly the responsibility of the regional water boards. Households, industry and agriculture pay a water pollution levy to these boards for the service of treating water. The levy covers the operation and maintenance costs of the wastewater treatment facilities. These regional water boards comprise smaller units than the actual water basins. In Sweden, river basin agencies draw up management plans, which contain a description of the river basins with analyses of anthropogenic pressure on water resources including water withdrawal, pollution from point source and non-point sources including land use and economic analyses of the use of water.

2.88. While the compilation of physical water accounts at river basin can be easily done (as river basin agencies generally collect physical data at river basin level), the compilation of monetary water accounts at river basin requires extra work to reconcile the spatial reference of economic information (such as output, value added etc.) which is only available at administrative region. Some countries have experimented in developing accounts at river basin level based on regional economic accounts. These techniques are discussed further in the rest of the handbook.

2.89. Depending on the characteristics of the administrative regions and river basins in a country, it may be useful to define regions for the compilation of water accounts for which both economic and physical data are more easily available. Such regions, that we refer to here as **accounting catchments**, would be composed by river basins or sub-basins and large enough so that economic information is available. An accounting catchment could consist, for example, of an administrative region and be composed by several river basins or it could be composed by several administrative regions to cover a whole river basin.

Temporal dimension

2.90. The temporal reference of economic data generally differs from that of hydrological data: hydrological data generally refer to the hydrological year (which is a 12-month period such that the overall changes in storage are minimal and carryover is reduced to a minimum[5]); economic data, and in particular accounting data, refer to the accounting year. It is imperative that the hydrological and economic data used in the accounts refer to the same temporal reference. Moreover, it is recommended

[5] UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992

that the reference period for the compilation of the accounts is the 12-month accounting period of the national accounts.

2.91. Yearly accounts often hide potential seasonal variability of water use and supply as well as of availability of water resources in the environment. Ideally, quarterly water accounts would be useful in the analysis of intra-annual variations. They are, however, very data demanding thus are often not considered a feasible option.

2.92. The choice of the frequency of the compilation of the accounts depends on the availability of data and the type of analysis. Annual accounts provide detailed information on water resources and their use and allow for a detailed time series analysis. However, there may be cases where compiling annual accounts on water use may not provide significant information: the inter-annual variability may not be greater than the variability of the estimation procedure. Moreover an increase of those water uses which depend heavily on the climatic variations (such as agriculture) may be interpreted as a structural change of water use while in reality it may just be a short term increase in response to a climatic change. An alternative could be the compilation of accounts on water use every three or five years which would allow for a sufficiently complete analysis of the water use trend (Margat, 1996).

2.93. To reflect long hydrological cycle (longer than a year) "budgetary" accounts could be compiled. These accounts combine average data on water resources (budgetary asset accounts) with actual annual information on water use. Budgetary asset accounts refer to an average year in a series of years long enough to be stable (20 or 30 years) and provide information on the average annual water availability in the environment. These accounts could be also supplemented with accounts for a particular year, e.g. the dry year, which would describe the worst condition of the natural water system. Annual water use accounts describe the water use of the economy in a particular year. Combining hydrological information on annual averages with economic information on water use for a specific year can be justified by the fact that while the variability of water resources is pseudo-cyclical and their average is relatively stable in the long term and in a given climatic situation (and it is often the reference for the assessment of water resources), water use tends to change over the years (due, for example, to increasing population and changes in the structure of the economy). Therefore the combination of these two types of information would allow for the analysis of the natural water supply in relation to the evolution of human water demand (Margat, 1996).

Part I

Chapter 3 Physical water supply and use tables

A. Introduction

3.1. Physical water supply and use tables (SUT) describe water flows, in physical units, within the economy and between the environment and the economy. These accounts follow water from its initial abstraction from the environment by the economy, its supply and use within the economy, to its final discharge back to the environment, all expressed in quantitative terms. Physical SUT have the same structure of the monetary SUT compiled as part of the standard national accounts compilation. Chapter 5 presents the monetary tables as well as the hybrid SUT, in which physical and monetary information are presented side by side. Organising physical information using the same framework as the monetary accounts is one of the characteristic features of the SEEAW.

3.2. The compilation of the SUT allows for (a) the assessment and monitoring of the pressure on water quantities exerted by the economy; (b) the identification of the economic agents responsible for abstraction and discharge of water into the environment; and (c) the evaluation of alternative options for reducing water pressure. In combination with monetary information on value added, indicators of water use intensity and productivity can be calculated. These indicators will be presented in chapter 5.

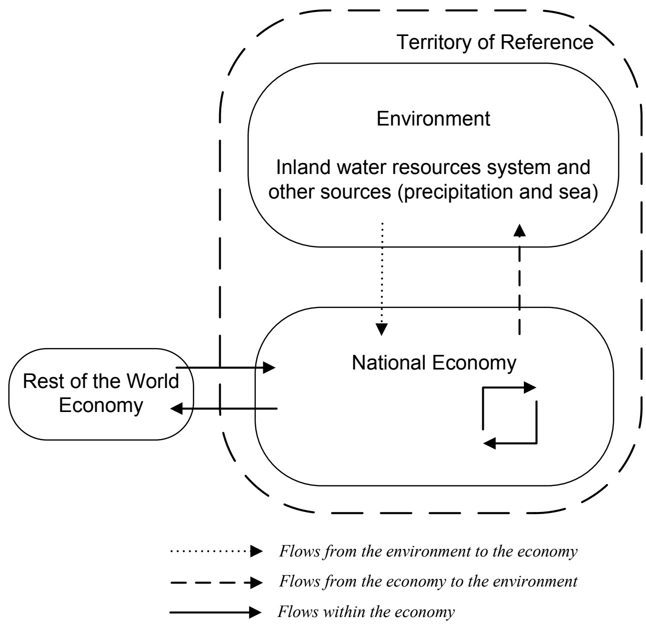
3.3. The objective of this chapter is to provide a comprehensive overview of physical supply and use tables and how these accounts have been used for the derivation of indicators. Section B of this chapter introduces the distinction between flows from the environment to the economy (i.e. abstraction), flows within the economy (i.e. supply and use of water between two economic units) and from the economy back to the environment (i.e. returns). This distinction is used to construct physical water supply and use tables and to show the basic accounting rules described in section C. Section C also presents the standard physical SUT that countries are encouraged to compile and supplementary tables which further disaggregate items of the standard tables and may be of interest for specific analyses and policies. Country examples of the compilation of physical water supply and use tables are described in section D. Section E presents some indicators that can be derived from the accounts together with examples of countries which have computed these indicators. Finally, section F presents data sources and methods needed for the compilation of physical supply and use tables.

B. Type of flows

3.4. When constructing a supply and use table for water resources, the SEEAW implicitly takes the perspective of the economy as it describes interaction between the environment and the economy. It describes: (a) flows from the environment to the economy; (b) flows within the economy; and (b) flows from the economy to the environment as described in Figure 3.1. Flows within the environment are described in the asset accounts in chapter 6.

3.5. For each type of flow, the origin of the flow (supply) and its destination (use) are clearly identified. Supply and use tables are constructed for each type of flow in such a way that the basic accounting rule, that supply equals use, is satisfied. Each flow is described in detail next.

Figure 3.1: Flows in the physical supply and use tables



1. Flows from the environment to the economy

3.6. Flows from the environment to the economy involve the abstraction/removal of water from the environment by economic units in the territory of reference for production and consumption activities. In particular, water is abstracted from the inland water resource system (which includes surface-, ground- and soil-water as defined in the asset classification, see chapter 6), and from other sources, which include abstraction from the sea (for direct use, for example, for cooling of pipes, or for desalination purposes) and collection of precipitation (which occurs, for example, in the case of water roof harvesting). The supplier of these flows is the environment and the user is the economy, more specifically, the economic agents responsible for the abstraction. It is assumed that the environment supplies all the water that is used (abstracted), hence the equality between supply and use is satisfied.

3.7. The use of water as a natural resource excludes the in-situ or passive uses of water, which do not entail a physical removal from the environment. Examples include the use of water for recreation or navigation. In-situ uses of water, although not explicitly considered in the supply and use tables, can easily be included as supplementary items in the accounts, in particular in the emission accounts as they can have a negative impact on water resources in terms of water quality. In addition, in-situ uses can also be affected by activities of abstraction and water discharge: for example, upstream over-abstraction may affect navigational and recreational uses of downstream waters. Thus, when allocating water to different users, consideration should be given to in-situ uses of water resources.

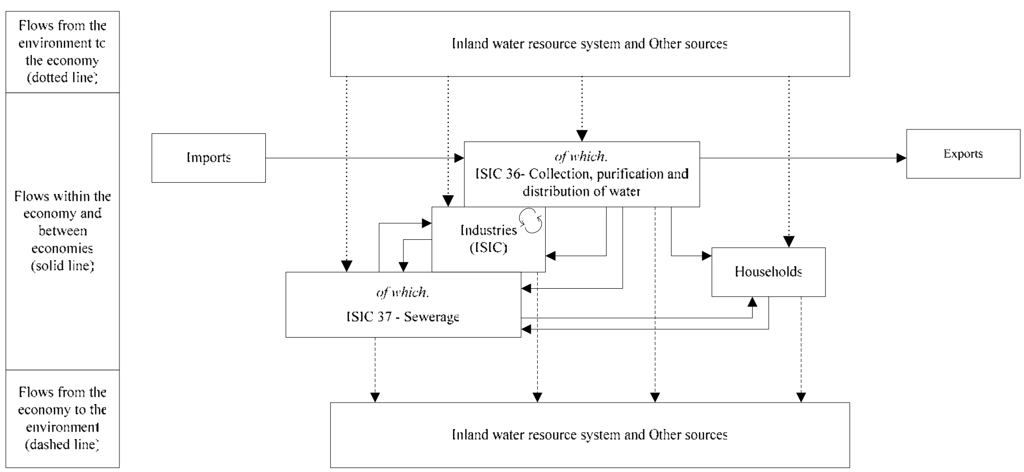
3.8. Water is abstracted either to be used by the same economic unit which abstracts it (in which case, we refer to it as *abstraction for own use*) or to be supplied, possibly after some treatment, to other economic units (*abstraction for distribution*). The industry which abstracts, treats and supplies water as a principal activity is classified under class 36 of ISIC - Water collection, treatment and supply. There may be, however, other industries which abstract and supply water as a secondary activity. This is the case, for example in Australia, where the mining industry supplies water to other industries (ABS 2004).

2. Flows within the economy

3.9. Flows within the economy involve water exchanges between economic units. These exchanges are usually carried out through mains, but other means of transporting water are not excluded. The origin and destination of these flow corresponds to those of the monetary SUT of the SNA, namely the agent providing water is the supplier and the agent receiving it is the user. (There is only one exception to this correspondence with the monetary SUT which involve the flows of wastewater: the industry collecting wastewater is a "user" in the physical SUT while in the monetary tables it is a "supplier" of wastewater collection and treatment services. This is explained in more detailed in the next paragraphs.)

3.10. Figure 3.2 presents a detailed description of the exchanges of water. The solid line arrows connect economic units, thus they represent the physical supply and use of water within the economy: the economic unit from which the arrow originates is the water supplier while the economic unit where the arrow points to is the water user.

Figure 3.2: Detailed description of physical flows within the economy



3.11. Most of the water is generally supplied by the industry *Water collection, treatment and supply*, ISIC 36, however, it can also be supplied by other industries and households. This includes the cases, for example, when water is supplied by industries and households for further use or is supplied to treatment facilities before being discharged into the environment. Note that the physical supply of water by households represents flows of wastewater to the sewerage industry (ISIC 37).

3.12. The collection of wastewater by *Sewerage*, ISIC 37, is recorded as use of wastewater by ISIC 37 and a supply of wastewater by the industry or households generating the wastewater. The corresponding monetary transaction is recorded instead in the opposite way: ISIC 37 supplies the service of wastewater collection and treatment which is in turn used by the economic units who physically generate wastewater.

3.13. During distribution of water (between a point of abstraction and a point of use or between points of use and reuse of water) there may be losses[6] of water. These losses may be caused by a number of factors: evaporation when, for example, water is distributed through open channels; leakages when, for example, water leaks from pipes into the ground; illegal tapping when users illegally divert water from the distribution network. In addition, 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, etc. In the SUT, the supply of water within the economy is recorded net of losses during distribution. Furthermore, the losses during distribution are recorded as return flows when they are due to leakages and as water consumption in all other cases (see section C.1 for further details).

3.14. The use table describing the flows within the economy shows the destination of these flows: water can be used by industries to produce other goods and services (intermediate consumption), by households for their own use (final consumption) and by the rest of the world (exports). Other economic uses, i.e. change in inventories, will be neglected for water, since these are usually negligible given that water is a bulky commodity.

3.15. The basic SNA supply-and-use identity is satisfied also for flows of water within the economy, as the total water supplied by the national economy plus imports equals the sum of water uses for intermediate consumption, final consumption and exports.

3. Flows from the economy back into the environment

3.16. Flows from the economy back to the environment consist of discharges of water by the economy into the environment. Thus the supplier is the economic agent responsible for the discharge (industries, households and rest of the world) and the destination (user) of these flows is the environment. The environment is assumed to use all the water that is returned (supplied) to it. Hence, also for these flows, the use equals the supply.

3.17. Flows from the economy to the environment are described in accounting terms through a supply table, in which each entry represents the amount of water generated by an economic unit and discharged into the environment (in this handbook discharges of water back to the environment are also referred to as *return flows*).

3.18. Returns are classified according to the receiving media: a distinction is made between 'water resources', which include surface-, ground- and soil water, and 'other sources' such as seas or oceans (as specified in the asset classification in chapter 6).

3.19. Discharges of water by the rest of the world are those locally generated by non-resident units. These are often insignificant. Even in a country where there is a large presence of tourists, the discharges would generally take place through resident units (i.e. hotels, restaurants, etc.).

C. Physical supply and use tables

3.20. Physical supply and use tables for water describe the three types of flows mentioned above: (a) from the environment to the economy, (b) within the economy, and (c) from the economy to the environment. In particular, the use table is obtained by merging information on water use: the total

[6] Note that the term "water loss" may have a different meaning in a different context. In this handbook the term refers to a loss of water for the economic system. Part of these losses can be actually seen as a resource from the point of view of the inland water resource system as water, by leaking back into water resources, becomes available for use again.

water intake of an economic unit is the result of direct water abstraction (flow from the environment to the economy) and water received from other economic units (flow within the economy). Similarly, the supply table is obtained by merging information on the two types of water flows leaving an economic unit: one destined to other economic units (flow within the economy) and the other destined to the environment (flow from the economy to the environment).

3.21. Physical supply and use tables can be compiled at various levels of detail, depending on the policy concern of a country and data availability. A simplified standard SUT, which countries are encouraged to compile, contains basic information on the supply and use of water and provides a complete picture of water flows. In addition, all the information contained in the table is balanced in the sense that supply equals use. As a second step, a more detailed SUT can be compiled, with a more detailed breakdown of items in the simplified SUT.

1. Standard physical supply and use tables for water

3.22. Table 3.1 shows a simplified physical supply and use tables for water. A detailed description of each flow in Table 3.1 is presented next.

3.23. **Abstraction** is defined as the amount of water that is removed from any source, either permanently or temporarily, in a given period of time for consumption and production activities. Water used for hydroelectric power generation, is also considered as abstraction. In Table 3.1 water abstraction is disaggregated according to the purpose (abstraction for own use and for distribution) and type of source (abstraction from water resources – surface water, groundwater and soil water as in the asset classification - and from other sources which include sea water and precipitation).

3.24. Water is abstracted either to be used by the same economic unit which abstracts it, **abstraction for own use,** or to be supplied, possibly after some treatment, to other economic units, **abstraction for distribution**. The industry which abstracts, treats and supplies water as a principal activity is classified under class 36 of ISIC - Water collection, treatment and supply. There may be, however, other industries, which abstract and supply water as a secondary activity. This is the case, for example, in Australia, where the mining industry supplies water to other industries (ABS 2004).

3.25. **Abstraction from other sources** includes the abstraction of sea water and the direct collection of precipitation for production and consumption activities. Water is generally abstracted from the sea 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. A typical example of collection of precipitation is roof rain harvesting by households.

3.26. **Abstraction from soil water** includes water use in rainfed agriculture. This is computed as the amount of precipitation that falls onto agricultural fields. The excess of water, e.g. the part that is not used by the crop, is recorded as a return flow to the environment from rainfed agriculture. It is important to record this flow for several reasons: it shows, for example, the relative contribution of rainfed and irrigated agriculture for food production. In addition, considering the importance of rainfed agriculture worldwide (more the 60% of all food production in the world is produced under rainfed conditions), this information can be used to assess the efficiency of rainfed agriculture (e.g. crop production per volume of water used) and to formulate water policies.

Table 3.1: Standard physical supply and use tables for water

Physical use table

Physical units

		Industries (by ISIC categories): 1	2-33, 41-43	35	36	37	38,39, 45-99	Total	Households	Rest of the world	Total
From the environment	U1 - total abstraction (=a.1+a.2= b.1+b.2):										
	a.1- Abstraction for own use										
	a.2- Abstraction for distribution										
	b.1- From water resources:										
	Surface water										
	Groundwater										
	Soil water										
	b.2- From other sources										
	Collection of precipitation										
	Abstraction from the sea										
Within the economy	U2 - Use of water received from other economic units										
U=U1+U2 - **Total use of water**											

Physical supply table

Physical units

		Industries (by ISIC categories): 1	2-33, 41-43	35	36	37	38,39, 45-99	Total	Households	Rest of the world	Total
Within the economy	S1 - Supply of water to other economic units										
	of which: Reused water										
	Wastewater to sewerage										
To the environment	S2 - Total returns (= d.1+d.2)										
	d.1- To water resources										
	Surface water										
	Groundwater										
	Soil water										
	d.2- To other sources (e.g. sea water)										
S - **Total supply of water** (= S1+S2)											
Consumption (U - S)											

Note: Grey cells indicate zero entries by definition.

3.27. Within the economy, the **use of 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 mains, but other means of transportation are not excluded (such as artificial open channels, etc.). The use of water received from another economic unit by the rest of the world corresponds to the **exports** of water. It is generally the industry, ISIC 36, which exports water.

3.28. The **total water use** of an industry is computed as the sum of the amount of water directly abstracted (row U1 in Table 3.1) and the amount of water received from other economic units (row U2 in Table 3.1). It might be perceived that water abstracted for distribution is counted twice: first as a use when water is abstracted by the distributing industry and then when water is delivered to the user. However, water abstracted for distribution is a water use of the distributing industry even though this industry is not the end user of this water.

3.29. The **supply of water to other economic units** refers to the amount of water that is supplied by an economic unit to another. It is recorded net of losses in distribution. The supply to other economic units generally occurs through mains, but can also occur through artificial open channels, trucks and other means. Note that the supply of water by the rest of the world corresponds to the **imports** of water.

3.30. The supply of water to other economic units can be disaggregated in several categories. However, in the standard tables only **reused water** is explicitly identified given its importance in water conservation policies.

3.31. The concept of reused water is linked to that of wastewater. **Wastewater** is water which is of no further immediate value to the purpose for which it was used or in the pursuit of which it was produced because of its quality, quantity or time of occurrence. 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) and supplied to another industry for further use (reused water). Total wastewater generated by an economic unit is obtained from Table 3.1 as the sum of the supply of reused water, wastewater to Sewerage and returns into the environment.

3.32. **Reused water,** defined as wastewater supplied to a user for further use with or without prior treatment, excludes recycling within industrial sites. It is also commonly referred to as *reclaimed wastewater*. It is important to record this flow as the reuse of water can alleviate the pressure on water resources by reducing direct abstraction of water: for example, watering golf courses and landscaping alongside public roads can be done by using (treated) wastewater instead of surface or groundwater. Also some industries, such as power-generation plants can use reclaimed wastewater: a lot of water is needed to cool power-generation equipment, and using wastewater for this purpose means that the facility won't have to use higher-quality water that may be best used somewhere else.

3.33. In order to avoid confusion, it should be noted that, once wastewater is discharged into the environment, its abstraction downstream is not considered as a reuse of water in the accounting tables, but as a new abstraction from the environment.

3.34. As already mentioned, reused water excludes the recycling of water within the same industry or establishment (on site). Information on recycled water, although very useful for analysis of water use efficiency, is not generally available. Thus the simplified standard tables do not explicitly report it. 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.

3.35. 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 has to sell water to another distributor in order for the water to be delivered. These sales artificially increase the physical supply and use of water within the economy, but do not influence the global (physical) balance of water with the environment thus they are not recorded in the physical supply and use tables.

3.36. **Total returns** include water that is returned to the environment. Total returns can be classified according to the receiving media (i.e. water resources - as specified in the asset classification - and sea water) and to the type of water (e.g. treated water, cooling water, etc.). The standard tables report only the breakdown according to the receiving media so as to ensure the links with the flows in the asset accounts. More detailed tables can be compiled to show returns of different types of water.

3.37. The **total water supply** of an industry is computed as the sum of the amount of water supplied to other economic units (row S1 in Table 3.1) and the amount of water returned to the environment (row S2 in Table 3.1).

3.38. **Storage of water**. Note that water can be temporarily stored in the economy, e.g. in water towers, in closed cooling or heating circuits, etc. Therefore, when comparing the situation at the beginning and end of the period, some changes in inventories may occur. However, they are generally rather small (as water is a bulky commodity and thus costly to store) in comparison with the other volumes and thus not reported in the physical SUT.

3.39. Table 3.1 is supplemented with information on the number of persons with sustainable access to an improved water source and with access to improved sanitation reported in supplementary tables as presented in Annex II. This information is particularly important for the management of water resources and for poverty reduction: it used to monitor progress towards Target 10 of the Millennium Development Goal to "halve, by 2015, the proportion of people without sustainable access to safe drinking water and sanitation". Presenting all water-related information, including social information, in a common framework has the advantage of allowing for consistent analyses and scenario modelling. For example, an analysis of the impact of investing in water infrastructure on the number of people having access to improved water sources could be easily undertaken if the information is organized according to the accounting framework.

3.40. In order to have a complete picture of the water flows within the economy, Table 3.1 can be supplemented by detailed information on the origin and destination of water flows by identifying who is supplying water to whom. Table 3.2 presents a matrix of transfers within the economy. Each entry represents a water exchanges from a supplier (by row) to a user (by column). For example, the intersection of row "ISIC 37" with column "ISIC 45 - Wholesale and retail trade and repair of motor vehicles and motorcycles" represents the amount of water that is supplied by ISIC 37 to ISIC 45, which could use treated wastewater, for example, for car washing.

Table 3.2: Matrix of transfers of water within the economy

Physical units

<table>
<tr><td colspan="2" rowspan="2">User ⇨
Supplier ⇩</td><td colspan="7">Industries (by ISIC categories)</td><td rowspan="2">Households</td><td rowspan="2">Rest of the world</td><td rowspan="2">Total</td></tr>
<tr><td>1</td><td>2-33, 41-43</td><td>35</td><td>36</td><td>37</td><td>38,39, 45-99</td><td>Total</td></tr>
<tr><td rowspan="7">Industries (by ISIC categories)</td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>2-33, 41-43</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>35</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>36</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>37</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>38,39, 45-99</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Total</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Households</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Rest of the world</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Total</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

2. Water consumption

3.41. The concept of water consumption gives an indication of the amount of water that is lost by the economy during use in the sense that it has entered the economy but it has not returned either to water resources or to the sea. This happens because during use part of the water is incorporated into products, evaporated, transpired by plants or simply consumed by households or livestock. The difference between the water use (row U in Table 3.1) and the water supply (row S in Table 3.1) is referred to as **water consumption**. It can be computed for each economic unit and for the whole economy. The concept of water consumption used in this handbook is consistent with the hydrological concept. It differs, however, from the concept of consumption used in the national accounts which instead refers to water use.

3.42. Since water consumption is calculated as a difference and includes flows that are very different in nature (for example, the part of the losses in distribution which do not return to the water resources), it is useful for analytical purposes to distinguish water consumption that results from evaporation and transpiration or enters into products (result of the production process) from consumption that results from illegal tapping and malfunctioning meters.

3.43. For the whole economy, the balance between water flows can be written as:

Total abstraction + Use of water received from other economic units = Supply of water to other economic units + Total returns + Water consumption

Note that since the total water supply to other economic units equals the total water use received from other economic units, the identity can be rewritten as:

Total abstraction = Total returns + Water consumption.

3.44. Water consumption can include water that is stored, for example, in water towers, but this quantity is usually very small as water is generally stored only for a short period of time.

3.45. When water consumption is computed for each industry, it gives an indication of the industry's water use efficiency. Since water supply does not equal water use by industry, water consumption is computed as a difference between the supply and use by industry:

Water consumption by industry i = Total water use by industry i – Total water supply by industry i

3.46. Note that water consumption includes the part of the losses in distribution which are not due to leakages.

3.47. If we take the perspective of the inland water resource system, the discharges of water into the sea should also be considered as lost water since this water, once in the sea, is not directly available for further use as it would be in the case, for example, of discharges into a river, where discharged water becomes a resources for downstream uses. The concept of *inland water consumption* is introduced to give an indication of the amount of water that is not returned to the inland water system. Inland water consumption is thus calculated as:

Inland water consumption = Water consumption + Returns to Other sources (e.g. sea water).

3.48. The concept of consumption can also be adapted to specific resources. For example, the 2002 Joint OECD/Eurostat Questionnaire on Inland Waters uses the concept of *freshwater consumption* which takes into consideration water which has been abstracted from fresh water sources and is discharged into non-fresh water sources[7].

3. Supplementary items in the physical supply and use tables for water

3.49. The standard physical supply and use table in Table 3.1 contains aggregate flows. In practice, when compiling these accounts, a more detailed breakdown both on the industry side as well as on the type of water is often necessary for more detailed analyses. The level of detail depends on the country's priorities and data availability. Table 3.3 presents an example of water flows' breakdowns (in italic) which are useful for analytical purposes together with a numerical example.

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[7] Where carried out, desalination of seawater, on the contrary, should be counted as a negative consumption.

3.50. In Table 3.3 abstraction for own use is further disaggregated in the following uses:

- Hydroelectric power generation
- Irrigation water
- Mine water
- Urban runoff

3.51. Water used for **hydroelectric power generation** consists of water used in generating electricity at plants where the turbine generators are driven by falling water. Usually this water is directly abstracted by the power plant and returned immediately to the environment. It is important to record the amount of water used and discharged by a hydropower facility especially for allocation policies as water used for the generation of hydroelectric power may be in competition with other uses.

3.52. **Irrigation water** consists of water which is artificially applied to lands for agricultural purposes.

3.53. **Mine water** consists of water used for the extraction of naturally occurring minerals including coal, ores, petroleum, and natural gas and it includes water associated with quarrying, dewatering, milling, and other on site activities done as part of mining. Mine water use generally involves a removal and displacement of water in the environment (during dewatering processes) when the mine extends below the water table. It might be argued that this should not be considered as part of abstraction. It is important, however, to record this flow as it often results in the disposal of large volumes of water and its displacement can be particularly damaging to the environment.

3.54. **Urban Runoff** is defined as 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. It is also referred to as *urban stormwater*. Note that here the term 'urban areas' may include also rural residential zones. When urban runoff is collected into the sewage system, it is recorded in the use table as an abstraction from other sources (in particular from precipitation) by ISIC 37, and when it is discharged into the environment it is recorded as a return flow in the supply table.

3.55. It is important to record the collection and discharge of urban runoff for two reasons: first, for management purposes, in order to design policies to reduce its negative impacts on the water resources as urban runoff usually contains relatively high concentrations of pollutants (including bacteria and viruses, solid waste, and toxics such as heavy metals and petroleum-based compounds) which reach receiving waters. Second, for practical reasons, in order to measure consistently the total use and supply of water of ISIC 37: since urban runoff ultimately merges into the return flow from ISIC 37 into the environment, the total return of ISIC 37 in the supply table would include urban runoff in addition to the discharges of wastewater collected from industries and households. Thus not recording the collection of urban runoff in the use table would underestimate the water consumption of ISIC 37.

3.56. Although separate estimates for urban runoff may be available in some countries, these flows generally cannot be measured directly: what can be measured is the difference between the volumes of wastewater discharged by economic units (industries and households) into sewers and the volumes of wastewater leaving the sewers with or without treatment. This difference includes therefore urban runoff but also potential leakage from the sewage network as well as potential infiltration of groundwater into sewers.

3.57. Note that in Table 3.3 abstraction for own use by ISIC 36 represents the part of the total abstraction for own internal use such as cleaning of pipes, filter backwashing, etc. This water is then discharged into the environment and is recorded as a return flow from ISIC 36. In the numerical example ISIC 36 abstracts a total of 427.6 millions cubic metres of water of which 23 are for own use and the rest for distribution.

Table 3.3: Detailed physical water supply and use tables

Physical use table

Millions m^3

		Industries (by ISIC categories)							Households	Rest of the world	Total
		1	2-33, 41-43	35	36	37	38,39, 45-99	Total			
From the environment	**U1 - Total abstraction** (=a.1+a.2= b.1+b.2)	**108.4**	**114.6**	**4210.8**	**427.6**	**100.1**	**2.3**	**4963.7**	**10.8**		**4974.5**
	a.1- Abstraction for own use	108.4	114.6	4210.8	23.0	100.1	2.3	**4559.1**	10.8		**4569.9**
	Hydroelectric power generation			*0.0*				***0.0***			
	Irrigation water	*108.4*						***108.4***			***108.4***
	Mine water							**0.0**			**0.0**
	Urban runoff					*100.0*		**100.0**			**100.0**
	Other		*114.6*	*4210.8*	*23.0*	*0.1*	2.3	**4459.1**	*10.8*		**4469.9**
	a.2- Abstraction for distribution				*404.6*			**404.6**			**404.6**
	b.1- From water resources:	108.4	114.6	4.2	427.6	0.1	2.3	**657.1**	10.8		**667.9**
	Surface water	3.1	9.7	1.0	4.5	0.1	0.0	**18.4**	0.0		**18.4**
	Groundwater	105.3	104.8	3.2	423.1	0.0	2.3	**638.7**	10.8		**649.5**
	Soil water							**0.0**			**0.0**
	b.2- From other sources	0.0	0.0	4206.6	0.0	100.0	0.0	**4306.6**			**4306.6**
	Collection of precipitation					100.0		**100.0**			**100.0**
	Abstraction from the sea			4206.6				**4206.6**			**4206.6**
Within the economy	**U2 - Use of water received from other economic units**	**38.7**	**45.0**	**3.9**	**0.0**	**427.1**	**51.1**	**565.8**	**239.5**		**805.4**
U - **Total use of water** (=U1+U2)		**147.1**	**159.5**	**4214.7**	**427.6**	**527.2**	**53.4**	**5529.5**	**250.3**		**5779.8**

Physical supply table

Millions m^3

		Industries (by ISIC categories)							Households	Rest of the world	Total
		1	2-33, 41-43	35	36	37	38,39, 45-99	Total			
Within the economy	**S1 - Supply of water to other economic units**	**17.9**	**117.6**	**5.6**	**379.6**		**49.1**	**569.9**	**235.5**		**805.4**
	of which: Reused water	-	-	-	-	-		**0.0**			
	Wastewater to sewerage	17.9	117.6	5.6	1.4		49.1	**191.6**	235.5		**427.1**
To the environment	**S2 - Total returns** (=d.1+d.2)	**65.0**	**29.4**	**4206.6**	**47.3**	**526.8**	**0.7**	**4875.9**	**4.8**		**4880.7**
	Hydroelectric power generation							**0.0**			
	Irrigation water	*65.0*						***65.0***			***65.0***
	Mine water							**0.0**			
	Urban runoff					*99.7*		**99.7**			**99.7**
	Losses in distribution because of leakages				*24.5*			**24.5**			**24.5**
	Other		*29.4*	*4206.6*	*22.9*	*427.1*	0.7	***4751.8***	*4.8*		***4756.5***
	d.1- To water resources	65.0	29.4	0.0	47.3	170.9	0.7	**313.3**	4.6		**317.9**
	Surface water		23.5			170.9	0.2	**194.6**	0.5		**195.1**
	Groundwater	65.0	5.9		47.3		0.5	**118.7**	4.1		**122.8**
	Soil water							**0.0**			**0.0**
	d.2- To other sources (e.g. sea water)		5.9	4206.6		256.3		**4468.8**	0.2		**4469.0**
S - **Total supply of water** (=S1+S2)		**83.0**	**147.0**	**4212.2**	**426.9**	**526.8**	**49.9**	**5445.8**	**240.3**		**5686.1**
Consumption (U - S)		**64.1**	**12.5**	**2.5**	**0.7**	**0.4**	**3.6**	**83.7**	**10.0**		**93.8**
of which: Losses in distribution not because of leakages					0.5			**0.5**			**0.5**

Note: Grey cells indicate zero entries by definition.

3.58. Similarly to abstraction for own use, returns to the environment can also be further disaggregated according to the type of water use. The following categories can be distinguished:

- Hydroelectric power generation
- Irrigation water
- Mine water
- Urban runoff
- Losses in distribution because of leakages

3.59. Information on the returns of **urban runoff** can be relatively straightforward to collect when a storm sewer system is in place and urban runoff is discharged separately from wastewater. In the other cases, when the discharge of ISIC 36 combines urban runoff with other wastewater discharges, estimates are necessary. Attention should be paid not to double count urban runoff in the return flow of ISIC 37: if it is explicitly identified in the breakdown of returns, it is not recorded under the "Other" category. In Table 3.3, 100 millions cubic metres of urban runoff is collected by the sewerage system and 99.7 per cent of it is discharged into the environment.

3.60. Note in Table 3.3 4,206.6 millions cubic metres of water are abstracted from and returned to the sea by the industry *Electricity, gas, steam and air conditioning supply*, ISIC 35. This flow corresponds to the abstraction of sea water for cooling purposes and its discharge. If necessary, a separate category could be made explicit to identify flows of *cooling water*.

3.61. Losses in distribution which are discussed in detail in the next section, are allocated to the water supplier. In this example, water is supplied only by the industry *Water collection, treatment and supply*, ISIC 36 (there is no supply of water as secondary activity) and the total losses in distribution amount to 25 millions cubic metres of water of which 24.5 are leakages into groundwater. The remaining part of the losses in distribution (which in the table corresponds to 0.5 million cubic metres) include both losses because of evaporation and apparent losses (illegal use and malfunctioning metering).

3.62. In addition to the breakdowns shown in Table 3.3, it is useful to record explicitly the supply of *desalinated water* and the *supply of wastewater to sewerage* as '*of which'* category of the supply within the economy.

4. Losses in distribution

3.63. The supply and use of water within the economy are recorded net of losses in distribution. Losses in distribution are recorded in the physical supply and use tables as follows:

- They are allocated to the supplier of water
- Losses due to leakages are recorded as return flow to the environment
- Losses due to evaporation when, for example, water is distributed through open channels, are recorded as water consumption as they do not directly return to water resources
- Losses due to illegal tapping and malfunctioning metering are included in water consumption

3.64. A supplementary table can be constructed to explicitly show the losses in distribution. Table 3.4 shows gross and net supply of water within the economy as well as the losses in distribution. It is obtained by reorganizing entries in the physical SUT. This table allows for the direct calculation of losses in distribution as a proportion of the gross water supply thus giving an indicator of the efficiency of the distribution network.

Table 3.4: Supplementary table of losses in distribution

	Industries (by ISIC categories)									
	1	2-33, 41-43	35	36	37	38,39, 45-99	Total	Households	Rest of the world	Total
S1 – (Net) Supply of water to other economic	17.9	117.6	5.6	379.6		49.1	569.9	235.5		805.4
L - Losses in distribution	0.0	0.0	0.0	25.0	0.0	0.0	25.0			25.0
Leakages	0.0	0.0	0.0	24.5	0.0	0.0	24.5			24.5
Other (e.g. evaporation, apparent losses)	0.0	0.0	0.0	0.5	0.0	0.0				
Gross supply within the economy (= S1 + L)	17.9	117.6	5.6	404.5	0.0	49.1	594.8			830.4

3.65. It should be noted that losses in distribution are generally calculated as a difference between the amount of water supplied and that received. In this case, losses in distribution include not only real losses of water (evaporation and leakages) but also apparent losses which consist of unauthorized water use (such as theft or illegal use) and all inaccuracies associated with production and customer metering.

3.66. There are cases where illegal tapping – that is the illegal removal of water from the distribution network – is significant in magnitude and affects not only the efficiency of water distribution network but, at times, could cause major problems within the network (e.g. cause contaminants to enter into the mains via back-siphonage). Specific analyses are required to determine the extent of this phenomenon.

3.67. It may be useful, for countries in which illegal tapping is significant, to identify the units (households or industries) responsible for illegally connecting to the distribution network as well as the amount of water used by these units. This can easily be shown as a supplementary item in the table. This information is very useful for policy purposes as it provides a more accurate indication of the water use by industries and households. When linked to the monetary accounts, the information could be used for pricing policies.

3.68. In the 1993 SNA, illegal tapping is not considered as a transaction (use) in the supply and use tables.

D. Country examples

3.69. This section presents two sets of country examples in the compilation of water accounts: the first describes the experience in the compilation physical SUT at national level for the Republic of Moldova. The second presents examples of compilation of physical SUT at river basin level in the Netherlands, Sweden and Australia.

1. The Republic of Moldova

3.70. The Republic of Moldova is a country with a rather high population density: more than 126 persons live per 1 km^2. The economy relies heavily on agriculture which produces more than one third of the national gross domestic product (GDP) and employs most of the population. Water security is a major issue in the country mainly due to water scarcity in terms both of water quality and quantity.

3.71. Physical water supply and use tables have been compiled in the Republic of Moldova for the years 1994, 1998, 2000 and 2002. Table 3.5 and Table 3.6 present the physical SUT and the matrix of transfers within the economy for 2002. In Table 3.5 abstraction from surface water resources is further disaggregated to show explicitly abstraction from lakes, rivers and artificial reservoirs. In addition, this table further disaggregates returns into the environment according to the type of water.

Table 3.5: Physical water supply and use tables, The Republic of Moldova, 2000

Physical use table

Million cubic metres

		Agriculture	Fisheries	Energy	Mining	Manufacturing & Construction	Distribution/ irrigation water	Distribution/ municipal water	Sewerage	Government	Household	Rest of the World	**Total**
From the environment	**U1 Total abstraction**	**31.1**	**8**	**558**	**5**	**20**	**64.1**	**200**	**0**	**4.6**	**30**	**0**	**920.6**
	from surface water	6	8	556	0	11	64	108	0	0	0	0	752
	from groundwater	25.5	0	2.3	5	9	0	92		5	30		168
	from other water (sea)												0
Within the economy	**U2 Use of water received from other economic units**	**46.045**	**0**	**6.57**	**0.016**	**12**	**0**	**3.007**	**143**	**15.425**	**132**	**0**	**358.41**
U- Total use of water		**77.15**	**8**	**565**	**5**	**32**	**64**	**203**	**143**	**20**	**162**	**0**	**1279**

Physical supply table

Million cubic metres

		Agriculture	Fisheries	Energy	Mining	Manufacturing & Construction	Distribution/ irrigation water	Distribution/ municipal water	Sewerage	Government	Household	Rest of the World	**Total**
Within the economy	**S1 Supply of water to other economic units**	**20.881**	**0**	**2.184**	**0**	**16**	**45**	**145**	**1**	**16.808**	**111**	**0**	**358.37**
	of which: Reused water			0.16		3							
	Wastewater to sewerage	0.738		2.024		13			0	16.435	111		143
To the environment	**S2 Total returns**	**30**	**6**	**557.1**	**5**	**16**	**19**	**58**	**143**	**3.1**	**50**	**0**	**887.7**
	of which: Irrigation water	15											15
	Treated waste water	1.9		3		4			160	1			170
	Untreated waster water	9	6		5	4	24		1	1	26		76
	Cooling water (energy)			533									533
	Water lost in transport	2.3		0.1	0	1	13	**52**		0.3			69
Total supply		**51**	**6**	**559**	**5**	**32**	**64**	**203**	**143**	**20**	**161**	**0**	**1246**
Consumption		**26**	**2**	**6**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**33**

Table 3.6: Matrix of transfers within the economy, The Republic of Moldova, 2000

Million cubic metres

	Agriculture	Fisheries	Energy	Mining	Manufacturing & Construction	Distribution/ irrigation water	Distribution/ municipal water	Sewerage	Government	Household	Rest of the World	**S2 Total water supplied**
Agriculture					0.004		0.006	0.738	0.099	20.034		**20.881**
Fisheries												**0**
Energy	0.003				0.137			2.024	0.02			**2.184**
Mining								0				**0**
Manufacturing	0.001		0.251				3.001	13				**16**
Distribution/ irrigation water	45.462											**45.462**
Distribution/ municipal water	0.559		6.319	0	12				15	111		**145**
Sewerage					0.6							**0.6**
Government	0.02				0.013			16		0.34		**16.808**
Household								**111**				**111**
Rest of the World												**0**
U2 Total water received (use)	**46.045**	**0**	**6.57**	**0**	**12**	**0**	**3.007**	**143**	**15**	**132**	**0**	**358.413**

2. Physical SUT at river basin level

3.72. Physical supply and use tables can be compiled at river basin level. The river basin is the recommended spatial unit for integrated water management in order to fully understand the impact of human activities on the waters in the basin and guarantee that measures in respect of surface water and groundwater belonging to the same ecological, hydrological and hydro-geological system are coordinated.

3.73. One of the main difficulties in the compilation of physical supply and use tables at river basin level is that economic data may be available at the level of administrative regions. In some cases, the economic units are identifiable on the basis of their locations and thus may be allocated to the river basin they belong using a Geographical Information System (GIS). In most of the cases, there is a need to use estimation methods to allocate information available at the administrative region level to the river basin level.

3.74. An increasing number of countries have already started the compilation of physical supply and use tables at the river basin level (for example, South Africa, Sweden, the Netherlands and Australia). The examples of Sweden and the Netherlands show two criteria for the allocation of information on the supply and use of water at the administrative level to different river basins: the one, in Sweden, is based on the number of people in urban areas , the other, in the Netherlands, on the number of employees. The Australian Bureau of Statistics (ABS) investigated a method of re-constructing water use in agriculture at river basin level from small area estimation. The criterion for allocating water use to different river basin regions for those small areas which overlap with several river basins is based on the proportion of overlap.

Physical SUT at river basin level for Sweden

3.75. Statistics Sweden has compiled water accounts (physical supply and use tables and expenditures accounts) for river basins for the year 2000. A project (Statistics Sweden, 2003) was carried out to test methods for disaggregating national water accounts to water districts. The accounts have been compiled for eight basins connected to major sea basins. These river basins cover the whole national territory.

3.76. In order to disaggregate data on supply and use of distributed water, both in physical and monetary units, aggregated municipality data were allocated to the different river basins by using Geographical Information Systems (GIS) to cross analyse maps of river basins, municipalities and urban areas. As a first step, the municipalities entirely located within a river basin were identified; then for the municipalities intersecting at least two river basins a more detailed analysis was performed. For the municipalities which have all major urban areas located within a river basin, the entire municipality was allocated to that river basin where the urban areas are located. For the rest of the municipalities, data were allocated to river basins according to the percentage of the population in urban areas. In Sweden about 85 per cent of the population and employment are in urban areas.

3.77. The different components of the supply and use tables at river basin level are calculated as follows:

(a) The abstraction and use of water by the manufacturing industry. water returns by by municipal wastewater treatment plants and some coastal industries are collected for 114 main drainage areas (with outflows to the sea). The aggregation of these data into river basins is then straightforward.

(b) The estimation of water abstracted for own use by households was carried out in two stages. First, Statistics Sweden obtained information on whether a property was connected to a water distribution network using the real estate register. Then, it obtained information on the population living in the area using the population registry. By combining these two sources of information, it was possible to estimate the number of people not connected to a water distribution network. The water abstracted for own use was then estimated by applying the average water use of people connected to public water supply.

3.78. Table 3.7 presents data on freshwater abstraction by sea basin.

Table 3.7: Abstraction of fresh water in 2000 by sea basin, 1000 m^3

Sea basin	Public waterworks ISIC 36	Abstraction for own use: Agriculture ISIC 01	Industry ISIC 05-35	Households	**Total**
Bothnian Bay	39 566	1 446	212 490	3 097	**256 599**
Bothnian Sea	125 698	7 076	635 327	15 882	**783 983**
Baltic proper,north	377 680	28 452	196 623	23 315	**626 070**
Baltic proper, middle	32 880	16 463	27 632	6 747	**83 722**
Baltic proper, south	52 755	29 622	72 063	7 004	**161 444**
The Sound	28 978	9 831	3 209	2 438	**44 456**
Kattegat	272 446	40 734	345 985	25 619	**684 784**
Skagerrak	11 675	1 280	8 065	5 269	**26 289**
Total	**941 676**	**134 906**	**1 501 393**	**89 385**	**2 667 360**

Source: Statistics Sweden, 2003.

Physical SUT at river basin level for the Netherlands[8]

3.79. In the Netherlands, regional accounts are compiled at the level of 40 COROP[9] areas which are the official regional economic units distinguished by Statistics Netherlands. These COROP areas are larger than the approximately 500 local authorities (municipalities) and smaller than the 12 provinces. Regional economic accounts focus on the production processes in each business unit in the various regions.

3.80. Regional data on water abstraction and discharge are collected by Statistics Netherlands through a National Water Survey once every five years. The most recent surveys were in 1996 and 2001 and comprise business level data on water use by industry, mining and electricity companies. Data are collected on the use of four types of water: groundwater (fresh and brackish), surface water, sea water and water distributed by the water supply industry. Water use is further broken down into water use for cooling purposes and other purposes. Additional information about water use in agriculture is supplied by the Agricultural-Economic Institute. The regional water flows add up to form the national water flow.

3.81. The regional water flow data at the level of the 40 COROPs are disaggregated into the seven river basins. Figure 3.3 describes the steps to reach the disaggregation. In a first step, data for COROPs which are situated entirely in one river basin are allocated directly to the river basin. This is the case for 23 of the 40 COROPs in total. For the remaining 17 COROPs, data are allocated in subsequent steps on the basis of the distribution of employees in the specific branches of industry: regional water flow data are allocated to two or more river basins based on the percentage of employees working in a specific river basin. These percentages are estimated by identifying:

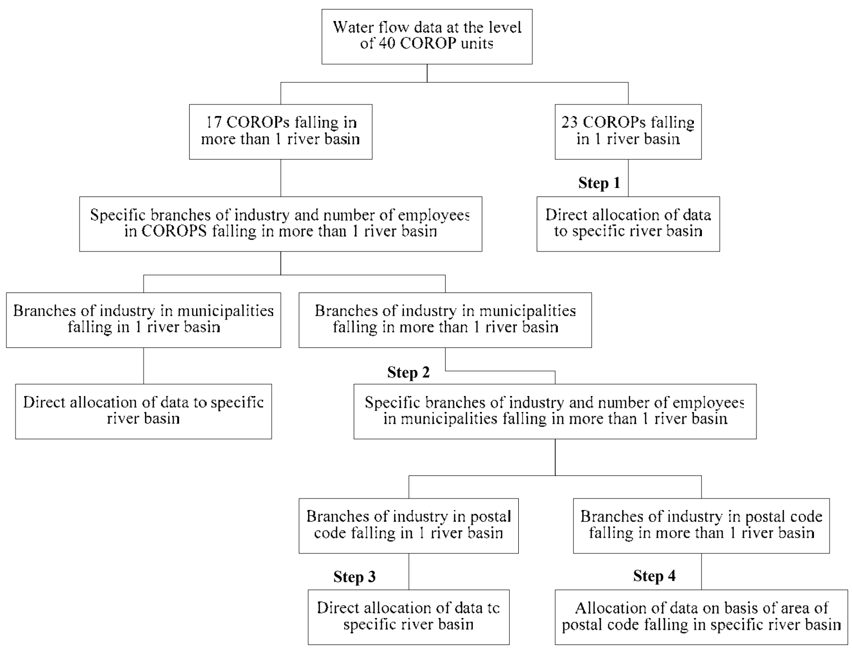
- the specific branches of industry in the COROPs which extend over more than one river basin;
- the total number of employees working in these branches of industry;

[8] Based on van der Veeren et al. (2004)
[9] COROP stands for **Co**ördinatie Commissie **R**egionaal **O**nderzoeks**p**rogramma.

- the municipalities in which the business units in these branches of industry are located**;**
- whether the municipalities where these business units are located fall entirely in one specific river basin, or overlap with other river basins.

3.82. After the specific branches of industry have been identified in these 17 COROPs, these branches of industry and the number of employees working in these branches of industry are linked to the municipalities in which the underlying business units are found. These municipalities are linked again to the specific river basins in which they fall. Business units and their number of employees in municipalities falling entirely inside a specific river basin are allocated directly to that specific river basin (Step 2 in Figure 3.3). For those municipalities located partly in one and partly in another river basin, the identified business units are linked in a next step to the postal codes within these municipalities. Also these postal codes are allocated to river basins.

Figure 3.3: Allocation of water flow data over river basins



3.83. Business units in postal code areas, which fall entirely within one specific river basin, are allocated directly to that basin (Step 3 in Figure 3.3). For those remaining postal codes found in two or more river basins, business units and their employees are allocated to a specific river basin on the basis of the physical area of the postal code falling in that river basin (Step 4 in Figure 3.3).

3.84. Most of the regional water flow data could be allocated in this way directly at the level of COROPs. On average, 65 per cent of the employees in each branch of industry are found in COROPs falling entirely in one specific river basin. Twenty seven percent of the regional water flow data per branch of industry are allocated at the level of municipalities and 3 per cent at postal code level. Five per cent of all data is allocated by looking at the area within postal code areas, which falls inside a specific river basin.

3.85. Confidentiality is an important issue when disaggregating data to the level of river basins as individual companies or business units could be identified. Confidentiality only plays a role in monetary and physical supply and use tables. The Netherlands tries to overcome problems of confidentiality by imposing some conditions. For economic data, the conditions are that an industry should consist at least of three or more companies and the largest company cannot employ more than 75 percent of all employees in a specific region. For physical data, the conditions are that a industry should consist at least of three or more companies (as for economic data) and the largest company in a specific branch of industry in a specific region cannot use more than 70 percent of the total freshwater use in that region. When these conditions are not met, data for specific industry are combined with those of another making sure, however, that confidential data remain confidential when combining information at national level and for each river basin (in case, for example, that two industries are combined in just one river basin, then national and river basin figures can reveal information for a particular business).

Physical SUT at river basin level for Australia

3.86. Agriculture in Australia accounts for more than 67 per cent of total water use in 2000 – 2001 (ABS, 2004). A detailed study of water use on Australian farms was undertaken for the year 2002 – 2003 (ABS, 2005) in order to analyse specific characteristics of water use in this sector. The study considered the area of different crops, water management practices and financial information related to irrigation. This analysis was conducted both at the level of administrative regions as well as at national level. However, because of the increasing demand for information at a finer geographical level than administrative and national level, the area-weighted-concordance method was used to provide estimates on agricultural water use at river basin level (Hawthorne, 2005).

3.87. In Australia, river basin areas do not coincide with Australian Standard Geographical Classification (ASGC) boundaries that are utilized by the ABS to collect and disseminate geographically classified statistics. The ASGC's boundaries are defined by population and they are built in a hierarchical structure: Statistical Local Areas (SLAs) are the smallest units which can be aggregated to form Statistical Sub-Divisions (SSDs), which in turn can be aggregated to form Statistical Divisions (SDs) and finally the state. In 2001, for example, in New South Wales there were 199 SLAs, 50 SSDs and 13 SDs. These geographical boundaries allow for statistics to be comparable and spatially integrated. River basins are not defined based on population criteria rather on the hydrological characteristics of a region (they are defined as the area drained by a stream and its tributaries where surface run-off collects).

3.88. A range of sources with a variable degree of consistency and reliability were used to estimate agricultural water use at the state and river basin level. The Agricultural Census which is undertaken every five years (the latest in 2001) provides estimates on irrigated area (hectares), and type of agricultural crops at state and SLA level but no information on the volume of water used by crops. In the interim years, only SD and state level estimates are available from the Agricultural Survey on irrigated area. Data on agricultural water use from the Water Accounts 2001 included output by agricultural commodity at the state level.

3.89. For the years where the Agricultural Census is undertaken, the methodology to estimate agricultural water use for river basins is based on SLA's estimates and it consists of the following steps:

- Step 1: Calculation of the average application rate (water use per hectares) for the State and crop. For example, in New South Wales in 2001, the Water Account estimated that there was 174,000 Megalitres of water used for Grapes. The Agricultural Census estimated that there were 31,600 hectares of land irrigated for grapes. From this information, the application rate for grapes grown throughout New South Wales in 2000/2001 is estimated to be 5.5 Megalitres/ha and it is assumed that it applies homogeneously for the entire state.

- Step 2: Calculation of SLA Total Agricultural Water Use. This is computed by multiplying the average application rate computed in Step 1 by the hectares of the crop within the SLA of interest. For example, in the Mudgee SLA (Mudgee is in NSW) it was estimated, from the Agricultural Census, that there was 2300 hectares irrigated for grapes. Combining this information with the application rate of 5.5Megalitres/ha, the estimate of total water use for grapes for Mudgee is 12,650 Megalitres. The total irrigated agricultural water use within the SLA is then calculated by summing together the water use for each crop type (grapes, vegetables, sugar, fruit, cotton, rice, dairy farming and other).

- Step 3: Estimation of water use for River Basins. In this step maps of SLA's and river basins are compared. If a SLA falls within a river basin, the total agricultural water use is entirely allocated to the river basin. On the other hand, if an SLA overlaps with two or more river basins, the total water use is allocated to each river basin proportionally to the overlap of the SLA with the river basins. For example, the Hay SLA falls within both the Murrumbidgee and Lachlan river basins. From Steps 1 and 2, the estimated total agricultural water use for Hay is 205,000 Megalitres. Since 48% of Hay's area falls in the Lachlan river basin and 52% of its area in the Murrumbidgee, according to the simple area weighting method, 98,400 Megalitres (0.48*205,000 Megalitres) of water use are allocated to the Lachlan river basin and the remaining 106,600 Megalitres (0.52*205,000) to the Murrumbidgee river basin.

3.90. For the intervening years, only estimates at the level of SD are available and the estimates of total water use for river basins can be significantly different from that obtained using information on SLA's. Research is currently being done at ABS to improve the estimates of water use at river basin level.

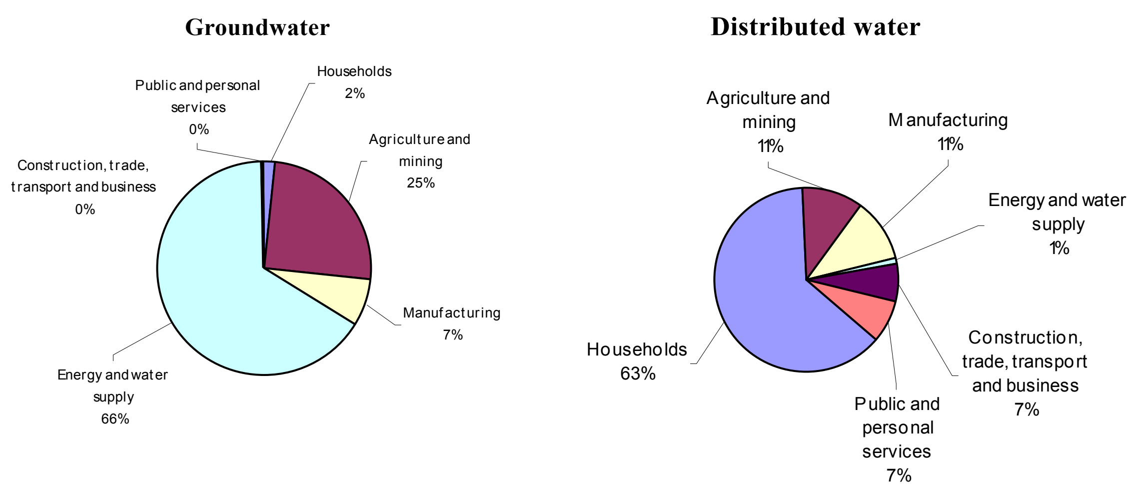
E. Derived indicators

3.91. This section presents the indicators that can be derived from the physical supply and use tables. They include, for example, water use, abstraction and consumption by industry per capita water use. Others indicators which link physical and monetary information such as water efficiency and productivity are discussed in Chapter 5.

1. Water abstraction, use and consumption by industry

3.92. Indicators on water abstraction, use and consumption by industry allow for comparisons between different types of water use. Figure 3.4 shows the breakdown of groundwater abstraction and use of distributed water in Denmark in 2001. This type of analysis helps to identify the industries that place the most pressure on water resources.

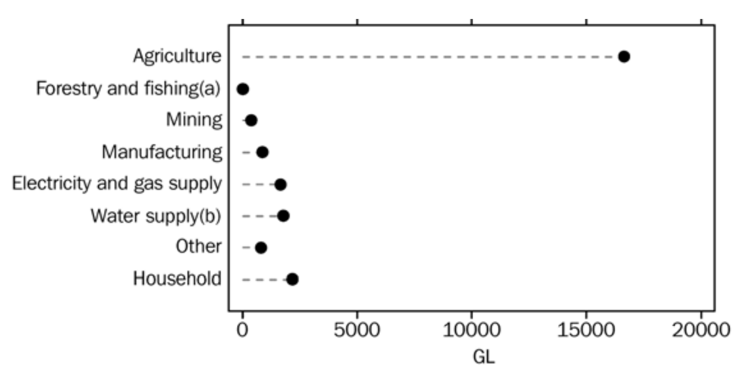
Figure 3.4: Abstraction of groundwater and use of distributed water, Denmark 2001



Source: Statistics Denmark, 2004.

3.93. The indicator of water consumption has been used by Australia. Figure 3.5 shows water consumption by industry for the years 2000-2001. The figure shows that agriculture has the highest consumer of water followed by households and water supply industry.

Figure 3.5: Water consumption, Australia, 2000-2001



(a) Includes Services to agriculture; hunting and trapping.
(b) Includes Sewerage and drainage services.

Source: Australian Bureau of Statistics, 2004.

2. Water use per capita

3.94. The indicator of per-capita water use is often computed for geographical comparisons as it relates the volume of water used to the population. This indicator is usually computed for domestic water use. In detailed analyses of water use and cross-countries comparisons other factors should also be considered, including the meteorological conditions, the importance of seasonal tourism and the level of income. Note that sometimes it is difficult to isolate actual use by households from use by urban small businesses.

3.95. Table 3.8 presents a comparison of water use among Botswana, Namibia, and South Africa. Among the three countries, total water use in 1996 was lowest in Botswana. However, the population and economy of South Africa is much bigger than either Botswana or Namibia, so comparison of total water use is not that useful. Per capita water use shows that Botswana has the lowest per capita use of water at 95 cubic meters per person per year; Namibia, a country fairly similar to Botswana in terms of population, follows with a per capita consumption that is 50% higher at 144 cubic meters of water per person. South Africa's per capita water use is more than four times that of Botswana's at 412 cubic meters per person.

3.96. The second part of Table 3.8 shows the structure of water use in 1996, which provides some indication of the causes of these differences. Botswana uses only 48% of its water for Agriculture compared to 62% in Namibia and 69% in South Africa. Per capita water use, excluding agriculture, is much more similar among the three countries: Botswana uses only 49 cubic metres of water per person, Namibia 55, and South Africa about twice that of the other two, namely 128 cubic metres. This analysis is further enhanced when looking at the prices paid by the users for water.

Table 3.8: Water use in Botswana, Namibia, and South Africa, 1996

	Botswana	Namibia	South Africa
Total water use (million m3)	**142**	**231**	**16,721**
Per capita water use (m3 per person)	95	144	412
Per capita water use excluding agriculture (m3 per person)	49	55	128
Percentage Distribution of Total water use			
Agriculture	48	62	69
Mining	11	11	4
Manufacturing	1	2	8
Trade, Services, Government	9	2	3
Households	31	22	17
Total	100	100	100

Source: Lange and Hassan, 1999 and Table 2.

3.97. Table 3.9 presents a comparison of water use by households between selected European countries. Presenting information on total and per capita water use side-by-side helps to explain some of the differences between countries in terms of the population size. For example, the difference in the total domestic water use in Poland and in the Czech Republic which is around 1000 million cubic metres, is explained by the different population size as the per capita water use in the two countries is the same.

Table 3.9: Water use by households in some European countries

	Year	Volume in million m^3	Water use per inhabitant in m^3/capita/year	Of which: from public supply
Denmark	1994	301	58	61%
Germany	1995	3 872	47	76%
Spain	1995	2 849	73	94%
Italy	1995	4 440	78	77%
Netherlands	1996	733	47	59%
Norway	1996	327	75	58%
Bulgaria	1998	302	37	34%
Czech Republic	1999	355	35	63%
Poland	1999	1 406	36	76%
Romania	1999	1 188	53	43%

Source: Eurostat, collection Statistics in focus, theme Environment and Energy – n° 6/2001 – 'Water resources, abstraction and use in European countries'

F. Data sources and methods

3.98. This section presents some of the possible data sources that can be used for the compilation of physical supply and use tables. First it presents the three types of data sources that are generally used: administrative data, surveys and application of coefficients. The choice of the data source generally depends on the institutional set-up of water management at the local level and at the national level. For ease of reference, this section also presents data sources according to the type of information that is required in the physical supply and use tables.

1. Administrative data

3.99. Line ministries responsible for environmental issues may collect data on physical flows in particular in the case they are in charge of the monitoring of abstractions and discharges. In some cases, however, it may be difficult to obtain harmonised data due to, for example, different regulations in different regions.

3.100. Administrative records can provide useful information in particular in the case in which taxes or licenses are linked to the quantity of water use. In these cases, very detailed information is readily available in the form needed for constructing the use table. In the case of Denmark and France, the tax payer is identified by the activity undertaken and the volumes it abstracts or discharges.

3.101. In some countries, in parallel to their annual economic accounts, large enterprises are asked to produce environmental reports, from which information about water is often compiled. When these reports are not compulsory, it may be difficult to obtain harmonised data.

2. Surveys

3.102. Information on the physical supply and use of water can also be obtained from specific surveys: economic units (or a sample of them) are asked about their behaviour with respect to water related issues. These surveys can be specific, that is entirely dedicated to water issues, or include questions about water in a multipurpose questionnaire (for instance surveys gathering structural business statistics). They are generally carried out every 3 to 5 years on an extensive scale and updated with the help of coefficients in the intervening years.

3.103. Households budget surveys can also be used to estimate data on abstraction, consumption and pollution by households. In the Republic of Moldova, for example, households surveys have been modified to include information on water use.

3. Application of coefficients

3.104. In the absence of specific data collection or for intervening years, the method often used is the application of coefficients. Coefficients are based on observations of the production process of some economic units in the past or in another country or region, or they are derived from literature or experts' assessment etc. The units with the same characteristics are assumed to have a similar behaviour, for instance the same water use per unit of sales. In a way, this method is very close to the sample survey method for which results in a sample are extrapolated to a whole class of units, but it is based on a less strong foundation. This method is typically used for estimating the water use by households and service industries: an average use per person (in households) or per employee (in the service industries) is applied.

3.105. In addition to coefficients, modelling can be used to estimate the water use, for example, for agricultural enterprises, the model can take into account their geographical location and its specific meteorological conditions, acreage, crop variety, livestock composition, irrigation system etc.

4. Data sources according to type of information

Abstraction

3.106. Generally the monitoring of the volumes of water abstracted is carried out by a variety of organizations or institutions in a country – typically the hydrological institute or the local/central governmental agencies in charge of water management. Attention should be paid to ensure that data are consistent with the classification of industrial activities and the classification of water resources (surface water, groundwater and soil-water) used in the accounting framework.

3.107. As discussed earlier, physical information on abstraction could be obtained through surveys and licenses/permits when they exist and are based on the volumes of abstracted water.

3.108. Water abstraction by households could also be estimated through coefficients. In general, households who abstract water directly are those living in rural areas and are not connected to a distribution network. Some countries use coefficients based on a daily (or yearly) per capita water use to estimate water abstraction by households.

3.109. Note that there may be cases when households use water not only for the satisfaction of their own personal needs (e.g. drinking, washing, etc.) but also for self-subsistence activities such small scale agriculture. In the SNA, whenever possible, these activities should be allocated to the corresponding ISIC class and they should not be combined with the final consumption of households.

Supply and use within the economy

3.110. Within the economy most of the water is supplied by ISIC 36, which generally also keeps the records on physical water supply and use including imports and exports. Volumes of wastewater and urban runoff collected by ISIC 37 are generally monitored by this industry hence they could be obtained by surveys of sewerage establishments or using administrative records.

Returns to the environment

3.111. Data sources for the return flows to the environment vary according to the industry discharging water. Discharges of water by ISIC 37 are generally monitored hence they are usually obtained through surveys or administrative records. When not regulated or metered, direct discharges of water can be estimated through the application of coefficients (based, for example, on water consumption).

3.112. Returns of agriculture and, in particular, returns of irrigation water are more difficult to obtain. Generally, these flows are estimated based on the amount of water used, the type of crop production, irrigation system, climate, etc.

Chapter 4 Emission Accounts

A. Introduction

4.1. Emissions to water can constitute a major environmental problem and cause the quality of water bodies to deteriorate. Different types of pollutants generated during production and consumption activities are discharged into water bodies either through the discharge of wastewater, with or without treatment, or directly. Some of the pollutants emitted into water resources are highly toxic and thus affect negatively the quality of the receiving water body and ultimately human health.

4.2. Emission accounts describe those flows of pollutants added to wastewater as a result of production and consumption, either directly into water resources or through the sewage network. They measure the pressure by human activities on the environment by presenting information on the activities responsible for the emissions, the types and amount of pollutants added to wastewater as well as the destination of the emissions (e.g. freshwater or sea). They are a useful tool for designing economic instruments, including new regulations, to reduce/abate emissions into water. When analysed in conjunction with the technology in place to reduce emissions and treat wastewater, they can be used for impact studies of new technologies.

4.3. There is limited experience in the compilation of emission accounts in countries. Nevertheless, an increasing number of European Union countries are implementing emission accounts to report to the Water Framework Directive and based on the country experiences, a set of standard tables has been developed.

4.4. Section B presents some basic concepts used in the compilation of emission accounts, defines the scope and coverage of the emission accounts and presents country examples of pollutants for which accounts are compiled. Section C describes in detail the set of standard tables for compiling emission accounts. Section D presents country experiences in the compilation of emissions accounts at national and river basin level. A number of indicators can be derived from emission accounts and those are presented in Section E. Data sources used for the compilation of these accounts are presented in Section F.

B. Coverage of emission accounts and basic concepts

4.5. Emissions to water are defined as direct release of a pollutant to water as well as the indirect release by transfer to an off-site wastewater treatment plant (European Commission 2000). Emissions to water therefore include the following: (a) discharge of pollutants contained in wastewater; and (b) discharge of substance to water resources such heavy metals and hazardous waste. The scope of emissions to water is much broader of the emission accounts which cover only the pollutants that are added to wastewater (category (a) above). The direct discharge of heavy metals and hazardous waste not through wastewater (category (b) above) is not covered in the water emission accounts but in the waste accounts as it involves the discharge of solid waste.

4.6. Emission accounts record the amount of a pollutant added to water by an economic activity during a reference period (generally the accounting year) and are expressed in terms of weight (kilograms or tonnes, depending on the pollutant under consideration). They describe in terms of pollutants the part of the water flows in the physical supply and use tables of chapter 3 that are destined to the environment either directly or through a treatment plant. Emission accounts cover: (a) pollutants added to wastewater and collected in the sewerage network; (b) pollutants added to wastewater discharged directly to water bodies; and (c) selected non-point sources emissions, namely emissions from urban runoff and irrigation water. The emission accounts thus provide the description, in terms of pollutants resulting from production and consumption, of the wastewater flows discussed in Chapter 3. Box 4.1 provides an overview of the types of emissions included in the emission accounts.

Point and. non-point source emissions

4.7. Source of pollution are classified in point source and non point source emissions. Point source emissions are those emissions for which the geographical location of the discharge of the wastewater is clearly identified. They include, for example, emissions from wastewater treatment plants, power plants, other industrial establishments. Non-point (or diffuse) sources of pollution are sources without a single point of origin or a specific outlet into a receiving water body. Pollutants are generally carried off the land by storm-water run-off or may be the result of a collection of individual and small scale polluting activities which for practical reasons cannot be treated as point sources of pollution. The commonly used categories for non-point sources include agriculture, forestry and urban areas.

4.8. Point source emissions are generally considered easier to measure since the point of emission to the water resources is clearly identified. This in turn allows for the identification of the economic unit responsible for the emission and for the measurement of the pollution content of the discharge at the precise location. Non-point source of emissions cannot be measured directly but need to be estimated through models which take into consideration several factors including the soil structure and the climatic conditions as well as the delay with which the pollutants reach the water table. Further, it is difficult to allocate non-point emission sources to the economic unit that generates them because of their nature.

4.9. Emission accounts include all point source emissions of pollutants in wastewater and those non-point sources for which physical flows are recorded in Chapter 3, namely urban runoff and irrigation water. Urban runoff is described in the emission accounts in terms of the pollutants deposited on urban areas and in the air, often as a result of transport or other economic activities. Irrigation water is described in terms of the pollutants which are added to the return flows from agricultural land, that is fertilizers and pesticides spread on the soil during infiltration into groundwater or runoff to surface water.

4.10. For the sake of simplicity as wells as to maintain consistency with the water flows in the physical supply and use tables presented in Chapter 3, we exclude a number of non-point source emissions, although they affect the quality of water resources. In a more comprehensive approach, all emissions to water would be included in the emission accounts. These include, for example, pollutants that reach the water bodies after leaking from a landfill site or having passed through natural land. As precipitation passes through waste, it collects polluting compounds including ammonia, heavy metals, chloride and oxygen-depleting substances which ultimately infiltrate the soil and reach a groundwater body. The same can occur when precipitation passes through natural land and it absorbs pollutants present in the air.

Box 4.1: Scope of emission accounts

Include:	Exclude:
Point sources:	Point sources:
Pollutants added to wastewater	Discharges of heavy metal and hazardous wastes not included in wastewater (*included in the SEEA waste accounts)*
	Pollutants resulting from in-situ use (e.g. navigation, fishing, etc.)
Non-point sources:	Non-point sources:
Urban runoff Irrigation water	All non-point sources except for urban runoff and irrigation water (*included in the quality accounts)*

Water pollutants

4.11. Before starting the compilation of emission accounts, a list of pollutants has to be defined. Most often this list is based on the country's environmental concerns as well as national legislation on water and, where applicable international agreements. For example, in the case of European Union countries, the EU Water Framework Directive (European Parliament and Council, 2000) provides an indicative list of pollutants (see Table 4.1).

Table 4.1: Indicative list of the main pollutants from in the EU

1. Organohalogen compounds and substances which may form such compounds in the aquatic environment.
2. Organophosphorous compounds.
3. Organotin compounds.
4. Substances and preparations, or the breakdown products of such, which have been proved to possess carcinogenic or mutagenic properties or properties which may affect steroidogenic, thyroid, reproduction or other endocrine-related functions in or via the aquatic environment.
5. Persistent hydrocarbons and persistent and bioaccumulable organic toxic substances.
6. Cyanides.
7. Metals and their compounds.
8. Arsenic and its compounds.
9. Biocides and plant protection products.
10. Materials in suspension.
11. Substances which contribute to eutrophication (in particular, nitrates and phosphates).
12. Substances which have an unfavourable influence on the oxygen balance (and can be measured using parameters such as BOD, COD, etc.).

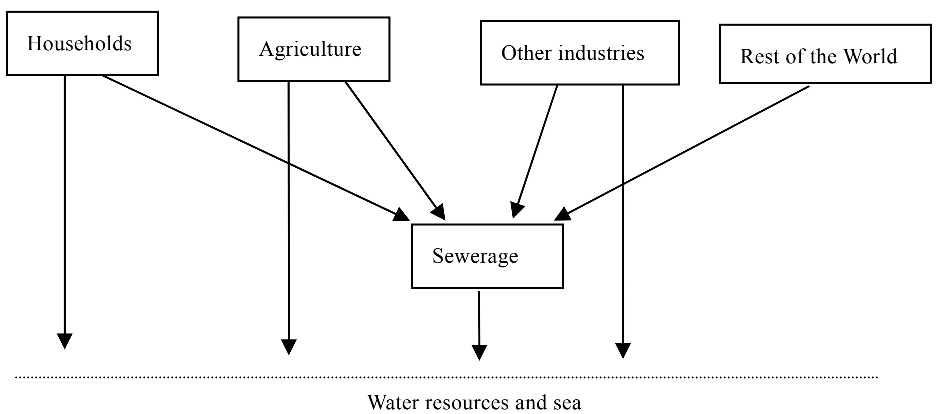
Source: European Parliament and Council, (2000) -Annex VIII.

Gross and net emissions

4.12. The pathway of pollutants from their origin to their release into the environment helps in defining the coverage of the emission accounts. Figure 4.1 shows schematically the path that the wastewater and associated pollutants generated by an economic unit (which in the figure is represented by households, agriculture, other industries and the rest of the world) follows. The wastewater and associated pollutants are either discharged directly into the environment with or without self-treatment, or supplied to a wastewater treatment plant.

4.13. The fact that the discharge of pollutants to the environment can occur in one or two steps (directly or through a treatment plant - ISIC 37) leads to the distinction between gross and net emissions. *Gross emissions* are the pollutants added to the water by an activity, assessed at the point where the wastewater leaves the activity's site (or the dwelling, in the case of households). *Net (or final) emissions* correspond to the pollutants discharged into water resources. When wastewater is discharged directly into a water body gross and net emissions coincide. An economic activity, for example, may discharge part of its wastewater directly into water resources (thus releasing the pollutants directly), and the rest can be supplied to a wastewater treatment plant which, after treatment, discharges into the environment the ‘treated’ wastewater. Since the ’treated wastewater’ may still contain traces of the pollutant generated by the economic activity, the net emission of the economic unit would correspond to the sum of the direct release of pollutants into water resources and the indirect release through wastewater treatment plants.

Figure 4.1: Wastewater and associated pollutant pathway



4.14. For the whole economy, the difference between gross and net emissions totals would correspond to the pollution removed by treatment plants. Of course the distinction between gross and net emissions is not applicable for non-point pollution (e.g. resulting from agriculture).

4.15. In the calculation of the net emissions, the release of pollutants by the sewerage industry, ISIC 37, has to be reallocated to the economic unit responsible for the discharge in the first place. This is often difficult to calculate as the industry ISIC 37 treats aggregated flows of wastewater coming from diverse users of the sewage system. In general, the allocation of emissions in the return flow of ISIC 37 to the original economic unit responsible for generating that pollution is obtained by applying global abatement rates of the treatment plant to every emission collected by the treatment plant.

4.16. The exchange of pollutants with the rest of the world (import and export) covers only exchanges of pollutants associated with the discharge of wastewater from one economy to a wastewater treatment facility (ISIC 37) of another economy. For example, the import of a pollutant corresponds to the import of wastewater from the rest of the world with the aim of discharging it, possibly after treatment, in the national territory. Emission accounts do not include 'imports' and 'exports' of pollutants through natural flows. This is the case, for example, of pollutant content of rivers crossing the country borders and/or flowing to the open sea, these are however covered in the quality accounts in Chapter 7.

C. Emission accounts

4.17. As discussed in Section B, the emission accounts record the pollution added to water by an economic unit and not the total pollution discharged with wastewater. This implies that, if an industry abstracts (or receives) 1 cubic metre of water which already contains *x* kg of a pollutant and returns to a river 1 cubic metre of wastewater containing *y* kg of the same pollutant, even though the total discharge of the pollutant to the river is *y* kg, only (*y*-*x*) kg is recorded as it represents the pollution generated by the industry. This has several implications for the measurement of emissions: the level of emissions is not given by the pollutants content of outgoing flows of water, but by the difference between the pollutants content of incoming and outgoing flows. While for drinking water the pollutant content should normally be negligible, for some other uses (e.g. cooling or process water) the pollutant content of the incoming water can be significant.

4.18. The pollution is generally measured in terms of quantity of a measured parameter (see for example, the list of pollutants in Section B of this chapter) released during a certain period of time. They can be expressed either directly in terms of the quantity of a parameter (for example, kilogram per year) or reported to an arbitrary unit that can represent one or more parameters (e.g. population equivalent made of five-day biochemical oxygen demand (BOD5), Nitrogen (N), Phosphorus (P), Suspended solids (SS)). One population equivalent (p.e.) means the organic biodegradable load having a BOD5 of 60 g of oxygen per day.

4.19. Information on emissions to water is organized in the accounts according to Table 4.2. The first part of the table reports:

- total amount of a pollutant generated by an economic unit (gross emission) measured at the point of discharge;
- the amount of pollutant that is released directly into water (contained in the direct discharge of wastewater into the environment) without treatment (row a1. in Table 4.2);
- the amount of pollutant that is released directly into water after having undergone some on-site treatment before being discharged into the environment (row a2. in Table 4.2)[10];
- the amount of pollutant that is released into the sewer system (row b. in Table 4.2). Note that the collected wastewater can be delivered to a wastewater treatment plant for treatment before discharge, or it can be discharged into the environment without treatment. Further information on the release of pollutant from the Sewerage industry, ISIC 37, is presented in the second part of Table 4.2.
- Direct emissions are further disaggregated according to receiving media. The breakdown in Table 4.2 explicitly shows water resources and the sea, where water resources include the categories specified in the asset classification, namely rivers, lakes, groundwater etc. The level of disaggregation depends on the data availability.
- The indirect emission to the environment of each industry through ISIC 37 (row d. in Table 4.2) and the net emission by industry (row e. in Table 4.2). These quantities can be calculated once the emissions to water by ISIC 37 are identified (as shown in the second part of Table 4.2)

[10] Note that it would be useful to have the amount of pollutant before the on-site treatment and after (to compute the depollution efficiency of an industry). However, since it is not required to report emissions to on-site facility in the emission registers for national policies (European Commission 2000 (Annex 2 page 77), they are not included in the tables.

4.20. The second part of Table 4.2 presents detailed information on the emission to water by the Sewerage industry, ISIC 37 and allows for the calculation of net emissions by industries. In particular, the second part of Table 4.2 presents the following information:

- total amount of pollutant released by Sewerage (row c. in Table 4.2);
- the amount of pollutant that is released directly into water after having undergone treatment before being discharged into the environment (row c.1. in Table 4.2). These emissions are further disaggregated according to receiving media.
- the amount of pollutant that is released directly into water without treatment (row c.2. in Table 4.2). This is the case, for example, of discharges of raw sewage through a sewage collecting system. These emissions are further disaggregated according to receiving media.

Table 4.2: Emission accounts

Pollutant COD (kg/year)	ISIC						Households*	Rest of the World	Total
	ISIC 1 Agriculture	ISIC 2-33, 41-43	ISIC 35	ISIC 36	ISIC 38,39, 45-99	Total			
Gross emissions (= a + b)	**19,482.40**	385074.6	**3.4**	**33.9**	**45,179.90**	**449,774.1**	**26,017.2**		**475,791.3**
a. Direct emissions to water (=a1 + a2=b1+b2)	15,277.10	4701.9	3.4	33	9,035.90	29,051.3	520.3		29,571.6
a1. Without treatment	15,277.10	4396.3	3.4	33	7,228.70	26,938.5	520.3		27,458.8
a2. After on-site treatment		305.5			1,807.20	2,112.7			2,112.7
b1. To water resources	*15,277.10*	4554.8	*0*	*33*	*7,529.90*	*27,394.9*	*494.3*		*27,889.1*
b2. To the sea	*0*	147.1	*3.4*	*0*	*1,506.00*	*1,656.4*	*26.0*		*1,682.4*
b. To sewage network (SIC 37)	4,205.30	380372.6	0	1	36,143.90	420,722.8	25,496.9		446,219.7
d. Reallocation of emission by ISIC 37	2,663.30	240902.6	0	0.6	22,891.20	266,457.8	16,148.0		282,605.8
e. Net emissions (= a. + d.)	17,940.40	245604.6	3.4	33.6	31,927.10	295,509.1	16,668.3		312,177.4

* estimated annual COD load (1000 tonnes per 1000 people).

Emissions to water by ISIC 37

Pollutant COD (kg/year)	ISIC 37
c. Emissions to water (= c.1 + c.2)	**282,605.8**
c.1. After treatment	133,865.9
To water resources	*53,546.4*
To the sea	*80,319.5*
c.2. Without treatment	148,739.9
To water resources	*59,496.0*
To the sea	*89,243.9*

Source: SEEAWLand Dataset

4.21. In order to calculate net emission by industry, the emissions to water by ISIC 37 have to be reallocated to the industry responsible for the discharge in the first place. Row d. in Table 4.2 explicitly shows the reallocation of emissions from ISIC 37. In this example, the emission by ISIC 37 has been reallocated to the industries applying a global abatement rate of 63 per cent (obtained by dividing row c. by total row b., 282,605.8/446,219.7 = 0.63) to the pollutant release of each industry to the sewage network (row c.2. in Table 4.2). Net emissions are calculated by adding row a. (direct emission of the industry) and row d. (Reallocation of emission by ISIC 37).

4.22. When information is available, emissions from wastewater treatment plants could be further disaggregated in Table 4.2 according to the type of treatment process. Three types of treatment processes are identified by the UNSD/UNEP Questionnaire (mechanical, biological and advanced) and the OECD/Eurostat Questionnaires (primary, secondary and tertiary) (see the glossary for the definitions).

4.23. For policy purposes, it is useful to record in a supplementary table additional information such as the pollutant content and volume of sludge generated by ISIC 37 and on the number of people with access to improved sanitation. Annex II provides an example of supplementary table to the emission accounts.

4.24. In some countries there are legislations regulating the generation and disposal of sewage sludge which require the collection of information on sludge production (usually in dry weight as, depending on the methods of water treatment and sludge treatment such as digestion, filter-pressing etc., the concentration of dry solids can be very variable) as well as its pollutant content. For European country, for example, there is a directive, Sewage Sludge Directive (Directive 86/278/EEC, European Parliament and Council 1986), which regulates the generation and use of sewage sludge (in order as to prevent harmful effects on soil, vegetation, animals and man) and seeks to encourage its use.

4.25. During wastewater treatment sewage sludge is generated as accumulated solids separated from water. Due to the physical-chemical processes involved in the treatment, the sludge tends to concentrate heavy metals and poorly biodegradable trace organic compounds as well as potentially pathogenic organisms (viruses, bacteria etc) present in wastewaters. On the other hand, sludge can be rich in nutrients such as nitrogen and phosphorous and contains valuable organic matter that is useful when soils are depleted or subject to erosion.

4.26. The indicator on the number of people with access to improved sanitation, target 10 of the Millennium Development Goals, is an important indicator of the ability of a country to prevent damages to human and environmental health originating from wastewater discharge (by avoiding, for example, the spread of excreta-related diseases and by reducing pollution of water resources). The indicator is based on the distinction between improved and not improved sanitation, where improved sanitation technologies consist of connection to a public sewer, connection to a septic system, pour-flush latrine, ventilated improved pit latrine; and not improved consist of service or bucket latrine (where excreta are manually removed), public latrine and latrine with an open pit (WHO/UNICEF). Presenting information on this indicator together with the accounts facilitates integrated analyses of emissions to water.

Urban runoff

4.27. Care has to be used when recording and allocating the pollutant load contained in the discharge of urban runoff. Urban runoff is storm water from city streets and gutters that usually contains a great deal of litter and organic and bacterial wastes. These include oil, antifreeze, detergents, pesticides and other pollutants that get washed from driveways, backyards, parking lots and streets and are usually collected through storm sewers (drains usually at street corners or at low points on the sides of the streets). Because this water is highly polluted, there is an increasing awareness in the potential danger of discharging urban runoff into the environment without treatment. Hence this flow is recorded both in terms of volume (in the physical supply and use table) as well as in terms of pollutant load (in the emission accounts).

4.28. When urban runoff is collected in the same sewer system that collects domestic and commercial wastewater (sanitary sewers), it is difficult to measure the amount of pollutant, which pertains specifically to urban runoff. Another difficulty in dealing with urban runoff is the allocation of the pollutant load: the pollution content of urban run-offs is certainly the result of a 'diffuse' pollution, but part of it can also be of a natural origin: for instance, the fall of leaves in the gutters creates an organic pollution. In the emission accounts, the pollutant load in the discharge of urban runoff is allocated to the Sewerage industry, ISIC 37.

"Water collection, treatment and supply" ISIC 36

4.29. Emission accounts report the direct and indirect (through ISIC 37) releases of wastewater pollutants to the environment. Thus the removal of pollutants during purification processes by the industry ISIC 36, "Water collection, treatment and supply", do not appear in Table 4.2. In addition, water supplied by ISIC 36 can, in most of the cases, be considered almost free of pollutants (such as those described in section B of this chapter) as purification of water generally involves other pollutants (e.g. microbiological pollutants).

4.30. Supplementary tables can be constructed to analyse the pollutant load of the water abstracted and supplied by ISIC 36 to study the efficiency of purification processes (removal of pollutant from abstracted water before distribution).

D. Country Examples

4.31. This section presents how selected countries have compiled emission accounts: France, the Netherlands and Sweden. The first case study describes the examples of emission accounts at the national level in the Netherlands where the origin and destination of pollutants are identified and emissions to water from mobile sources are computed. The second set of country's case studies covers the compilation of emission accounts at river basin level which provide information on the spatial distribution of the economic pressure on water resources.

1. The Netherlands

4.32. Table 4.3 presents an example of water emission accounts in the Netherlands. The water emission accounts describe the origin and destination of emission. In particular, it contains gross emissions of phosphorus, nitrogen, organic pollution and heavy metals by households and industry and the total release of pollutant to the Sewerage industry, ISIC 37.

4.33. Net emissions by industry are not calculated but total net emissions are obtained by deducting emissions to ISIC 37 from total gross emissions. The data for the emission accounts are obtained from the Dutch National Emission Registration.

4.34. Emissions that could not be attributed to an economic activity or to households are recorded under the category "other domestic origin". They include emissions resulting from atmospheric deposition, waste dumping sites and transport difference. The atmospheric deposition may partly originate from abroad. Emissions from waste dumping site occur through leakage processes through a waste dumping site. Transport difference records the difference between the sum of all emissions entering the sewer system and what actually reaches the sewage treatment plants.

Table 4.3: Emission accounts to water for the Netherlands, 2000

	heavy metals										
	Arsenic	Cadmium	Mercury	Chrome	Copper	Lead	Nickel	Zinc	Phosphorus	Nitrogen	Wastewater
	kg			*tonnes*					*1000 tonnes*		1000 i.e.
EMISSIONS BY HOUSEHOLDS											
Households transport	479	11	-	-	10	1	-	37	-	-	0
Households other	3153	788	284	3	199	79	8	212	9.8	67.8	15926
EMISSIONS BY INDUSTRIES											
Agriculture	-	168	-	-	17	37	16	118	6	76	116
Fishing	-	10	-	-	10	-	-	19	-	-	6
Mining and quarrying	5	-	-	-	-	-	-	-	-	-	5
Manufacturing											
Manufacture of food products, beverages and tobacco	82	15	1	2	3	-	1	9	1.5	5.2	1730
Manufacture of textile and leather products	1	-	-	1	3	-	1	2	-	0.6	177
Manufacture of wood and wood products	87	8	2	1	1	-	-	3	0.1	0.4	223
Manufacture of paper and paper products	-	-	-	1	-	-	1	-	-	-	56
Publishing and printing	33	3	-	-	3	-	-	2	-	0.6	102
Manufacture of petroleum products; cokes, and nuclear fuel	554	114	24	3	5	1	3	27	1.4	2.3	426
Manufacture of basic chemicals and man-made fibres	23	51	1	1	-	-	1	2	0.1	0.8	183
Manufacture of chemical products	1	5	-	-	-	-	-	-	-	-	13
Manufacture of rubber and plastic products	1007	123	3	2	2	1	1	6	-	0.5	103
Other manufacturing	11	7	0	12	13	3	8	9	0	1	229
Electricity, gas and water supply											
Electricity and gas supply	1	1	-	-	-	-	-	-	-	-	8
Water supply	-	-	-	-	-	-	-	-	-	0.1	7
Construction	0	0	0	0	1	0	0	6	0	0	44
Wholesale and retail trade; repair of motor vehicles/cycles	1	1	-	-	3	1	-	11	0	-	1046
Hotels and restaurants	-	-	-	-	1	-	-	1	-	-	466
Transport and storage	1189	72	0	0	41	1	0	190	0	0	133
Financial and business activities and communication	1	1	0	0	3	0	0	18	0	0	457
Public administration and social security	3079	-	-	-	3	-	-	4	-	-	0
Defence activities	-	-	-	-	-	-	-	1	-	-	0
Subsidized education	4	-	1	-	1	-	-	3	-	0.1	227
Health and social work activities	-	-	362	-	2	1	-	5	-	-	753
Sewage and refuse disposal services	3075	509	276	6	20	11	13	110	3.0	31.8	174
Other service activities	1	1	-	-	-	-	-	3	-	-	414
OTHER DOMESTIC ORIGIN											
Waste dumping sites	309	43	16	1	-	-	1	3	-	2.2	
Atmospheric deposition	-	796	415	1	22	37	16	92	-	15.8	
Transport differences	1970	-235	-539	-2	-9	-14	-2	74	2.1	2.8	4028
TOTAL GROSS EMISSIONS	15068	2497	847	34	358	166	70	968	24.4	207.9	27052
Emissions released to ISIC 37	5680	1000	470	21	158	53	26	403	13.3	84.7	23193
Total net emissions	9388	1497	377	14	200	113	45	565	11	123	3860

(*) Organic pollution is quantified in inhabitant equivalents (i.e.): an inhabitant is supposed to emit 54 grams of BOD per day.

Source: Adapted from Statistics Netherlands, 2004

4.35. Emissions to water from mobile sources have been allocated to the corresponding economic activity using the so-called "transport module". Statistics Netherlands has developed this transport module to allocate air emissions from mobile sources to the relating industries and households. In standard environment statistics, in fact, all emissions from mobile sources are lumped together under a category called "transport" which is much broader than the transport industry in the ISIC classification.

To overcome this problem, the transport module was developed as an integral part of the National Accounting Matrix including Environmental Accounts (NAMEA). Therefore, it is fully linked with the complete set of environmental accounts covering also other resources in addition to water.

4.36. Emissions to water from mobile sources include the release of pollutants associated with the following discharges to water:

- Leakage of motor oil and petrol,
- Urban runoff (due to wearing of tires, wearing of roads, corrosion of vehicles),
- Wastewater from ships.

4.37. Leakage of motor oil and petrol as well as wastewater from ships are not included in the emission accounts described in this chapter.

4.38. In the transport module, the energy use by mobile sources (road transport, water transport, air transport) is distributed over the industries and households. This is done by using monetary data on fuel use that can be obtained from the National Accounts. Consistent to the SNA concepts, energy use includes both the fuel used within the national territory as well as the fuel used outside the national territory by resident units. Subsequently, the distribution of fuel use over households and industries can be used as a key to allocate the emissions to water from mobile sources.

2. Country Examples of Emission Accounts at river basin level

France

4.39. Table 4.4 presents emissions accounts for a French river basin, the Loire-Bretagne basin. In this table gross and net emissions are calculated according to the source. Very detailed geo-referenced data have been used, so that a specific treatment plant could be attributed to each point source of pollution with the help of its geographical location. De-pollution ratios of the identified treatment plants were then applied. Consequently, the direct discharge of the sewage industry, ISIC 37 (86 tonnes per day in Table 4.4) could be reallocated to the original emitter (row d.).

Table 4.4: Emissions of Nitrogen in the French Loire-Bretagne hydrological basin (in tonnes of N per day)

Pollutant N	ISIC		Households		Non-point sources	Total
	ISIC 1 Agriculture	Other	Scattered population	Urban population		
Gross emissions (= a + b)	582.0	43.0	2.0	122.0	37.0	786.0
a. Direct emissions to water	582.0	15.0	2.0	7.0	37.0	643.0
b. To sewage network	0.0	28.0	0.0	115.0	0.0	143.0
Removed during on-site treatment	*322.0*	*28.0*	*35.0*	*0.0*	*0.0*	*385.0*
d. Re-allocation of the emissions by ISIC 37		13.0		73.0		86.0
e. Net emissions (= a. + d.)	582.0	28.0	2.0	80.0	37.0	729.0

Discharges from treatment/collection facilities to water

Pollutant N	ISIC 37
c. Emissions to water (=c.1. + c.2.).	**86.0**
c.1. After treatment	72.0
c.2. Without treatment	14
Removed during treatment	*57.0*

Source: Adapted from Ifen, 2000.

4.40. Since in France information is available on the removal of pollutant during on-site treatment, Table 4.4 explicitly reports this information as it gives an indication of the effectiveness of on-site treatments. Note that the removal of pollutant during on-site treatment for agriculture includes spontaneous de-nitrification process of the soils (322 tonnes per day).

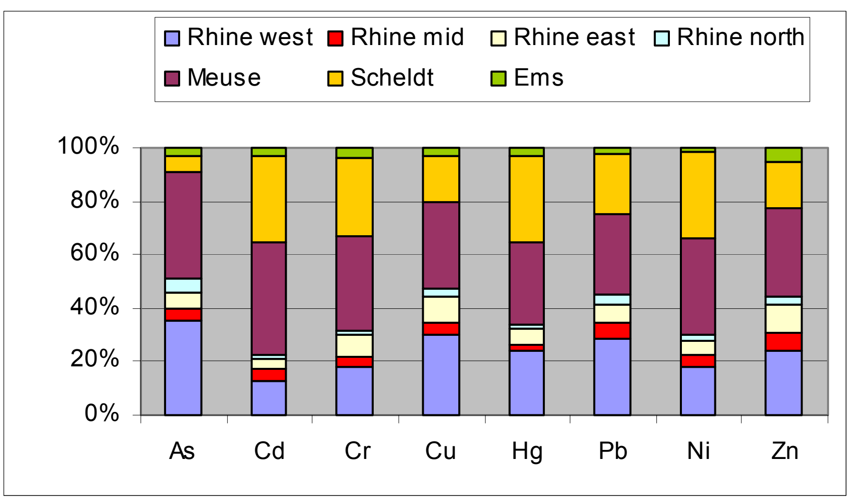
4.41. In this presentation, urban run-offs (column non-point sources) have been assumed bypassing the sewage system. The pollution content of these flows (or at least part of it) has nevertheless been attributed to the economy as a 'non-point source'. No breakdown of urban runoff between what is natural and what is of an economic origin was calculated as it was not considered to be a meaningful estimate. It is important to take into account flows of the rainwater runoffs to the sewers and, possibly, their treatment as they undergo an economic treatment which is accounted for in the expenditures (e.g. the investment in sewers for urban run-offs). In order to keep coherence within the different accounts, the pollutant content of these flows should be studied.

The Netherlands[11]

4.42. In the Netherlands emission registers, in addition to emitted substances, provide information on the activities which emit pollutant as well information on their location. This allows the allocation of emission to river basins.

4.43. In the Netherlands, regional emission data are supplied by the Regional Emission Registration and include the same substances as the national emission data. Most data are available at the level of individual plants, including their spatial coordinates, making it relatively easy to attribute these emissions to one of the river basins. The regional emissions add up to the national totals. Accordingly, emissions can be allocated to the different river basins. For example, Figure 4.2 shows the share of different river basins in the total emission of specific metals in the Netherlands.

Figure 4.2: Share of different river basins in the total emission of specific metals in the Netherlands in 2000



4.44. In some cases a problem arises if the location of an economic activity does not correspond with the location of the emission source. For instance, a factory is located in one river basin, but its

[11] Statistics Netherlands, 2004

wastewater is transported to and discharged in another river basin. In the Netherlands these emissions are allocated to the river basin in which the economic activities take place, i.e. where the factory is located, although the actual pressure occurs in another river basin.

4.45. Emission accounts in the Netherlands record also emissions associated with mobile sources. There are, however, problems in the allocation of emissions: according to the NAMEA principles, the emissions of mobile sources should be allocated to the economic activity that generates the emission. When regionalising the emission data for mobile sources, this means that the emissions are allocated to the river basin where the corresponding economic activity is located, and not to the river basin(s) where the emissions actually occur. For example, lorries belonging to a company located in a certain river basin drive and pollute in other river basins, whereas the emissions are all allocated to only one river basin area.

Sweden[12]

4.46. Emission accounts have been compiled in Sweden for the six major drainage basins for the year 2000. Table 4.5 summarizes information on the discharges to water from of municipal wastewater treatment plants: the pollutants reported in the tables are phosphorus, nitrogen, BOD_7 (biochemical oxygen demand) and COD_{Cr} (chemical oxygen demand).

Table 4.5: Discharges to water from municipal wastewater treatment plants in 2000 by major drainage areas, tonnes

Major drainage area		Tot-P	Tot-N	NH-N	BOD_7	COD_{Cr}
Bothnian Bay		21	1 176	820	839	2 752
Bothnian Sea		69	3 212	2 317	2 003	8 579
Baltic proper		145	8 080	3 413	3 156	24 359
The Sound		32	1 058	273	792	4 609
Kattegat		148	5 069	2 925	2 813	15 585
Skagerack		9	382	206	182	1 586
Total	2000	424	18 977	9 954	9 784	57 472
Total	1998	430	21 376	..	11 270	58 463
Total[1]	1995	470	25 940	..	13 060	66 840
Total[2]	1995	415	25 430	..	11 670	63 030
	1992	470	25 310	..	12 205	62 190
	1990	655	26 200	..	14 050	69 150
	1987	1 050	25 600	..	16 700	66 300

1) Includes temporary large emissions from a plant located on the Kattegatt, due to reconstruction.

2) Excluding the above-mentioned temporary emission.

4.47. The information on wastewater and wastewater treatment has been taken from the database connected to the publication MI 22 SM 0101 *Discharges to water and sludge production in 2000 – Municipal wastewater treatment plants and some coastal industry*. The report was made by Statistics Sweden on behalf of the Swedish Environmental Protection Agency (Swedish EPA).

4.48. Under Swedish environmental protection law, special permits are required to perform certain activities which are potentially harmful to the environment. In addition, establishments performing these activities (which are more than 2,000 in number) are required to report their emission data to the

[12] Based on Statistics Sweden (2003).

supervisory agency once a year. Estimates of the emission are usually based on results of measurement programs. The primary data for the statistics stem from these reports.

4.49. Municipal wastewater treatment plants designed for more than 2,000 person equivalents, including industrial wastewater, are required to produce environmental reports. Information on the discharge is based on these environmental reports and cover 478 wastewater treatment plants in the year 2000. Data been mainly collected through a postal survey except for 75 plants situated in Västra Götaland which have been taken from the Swedish EPA's database EMIR.

4.50. Some pollution sources were not included. They included: (i) small wastewater plants as there are no measurements of their emissions but it is estimated that they account for less than 10 percent of municipal wastewater and therefore they were assumed to make a similar contribution to emissions; (ii) people living outside urban areas (which amount to slightly more than one million people) which usually depend on self -supplied water and use septic tanks or similar devices to dispose of their wastewater; and (iii) establishments which are too small to be covered by the reporting requirement and which are also beyond the reach of municipal wastewater networks.

4.51. Regarding industrial emissions, the most water-intensive industry in Sweden is the pulp and paper industry, which consists of around 75 plants. A special survey of these plants was conducted by the Swedish EPA. Emissions from 22 coastal plants in other industries are also included in the statistics. Inland factories outside of the pulp and paper industry were excluded.

4.52. The allocation of emissions from wastewater treatment plants and other industries to the different drainage areas was straightforward as the basic data refer to individual plants whose spatial location is known.

4.53. A special project was carried out in Sweden in connection with the reporting to HELCOM, PLC-4, Recommendation 19/04. Yearly emissions of nitrogen and phosphorus were estimated for all known point sources, even those that do not produce environmental reports. Also diffuse leaching from various types of land was estimated based on very detailed data. Incorporating weather data for 30 years, model calculations of leaching and transport were performed and calibrated to most known measurements in Swedish rivers during this period. The “gross” (average) load, emissions and leaches, of phosphorus and nitrogen, was calculated for drainage areas larger than 1,000 km2. For nitrogen, “net” loads were also calculated using a special hydrological nitrogen retention model. The project is presented on the Internet at http://www-nrciws.slu.se/TRK/index.html.

4.54. Table 4.6 shows emissions to water for one of the drainage areas, the Bothnian Sea, for the year 2000. The table present additional information such as value added, number of employees and households, number of establishments and volume of wastewater collected by the sewage network in order to have a more complete picture of the economic profile of the industries emitting pollutants to water.

Table 4.6: Environmental economic profile for Water district Bothnian Sea, 2000

NACE	Agriculture, forestry, fishing 01-05	Water intensive industries 21+24 +27+40	Manufacturing industries others 10-37 [1]	Water supply and waste water 41+90001	Services 45-99 others	Households	Public adm.	Undistri-buted	Total
Value added (Milj SEK)	9 023	27 498	23 335	639	77 066	2643 [2]	41 703	20 310	199 574
Number of establishments	5 449	356	3 899	105	34 835	-	-	2 571	47 215
Number of employed	11 320	27 840	53 871	237 [3]	149 899	7 835 [2]	142 460	5 643	399 105
Number of households	-	-	-	-	-	469 581	-	-	469 581
Wastewater collected and treated by sewage networks (1000 m^3) [9]	-	217 239	2 793	152 373	-	-	-	-	372 405
Emission of P (ton) [10]	-	168	0,3	58	-	-	-	-	226
Emission of N (ton) [10]	-	1 561	0,3	2 660	-	-	-	-	4 221
Emission of BOD_7 (ton) [10]	-	29 929	0,3	1 586	-	-	-	-	31 515
Emission of COD_{Cr} (ton) [10]	-	119 587	0,3	7 225	-	-	-	-	126 813
Emission of Hg (kg) [11]	-	-	-	11	-	-	-	-	11
Emission of Cd (kg) [11]	-	-	-	24	-	-	-	-	24
Emission of Pb (kg) [11]	-	-	-	141	-	-	-	-	141
Emission of Cu (kg) [11]	-	-	-	1 799	-	-	-	-	1 799
Emission of Zn (kg) [11]	-	-	-	7 808	-	-	-	-	7 808
Emission of Cr (kg) [11]	-	-	-	213	-	-	-	-	213
Emission of Ni (kg) [11]	-	-	-	515	-	-	-	-	515

Note: NACE -- Classification of Economic Activities in the European Community
[1] Excl 21, 24, 27
[2] NPISH
[3] Employed in NACE 90001 – not included, here part of NACE 90
[9] Discharge of treated water, for NACE 10-37 direct discharge
[10] For NACE 24, 27 and 40, only establishment by the coast
[11] Data for year 2002
Source: Statistics Sweden (2003).

E. Derived indicators

4.55. Emission accounts allow for the identification of the activities responsible for the emission of polluting substances into water. This information can be shown through straightforward tables or graphs showing the distribution of emissions between the various activities or different river basins. More elaborated indicators can be computed from the emission accounts together with additional information from the physical and monetary accounts (for example, value added, volume of wastewater discharge etc.). In Belgium pollution intensity ratios have been used to assess the relative contribution of an industry to the emission of a specific pollutant. In the Netherlands different pollutants are aggregated into environmental "themes" to give an indication of the contribution of the different economic activities to the pollution.

1. Pollution intensity ratios

4.56. Pollution intensity ratios can be defined with reference to physical data on water (e.g. volumes of wastewater discharged) or to economic data (e.g. value added, employment by sector etc.). These ratios allow for a comparison between activities, not in absolute terms, but relatively to the wastewater generated, their relative contribution to value added, and employment. Examples of these indicators are:

$$\text{pollution intensity of water use}_{ij} = \frac{\text{share of industry } i \text{ in total discharge of water pollution } j}{\text{share of industry } i \text{ in total volume of wastewater discharge}}$$

$$\text{pollution intensity of value added}_{ij} = \frac{\text{share of industry } i \text{ in total discharge of water pollution } j}{\text{share of industry } i \text{ in total value added}}$$

$$\text{Pollution intensity of employment}_{ij} = \frac{\text{share of industry } i \text{ in total discharge of water pollution } j}{\text{share of industry } i \text{ in total employment}}$$

4.57. Table 4.7 presents an example of calculation of pollution intensity ratios in Belgium for six pollutants. The table shows that the electricity and water supply industries contributed very little to the global pollution even though they produce more than half of total wastewater discharges in Belgium in 1998: the pollution intensity ratio of the volumes of water they discharge is not higher than 0.1 percent whichever pollutant is considered (not all heavy metals have been reproduced in the table).

4.58. The combination of the emissions with economic data allow for the identification of the sectors that are important water polluters because of the kind of activity they perform, from those that are important polluters because of their size: agriculture and mining industries contribute much more to the pollution of the Belgian waters than they contributes to the national value added as regards nitrogen, phosphorous, biochemical and chemical oxygen demands. Manufacturing industries contribute more to the pollution of water (ratio > 1) with any form of pollutant than they contribute to value added, except for nitrogen.

Table 4.7: Breakdowns of emissions in Belgium in 1998 and corresponding pollution intensity ratios

		BOD	COD	Lead (Pb)	Zinc (Zn)	Phosphorus (P)	Nitrogen (N)
Agriculture and mining industries	share in total pollution	16.2%	7.0%	6.3%	0.8%	24.0%	54.2%
	pollution intensity of water use	4.52	1.95	1.77	0.21	6.72	15.19
	pollution intensity of added value	25.6	11.94	3.76	0.45	38.3	50
Manufacturing industries	share in total pollution	19.5%	25.6%	92.9%	98.8%	11.9%	9.0%
	pollution intensity of water use	0.73	0.96	3.46	3.69	0.44	0.33
	pollution intensity of added value	2.71	3.84	4.81	5.1	1.66	0.72
Electricity & water supply	share in total pollution	0.0%	0.1%	0.0%	0.0%	0.0%	0.1%
	pollution intensity of water use	0	0	0	0	0	0
	pollution intensity of added value	0.02	0.08	0	0	0.04	0.07
Services	share in total pollution	1.4%	1.6%	0.0%	0.0%	0.9%	0.5%
	pollution intensity of water use	2.93	3.42	0.05	0.04	1.94	0.98
	pollution intensity of added value	0.05	0.06	0	0	0.03	0.01
Households	share in total pollution	62.9%	65.7%	0.8%	0.4%	63.2%	36.2%
	pollution intensity of water use	4.93	5.15	0.04	0.03	4.95	2.84

Source: The NAMEA Water for Belgium (1998) - Report to Eurostat from Bureau Fédéral du Plan - February 2002

2. Environmental themes

4.59. For presentation to the users, it may be useful to aggregate the different pollutants to give a synthetic view of the contribution of the economy to the pollution in the country. For instance, in the Netherlands, pollutants are aggregated into three environmental “themes”: eutrophication, dispersion of heavy metals and a general "wastewater" theme (organic pollution). The 'contribution to environmental themes' presents the actual pressure on the environment caused by a particular substance or set of substances in the environment. For example, excess amounts of nitrogen (N) and phosphorous (P) contribute to eutrophication; emissions of heavy metals contribute to the dispersion of heavy metals in the environment; and emissions of wastewater contribute to excess amounts of organic substances in surface waters. Note, however, that environmental themes describe only environmental pressures and not the extent to which these pressures actually result in environmental problems or damage (i.e. impacts).

4.60. Statistics Netherlands calculates the contribution to environmental themes based on a measure of the pollution accumulated in the country calculated as the sum of total net emissions (from Table 4.3) and the loads in the inflows from upstream countries minus the loads in the outflows to downstream countries, see Table 4.8. This indicator mixes emissions, which are the amount of pollutants added to wastewater with the loads which represent the amount of pollutants present in the water bodies. The two concepts are different as the impacts, in terms of loads of emissions of pollutants, depend on many factors. The difference between the loads from upstream countries to downstream countries is however an important indicator as it provides an indication of the quality of water received by upstream countries and that released to downstream countries.

4.61. Table 4.8 records emissions and the contribution to environmental themes of each pollutant for the year 2000.

Table 4.8: Contribution to environmental themes, The Netherlands 2000

	Heavy metals								Phosphorus	Nitrogen	Wastewater
	Arsenic	Cadmium	Mercury	Chrome	Copper	Lead	Nickel	Zinc			
	kg			*tonnes*					*1000 tonnes*		1000 i.e.
Total net emissions	9388	1497	377	14	200	113	45	565	11.1	123.2	3860
Inflows from upstream countries	128599	9450	2130	131	423	346	264	1746	19.4	340.3	
Outflows to downstream countries	118048	9170	2143	142	372	272	245	1400	22.5	401.7	
Contribution to environmental themes											
Eutrophication									7.9	61.7	
Wastewater (organic pollution)											3860
Dispersion of heavy metals	19939	1777	365	3	252	187	64	911			

Source: Statistics Netherlands, 2004

4.62. The contribution of polluting substances to the environmental themes (CET) can also be expressed in equivalent units using different weights. In this way the contribution of the different substances to the environmental theme can be aggregated into one single indicator. The weights reflect the potential pressures on the environment by the respective substances. In particular, they include (i) a correction factor for the decay of substance and (ii) the Maximum Allowable Concentration, based on the maximal allowable risk (Statistics Netherlands, 2004).

F. Data sources and methods

4.63. As mentioned in the introduction, there is limited experience in countries on the implementation of emission accounts. Most of the experience is concentrated in EU countries, which are increasingly compiling this module of water accounting to report to the Water Framework Directive as well as to specific legislation and conventions.

4.64. A combination of different sources is generally used by the institution in charge of the compilation of emission accounts to gather data to populate the tables for emissions to water: different sectors of the economy as well as different pollutants often require specific methods for the assessment of their emissions. The most common data sources include: surveys, including reduced surveys for estimating emission coefficients; emission registers and registers of licences to pollute. In addition, if there is a legislation requiring monitoring and reporting the release of pollutants (permits, taxes on pollution, emission inventories etc.), administrative records can also be used to obtain information on industrial emissions. When measurements on emissions are not available, estimates could be made for example by applying emission factors, using coefficients relating emissions to population or number of employees etc.

4.65. It should be noted that it is important to collect also information on the estimation methods used in the calculation of emissions. In the EPER guidelines (European Commission, 2000), for example, a distinction is made for emission data based on: (i) measurement using standard or accepted methods (often additional calculations are needed to convert the results of measurements into annual emission data), (ii) calculations using nationally or internationally accepted estimation methods and emission factors, which are representative for the industrial sectors, and (iii) non-standardised estimations derived from best assumptions or expert guesses.

1. Surveys

4.66. When there exists a monitoring system for emissions (either self-monitoring or carried out by the authorities), surveys can be carried out to obtain relevant data from industries. Questions about emissions to water can be added to annual business surveys, not necessarily every year. However, given the technical complexity of the evaluation of the emissions, it may be more appropriate to build a specific survey on an ad hoc sample.

4.67. Estimates of industrial emissions, for example, are increasingly carried out by companies through self-monitoring programmes, in particular in the context of company environmental management systems (International Office for Water, 1998). Thus information on industrial emissions can be collected with specific surveys.

4.68. When information on emissions is not collected through surveys, it is common practice to use emission coefficients. Coefficients are selected on the basis of for example, emissions per person for households, per employee for industries, per ton of final product, etc.. and then applied to population or economic data accordingly. Coefficients are usually based either on (a) preliminary surveys or (b) other studies. The surveys needed for the identification of coefficients are generally on a smaller scale than the surveys described above. This method is mostly applied when the economic units to survey are very numerous and show a rather homogeneous behaviour in their water use. Results may vary considerably according to the method of estimation used.

4.69. Coefficients based on other studies are generally applied in pilot compilations of the accounts when preliminary results are needed and it is too costly to develop a complete collecting system. Coefficients could be taken from studies in other countries, other regions, other sources, etc. Care is necessary when applying coefficients especially those taken from other studies: emissions vary greatly depending on a number of determining factors (e.g. time, technology in place, company size, region) and the use of coefficients relies on the assumption that these determining factors are similar.

2. Emission registers

4.70. Emission registers are multi-purpose databases of releases of specific substances of interest. Usually, facilities which release one or more substances are required to report periodically as to what is released, how much and to what environmental media (air, water and soil). Other information is also reported such as the type of activity (e.g. industrial enterprise, wastewater treatment plant) and the location of the emitter. In some emission registers, releases from diffuse sources such as transport and agricultural pursuits are estimated using statistical methods.

4.71. Emission registers may differ in a number of ways: type of data used, choice of industrial sites included, time reference (daily or annual), inclusion of indirect discharges and extent of publication of results. The parameters covered by regular emissions inventories are also highly variable, generally including organic matter, nutrients and heavy metals, but in some cases including organic compounds. Catchment aggregations are in all cases possible, though not always carried out (International Office for Water 1998). Care must be used to ensure that the data are compatible with the accounting tables in the time scale (annual emission) and in the coverage of the emissions: some registers cover only large and medium-sized industrial plants which exceed specified emission thresholds.

4.72. Information from the registers may have to be complemented with other information to fill the accounting tables: for example, since emission registers generally cover gross emissions by industry, estimates have to be made to allocate the pollution emitted by urban wastewater treatment plants to the different economic units that made use of the treatment plants (e.g. economic activities, households) in order to calculate net emissions.

4.73. Data in emission registers can also serve for reporting to international organization such as the European Commission, the OECD, OSPARCOM for compliance with international conventions which are targeted to some category of pollutants, some substances or some receiving environmental media regarded as more sensitive or impacted. For example, the inventories stemming from the Integrated Pollution Prevention and Control (IPPC) Directive mainly address emissions from industry; the emission data from the reporting to the Directive 91/271/EEC on Urban Waste Water Treatment[13] mainly address the emissions from households and food industry and a very limited number of parameters; Marine Conventions such as the OSPAR Convention, only cover load to the marine environment (Preux and Fribourg-Blanc, 2005)

4.74. Box 4.2 presents a review of existing data collections which cover information on emissions to water. These respond either to specific legislations or to international conventions. Note, in particular, that the European Community and its Member States negotiated and finally signed, with the exception of two countries, an UN-ECE Protocol on Pollutant Release and Transfer Registers (PRTRs) on the fifth Ministerial Conference "Environment for Europe" in Kiev, May 2003. Under this Protocol a comprehensive European PRTR will replace the more limited (in terms of pollutants, emitting activities and periodicity of reporting) European Pollutant Emission Register (EPER). Each party to the Protocol should thus develop a public accessible national PRTR.

4.75. The European PRTR will be the successor of EPER presumably in the year 2007. In the mean time, the former EPER register has been released to the public, the EEA hosts the Web http://eper.cec.eu.int/eper/SupportingDocuments.asp which includes country data that can be consulted and downloaded.

[13] Available on the web at http://europa.eu.int/comm/environment/water/water-urbanwaste/index_en.html

Box 4.2: Existing data collections covering emissions to water

The European Pollutant Emission Register (EPER)

EPER was established by Commission decision 2000/479/EC of 17 July 2000 on the implementation of a European Pollutant Emission Register (EPER) according to Article 15 of Council Directive 96/61/EC concerning Integrated Pollution Prevention and Control (IPPC). It is a system of reporting large emissions to air and water for 50 substances from a list of 56 industrial sectors, and intensive animal husbandry sites. It includes a European database, hosted by the EEA, and the associated public website that allows for the consultation of the data reported (http://eper.eea.eu.int/eper/).

Only the facilities located in the European Union that carry at least one IPPC Annex I activity, and that emit at least one of the 26 EPER Annex A1 pollutants, directly or indirectly to water (organic pollution, nutrients, heavy metals, micro pollutants) above the threshold mentioned in this Annex should report their emission. At present, reporting is due every third year, and the first reporting cycle was completed in 2003.

The Urban Waste Water Treatment Directive (UWWTD)

Directive 91/271/EEC sets minimum standards for the collection, treatment and disposal of wastewater originating from urban areas and some industrial sectors, depending upon the size of the discharge, and the type and sensitivity of the receiving waters. It covers urban wastewater and industries connected to Urban Waste Water Treatment Plants (UWWTP), as well as industrial sectors listed in Annex III of the Directive (food industry) discharging directly in the receiving waters.

Only the wastewater treatment systems with a treatment capacity above the thresholds of the Directive (2 000 population equivalent in 2005 for urban areas, 4 000 population equivalent for food industry with direct discharge) and located in the European Union should report collected load and percentage reduction for 5 parameters (COD, BOD5, total nitrogen, total phosphorus and suspended solid). Reporting is due every second year, since 1994.

OSPAR Convention

Initiatives to protect the north-east Atlantic were first established in 1969 and the OSPAR Convention signed in 1998 is the most recent tool in this process. Although with no real legal burden, once signed the Convention should be respected. It aims at preventing and eliminating pollution and to protect the maritime area (geographically well defined in the Convention) against the adverse effects of human activities; it thus addresses all human activities. The Convention includes Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, The Netherlands, Norway, Portugal, Spain, Sweden, UK, Luxembourg and Switzerland. A priority list of 66 substances is established with a 50% emission reduction target. Inventories were made in 1985 and 1999 to assess if the target was reached.

Helcom Convention

The Convention was first established in 1992 and ratified in 2000. It aims to control and minimise land-based pollution of the marine environment of the Baltic Sea Area and thus addresses all human activities. Contracting parties to the convention are European Economic Commission, Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland, Russia and Sweden.

A priority list of 48 substances is established and the Convention has a wide variety of activities, each addressing a specific list of substances. Every 5 years, inventories of loads are made and the last included an emissions inventory and was done in 2004

Eurostat/OECD Joint questionnaire

Emissions are collected from point and non-point sources. The nationally aggregated point sources are divided into 8 sectoral activities using ISIC and NACE classifications. The population connected to the different sewage treatment types, the capacity of wastewater treatment plants and the wastewater generated by source and sector in terms of the main determinands are collected.

Eurostat covers the EU-15 countries, the 3 associated European Free Trade Association (EFTA) countries and the 10 Accession Countries (AC10) from Eastern Europe and the questionnaire collects information at a nationally aggregated level. 15 parameters are requested. They include Volume, Suspended Solids, BOD, COD, Population Equivalent, total Phosphorus, total Nitrogen, heavy metals and Arsenic. The questionnaire is circulated by OECD since 1981 and by Eurostat every second year since 1988.

Source: Preux and Fribourg-Blanc, 2005

3. *Exploitation of licenses to pollute*

4.76. In order to fight against the degradation of their inland waters, a number of countries have already settled systems of licenses to pollute: with or without a financial counterpart (fee, tax, etc.), companies (generally manufacturing industries) are authorized to discharge a certain amount of pollutants. The records established in the framework of these systems can serve as a basis for an estimation of the emissions.

4.77. However, experience suggests that the exploitation of such records can be difficult. The United Kingdom, for example, tried to confront the emission consents granted to the industries (the levels of discharges which the sector had permission to discharge) with their measured emissions (ONS, 2000).

This comparison was based on data from water companies from the England and Wales regions. Actual emissions as a ratio of the consented emissions were calculated per industry: out of the 300 ratios calculated, about two thirds were nil (no actual emissions at all) and a further quarter was below 10% of the consented level.

4.78. Although this result could be specific to the United Kingdom, the data derived from licenses to pollute should only be applied to small polluters: for example, to assess emissions to water, Austria directly surveyed its largest manufacturing establishments and assumed that the emissions by smaller companies were 50% of the limit value laid down in the Ordinance on Wastewater Emissions.

4. Calculation of nutrient surplus for agriculture

4.79. Specific devices are needed to estimate diffuse emissions by agricultural activities, including cattle breeding, since, as indicated before, some of these emissions should be accounted for to respect the overall coherence of the accounts. Models to calculate the emission to water from agriculture often involve information on sales figures (fertilizers, grain,etc.), the ‘nutrient surplus’ which occurs when not all the fertilizers and animal manure applied to the land are absorbed by the plants or removed during harvest, and characteristic of the soil, etc..

4.80. EEA (2000) describes how to calculate nutrient surpluses from agricultural sources based on information on: (i) land cover provided by CORINE Land cover; (ii) corresponding administrative, hydrographical and geographical layers (municipalities, drainage basins, etc.); (iii) information derived from the agricultural census (crops, livestock, etc.); (iv) agronomic data on fertilisers spread and yields obtained; and (v) technical coefficients such as the nutrient content of the crops or the manure per head of cattle.

Chapter 5 Hybrid and economic accounts for activities and products related to water

A. Introduction

5.1. The objective of this chapter is to study the economy of water, that is to describe in monetary terms the use and supply of water related products, identify the costs associated with the production of these products, the income generated by them, the investments in water related infrastructure and how much it costs to maintain them; and the economic instruments to manage water, namely taxes on the use of the resource and permits to access it. This information is useful for formulating and evaluating a wide range of policies related to water such as those aiming at efficient water allocation and the recovery of the costs of water services.

5.2. A logical starting point to study the economy of water is to present the conventional national accounts together with physical information on water abstraction, use and supply within the economy, and discharges of water and pollutants into the environment. These accounts, which are referred to as "hybrid accounts", do not modify the basic structure of the conventional SNA accounts. The linkage between physical and monetary information provided by hybrid accounts allows for the evaluation, through consistent indicators, of the impact on water resources of changes in the economy, e.g. changes in the economic structure, changes in interest rates etc. Using the hybrid accounts in economic models permit the analysis of possible trade-offs between alternative water and economic strategies. Hybrid accounts are presented in section B.

5.3. In a second step, economic accounts are compiled for water-related activities carried out for own use or as a secondary activity. Industries, as well as households may, for example, abstract water for own use or treat the wastewater they generate. In addition, industries may supply water as a secondary activity. Even though the value of these activities is likely to be small compared with the other activities of an enterprise, the full extent of national expenditures on water can be understood only when all these activities are accounted for. Economic accounts for ancillary and secondary activities related to water are described in section C.

5.4. Even though they are not explicitly discussed in this handbook, (stock) accounts (in physical and monetary units) for water-related infrastructures are included in the tables presented in this chapter. These accounts are already part of the conventional SNA, but additional data sources and data collection activities are often necessary to separately identify those assets in monetary terms in the standard national accounts as well as to obtain information on the physical characteristics of these structures (e.g. number, capacity, lifetime, etc.) These accounts assist in evaluating progress towards the Millennium Development Goals target 10 to halve, by 2015, the proportion of people without sustainable access to safe drinking water and sanitation, as the access depends on the infrastructure in place.

5.5. Users of water and water related products do not always bear the entire costs associated with the use; they benefit from transfers from other economic units (generally the government) which bear part of the costs. Similarly investments in infrastructures can also be partly financed by different units. The analysis of the financing of the use of water and water related products as well as investment provides information on how the expenditures are financed, by which agent and by means of which instrument (sales of services, environmental taxes, etc.). This information is relevant for assessing the implementation of the polluter/user-pay principle as it allows for the assessment of the portion of the total cost paid by the polluter/user. Section D presents tables to analyses the financing of water related expenditures.

5.6. Section E discusses how other monetary flows related to water, such as taxes and subsidies are recorded in the accounts. Section F presents some indicators that can be derived from the accounts and section H presents data sources for the compilation of these accounts.

B. Hybrid supply and use tables

5.7. Hybrid supply and use tables (SUT) juxtapose the standard SNA supply and use table with the corresponding physical tables, described in chapters 3 and 4. In so doing, the physical and monetary data share the same structure, classification and concepts. Physical information on (a) water abstraction, use and supply within the economy, returns into the environment; and (b) emission of pollutants is juxtaposed to the monetary supply and use tables. At finer levels of disaggregation, the hybrid accounting framework provides the scientific community with access to a structured database for further research to monitor the overall environmental-economic performance of national economies. In this way, hybrid accounts build a bridge between (aggregate) policy assessment and (underlying) policy research. (SEEA para 4.6.)

5.8. Hybrid accounts can be presented in different ways: one based on supply and use tables and the other on input-output tables. For a more general and extensive description of hybrid accounts, we refer to Chapter 4 of the SEEA-2003 (UN at al., 2003).

5.9. The starting point for hybrid SUT is the conventional SNA supply and use tables. As the term suggests, these tables record the value of the production (supply) and consumption (use) of products. The supply and use tables show, by row, products classified according to the Central Classification of Products (CPC) Ver. 2.0 (UN, 2006a). The industries are classified, by column, according to International Standard Industrial Classification of all Economic Activities, ISIC Rev. 4 (UN, 2006b).

5.10. Since hybrid SUT link physical and monetary information related to water, the supply and use tables explicitly identify only the water-related products which have associated a physical exchange of water. In particular, the following two products are identified in the tables:

- *Natural water* - CPC 1800, which is primarily associated with the output of the activity “Water collection, treatment and supply”, ISIC 36. In the monetary supply and use tables, natural water corresponds to the exchanges of water between economic units (mainly ISIC 36) and other economic units (industries, households, and rest of the world). Note that this class is very broad and it covers very different types of water exchanged in the economy, such as reused water.

- *Sewerage, sewage treatment and septic tank cleaning services* - CPC 941. This group include *Sewerage and sewage treatment services* (CPC 9411) and *Septic tank emptying and cleaning services* (CPC 9412). These services are primarily associated with the output of “Sewerage” industry, ISIC 37.

5.11. Other products related to water, even though they are not explicitly identified in the table, can be identified by the industry they are produced. For example, hydroelectric energy which is part of the class CPC 1710, is almost uniquely associated with the output of ISIC 35 - Electricity, gas, steam and air conditioning supply. The Operation of irrigation systems for agricultural purposes, which is part of CPC 86110 is primarily (and uniquely) associated with the output of "Support activities for crop production", ISIC 0161. Depending on data availability other products related to water could also be explicitly identified in the tables.

5.12. The industrial activities, classified according to ISIC Rev.4, are identified in the tables by column. The level of disaggregation of industries depends on the country situation and data availability, but at minimum the following activities which are relevant for the supply and use of water should be identified.

- *Agriculture* (ISIC 01), which is not only a major use of water but may also supply water through the activities of *Operation of agricultural irrigation equipment* (part of ISIC 0161).
- *Electricity, gas, steam and air conditioning supply* (ISIC 35) in particular, *Hydroelectric power generation, transmission and distribution* (part of ISIC 3510).
- *Water collection, treatment and supply* (ISIC 3600).
- *Sewerage* (ISIC 3700).

5.13. The output of these activities is associated with a physical flow of water. For this reason, they are particularly relevant in the hybrid SUT. Other activities related to water, such as *Remediation activities and other waste management services related to water* (part of ISIC 3900), and the *Administration of water related programmes* (part of ISIC 8412), are not explicitly identified in the hybrid SUT as there is no link with the physical flows of water. However, since it is important to identify the expenditures of those industries, economic accounts are compiled for these activities and are presented in section C.

Box 5.1: Disaggregation of activities in Sweden

In Sweden, the pricing system for water supply and wastewater services is so that there is one price for both services: enterprises and households are normally charged one fee related to the amount of water they use and the wastewater services they receive. The fact that expenditures for both water supply and wastewater services are combined together makes the disaggregation of the costs for each type of service very difficult.

Basic information on expenditures and revenues for public water and wastewater service is available in Sweden in the municipal accounts. These accounts are based on a yearly survey to all municipalities which are asked to report their revenues, investments and expenditures for different domains (e.g. for production of water and wastewater treatment). The statistics, however, are aggregated so that a division between data for municipal waterworks and municipal wastewater treatment plants is not possible.

Coefficients are used to disaggregate the combined expenditures between water supply activities and wastewater services. These coefficients are based on a supplementary source of information: the yearly statistics on tariffs (for an average household in a one-family building charged by each municipality) from the trade association for Swedish water utilities, the Swedish Water and Wastewater Association, Svenskt Vatten AB. These statistics provide information also on the percentage of the tariff that covers the cost for water and the percentage that covers the cost for wastewater treatment. These percentages are used as coefficients.

5.14. Note that in some countries activities of water supply (ISIC 36) and sewerage (ISIC 37) are carried out by the same establishment and no separate accounts are kept by the establishment thus making it difficult to separate information on the costs related to the two separate ISIC classes. To the extent possible, information should be disaggregated so as to show explicitly the costs and output of these activities. Additional information and estimation may be needed to separate these activities. For example, one may use the cost structure of a firm which is treating wastewater only and apply it to estimate the portion of the cost for treating wastewater in the case water and wastewater are produced in an integrated production process. Box 5.1 describes the methodology used in Sweden to calculate the accounts for ISIC 36 and 37 separately when the activities of collection, treatment and distribution of water are integrated with sewerage.

5.15. Table 5.1 shows the form of the standard hybrid supply table. It consists of three parts:

- *Monetary supply table.* It describes in monetary units the origin of products. This information is organized according to the conventional SNA supply table where products are shown in rows and the producers are presented in columns.
- *Physical supply table of water*. This information corresponds to the physical supply table described in chapter 3: it contains information on the volumes of water supplied to other economic units (row S1) and discharged (returns) into the environment (row S2).
- *Total emission of pollutants in physical units*. This information corresponds to the emission accounts described in chapter 4. For the sake of simplicity, Table 5.1 shows only gross emission, but information on net emissions could also be shown.

5.16. The monetary supply table in Table 5.1 presents by column the following information:

- Output (recorded at basic prices) by industries classified according ISIC, Rev. 4.
- Imports.
- Other items to derive the total supply at purchasers' prices: (i) taxes and subsidies on products and (ii) trade and transport margins. Trade and transport margins include trade margins plus any transport charges paid separately by the purchasers in taking delivery at the required time and place (SNA para. 15.40). In the case of water, transport margins are generally not separately invoiced and trade margins are often insignificant.

5.17. The bulk of the supply of Natural water (CPC 1800) and Sewerage services (CPC 941) appears in the columns corresponding to ISIC 01, 36, 37. There can be cases, however, when these water-related products are supplied, as a secondary activity, by other industries. In Australia, for example, the mining industries provide water to the towns close to the mining sites (ABS 2000, 2004).

5.18. Table 5.2 shows the format of a hybrid use table which consists of two part:

- *Monetary use table*. It provides information on the destination (use) in monetary units of products and, in particular, water-related products. The information is organized according to the conventional SNA use table where products are shown in rows and uses are presented by columns.
- *Physical use table*. This information corresponds to the physical use table described in chapter 3: it contains information on the volumes of water abstracted from the environment (row U1) and received by other economic units (row U2).

Table 5.1: Hybrid supply table

Physical and monetary units

	Output of industries (by ISIC categories)								Imports	Taxes on products	Subsidies on products	Trade and transport margins	Total supply at purchaser's price
			35										
	1	2-33, 41-43	Total	*of which*: Hydro	36	37	38,39, 45-99	Total output, at basic prices					
Total output and supply (monetary units)													
of which: Natural water (CPC 1800)													
Sewerage services (CPC 941)													
Total supply of water (physical units)													
S1 - Supply of water to other economic units													
S2 - Total returns													
Total (gross) emissions (physical units)													
Pollutants													

Note: Grey cells indicate zero entries by definition.

5.19. The monetary use table in Table 5.2 describes by column the use of products including water-related products in terms of: intermediate consumption, and final consumption, exports and gross capital formation.

5.20. **Intermediate consumption** by industries refers to the value of the goods and services consumed as inputs in production, excluding the using up of fixed assets, which is recorded as consumption of fixed capital in value added. Intermediate consumption is valued at purchaser's prices.

5.21. Final consumption is measured in Table 5.2 in terms of actual consumption rather than in terms of expenditures which is common practice in the 1993 SNA (see Box 5.2). This is done for the identification of the values of the goods or services delivered to households regardless of whether they are paid by households themselves or by government units or non-profit institutions serving households (NPISHs) through social transfers in kind.

5.22. Actual final consumption comprises the following two categories:

- **Actual final consumption of households** which includes the costs that households actually incur for the purchase of products (this corresponds to the concept of final consumption expenditure of households) and social transfers in kind from government and NPISHs. These transfers correspond to the final consumption expenditure incurred by NPISHs (all considered individual) and individual consumption expenditure of government.

- **Actual final consumption of government** which corresponds to its collective (as opposed to individual) consumption expenditures (SNA 15.82). This is the case, for example, of services provided by the government for the benefit of all members of the community or of the society as a whole in the sense that the consumption of one individual does not reduce the supply of the product to other individuals. Although collective services benefit the community, or certain sections of the community, rather than the government, the actual consumption of these services cannot be distributed among individual households, or even among groups of households such as sub-sectors of the household sector. It is therefore attributed to the same government units that incur the corresponding expenditures. (SNA para. 9.91). In the case of water, administrative services of water control and water quality monitoring are examples of services provided to the community as a whole and their use is attributed to the government as a collective consumer.

5.23. Recording final consumption in terms of actual final consumption is to reflect the fact that often water related services are not purchased directly by households, but are provided to them by government and NPISHs free or almost free of charge. Actual consumption measures the value of the water related services received. Thus it is consistent with the physical flow of water used.

5.24. Actual final consumption is also useful for the analysis of the cost recovery of water related services. It shows the total cost of water supply, the portion of the cost incurred by households and that incurred by the government and NPISHs. Section D of this chapter discusses more in detail the financing of water-related expenditures, including those incurred by households.

5.25. **Gross capital formation** (GCF) is the sum of the value of gross fixed capital formation, changes in inventories and acquisitions less disposals of valuables for a production unit or an institutional sector. It is included in the table at the aggregated level for consistency of presentation with the SNA tables to show the basic identity that supply equals use.

5.26. **Exports** consist of sales of products from residents to non-residents.

Table 5.2: Hybrid use table

Physical and monetary units

	Intermediate consumption of industries (by ISIC categories)								Actual final consumption				Capital formation	Exports	Total uses at purchaser's price
			35						Households			Government			
	1	2-33, 41-43	Total	*of which*: Hydro	36	37	38,39, 45-99	Total industry	Final consumption expenditures	Social transfers in kind from Government and NPISHs	Total				
Total intermediate consumption and use (monetary units)															
of which: Natural water (CPC 1800)															
Sewerage services (CPC 941)															
Total value added (monetary units)															
Total use of water (physical units)															
U1 - Total Abstraction															
of which: a.1- Abstraction for own use															
U2 - Use of water received from other economic units															

Note: Grey cells indicate zero entries by definition.

Box 5.2: From final consumption expenditure to actual final consumption

In the conventional SNA use table (table 15.1 of the 1993 SNA) final consumption is recorded in terms of *final consumption expenditure* instead of *actual final consumption*. The table below shows how to obtain information on actual final consumption from the conventional SNA use table. Final consumption expenditure is attributed to the units (households, NPISHs and government) who ultimately bear the costs. In addition, government final consumption expenditure is further subdivided between expenditure incurred by the general government on individual consumption products and on collective consumption services.

Actual final consumption in the hybrid use table is obtained by reorganizing the columns of final consumption expenditures as shown in the following table.

Final Consumption recorded in the SNA use table

	Final consumption expenditures				
			Government		
	Households (a)	NPSHIs individual (b)	Collective (c)	Individual (d)	Total (a)+(b)+(c)+(d)
Total use of products					

⇒

Final consumption recorded in water accounts

Actual Consumption			
Households			
Final consumption expenditures (a)	Social transfers in kind from Government and NPISHs (b)+(d)	Government (c)	Total (a)+(b)+(c)+(d)

C. Economic accounts

1. Hybrid account for supply and use of water

5.27. From the hybrid supply and use tables, presented in Table 5.1 and Table 5.2, the hybrid accounts for the supply and use of water can be compiled. It is presented in Table 5.3 and provides information by industry on the output produced, including water-related output, the intermediate consumption, including the costs of purchasing water and sewerage services and value added. These economic accounts form the basis for the calculation of a consistent set of hydro-economic indicators (see section F).

Table 5.3: Hybrid account for supply and use of water

Physical and monetary units

	Industries (by ISIC categories)									
			35							
	1	2-33, 41-43	Total	*of which*: Hydro	36	37	38,39, 45-99	Total industry	Households	Rest of the world
1. Total output and supply (monetary units)										
of which: Natural water (CPC 1800)										
Sewerage services (CPC 941)										
2. Total intermediate consumption and use (monetary units)										
of which: Natural water (CPC 1800)										
Sewerage services (CPC 941)										
3. Total value added (gross) (= 1-2) (monetary units)										
Gross fixed capital formation for water-related infrastructure (monetary units)										
Total use of water (physical units)										
U1 - Total Abstraction										
of which: a.1- Abstraction for own use										
U2 - Use of water received from other economic units										
Total supply of water (physical units)										
S1 - Supply of water to other economic units										
S2 - Total returns										
Total (gross) emissions (physical units)										
Pollutants										

Note: Grey cells indicate zero entries by definition.

5.28. Information on gross fixed capital formation for water-related infrastructure represents investments in fixed capital related to water (infrastructure). When calculated for households, it includes to the acquisition of septic tanks, the installation of pumps, wells etc. These are classified in the national accounts as improvements on dwellings.

5.29. Note that activities are classified regardless of the kind of ownership, type of legal organization or mode of operation. Therefore, even though activities for water collection, treatment and supply (ISIC 36) and sewerage (ISIC 37) are carried out by the government (as it is often the case), they should be classified to the extent possible in the specific classes (ISIC 36 and 37) and not in ISIC 84 – Public administration.

5.30. When information is available, the producing units could be further disaggregated according to the type of institutional sector that owns them (government, corporation and household). This information can be useful to assess, for example, the degree of involvement of the government in water supply or wastewater sanitation.

5.31. To enhance the analytical capacity of the accounts, the accounts can be augmented with supplementary information on specific aspects related to water. Table 5.4 presents an example of additional information to be presented side-by-side with the monetary accounts. Some of the variables included in Table 5.4 are already part of the national accounts, (e.g. closing stocks of water-related infrastructure and labour input), others are more linked to the social dimension of water.

5.32. Information on the labour input may be important to analyse the impact on employment of water allocation policies; similarly, information on access to water and sanitation may be used to evaluate policy reforms and structural changes. Given the policy relevance of indicators on access to water and sanitation (Target 10 of the Millennium Development Goals) and their link to the monetary information presented in the accounts, a supplementary table presenting these indicators is included below Table 5.4.

Table 5.4: Economic accounts - supplementary information

	Industry (by ISIC categories)								
			35						
	1	2-33, 41-43	total	*of which*: hydro	36	37	38,39, 45-99	Total industry	Households
Fixed capital of water-related infrastructures									
Closing stocks of fixed assets									
Labour input									
Number of workers									
Total hours worked									

Note: Grey cells indicate zero entries by definition.

Access to water and sanitation
Proportion of population with sustainable access to an improved water source, urban and rural
Proportion of population with access to improved sanitation, urban and rural
Total population

2. Economic accounts for collective consumption of government

5.33. For analytical purposes and, in particular for compiling the table of financing, it is useful to develop economic accounts for collective consumption of the government expenditures for water-related activities. These are classified according to the Classification of the Functions of Government (COFOG) (UN, 2000b).

5.34. The following groups of COFOG are relevant for water:

- *Wastewater management* - COFOG 05.2. This group covers sewage system operation and waste water treatment. Sewage system operation includes management and construction of the system of collectors, pipelines, conduits and pumps to evacuate any waste water (rainwater, domestic and other available waste water) from the points of generation to either a sewage treatment plant or to a point where waste water is discharged to surface water. Wastewater treatment includes any mechanical, biological or advanced process to render waste water fit to meet applicable environment standards or other quality norms.

- *Soil and groundwater protection* – part of COFOG 05.3. It covers activities relating to soil and groundwater protection. These activities include construction, maintenance and operation of monitoring systems and stations (other than weather stations); measures to clean pollution in water bodies; construction, maintenance and operation of installations for the decontamination of polluted soils and for the storage of pollutant products.

- *Environmental protection not elsewhere classified* (n.e.c.) (related to water) – part of COFOG 05.6. This group, with focus on water, cover administration, management, regulation, supervision, operation and support of activities such as formulation, administration, coordination and monitoring of overall policies, plans, programmes and budgets for the promotion of environmental protection; preparation and enforcement of legislation and standards for the provision of environmental protection services; production and dissemination of general information, technical documentation and statistics on environmental protection. It includes environmental protection affairs and services that cannot be assigned to the previous classes (05.1), (05.2), (05.3), (05.4) or (05.5).

- *Water supply* – COFOG 06.3. This group covers (i) administration of water supply affairs; assessment of future needs and determination of availability in terms of such assessment; supervision and regulation of all facets of potable water supply including water purity, price and quantity controls; (ii) construction or operation of non-enterprise-type of water supply systems; (iii) production and dissemination of general information, technical documentation and statistics on water supply affairs and services; (iv) grants, loans or subsidies to support the operation, construction, maintenance or upgrading of water supply systems.

5.35. Table 5.5 presents economic accounts for collective consumption of the government expenditures for water-related activities. They can be further disaggregated for central, state and local government. This table serves as input in the compilation of the table on financing in section D.

Table 5.5: Economic accounts for collective consumption of government

monetary units

	Government (ISIC 84) (by COFOG categories)			
	05.2 Wastewater management	05.3 (part) Soil and groundwater protection	05.6 Environmental protection n.e.c.	06.3 Water supply
1. Total output				
2. Intermediate consumption				
3. Value added (gross) (= 1-2)				

3. Hybrid accounts for secondary and ancillary activities

5.36. The accounts presented in this section explicitly identify the intermediate costs and output of water-related activities when they are carried out by industries other than water supply and sanitation and households either for own use or for distribution. To assess the contribution of water-related activities to the economy, the output and the costs of water-related activities have to be separately identified. Hybrid accounts are compiled for activities of:

- Water collection, treatment and supply (ISIC 36),
- Sewerage (ISIC 37) and
- Remediation activities related to water (part of ISIC 39).

Only the hybrid accounts for the Sewerage industry (ISIC 37) are presented in Table 5.6. The accounts for the other activities look exactly the same. For this reason, they are not presented in a tabular form.

5.37. The SNA makes a distinction between activities carried out as primary, secondary or ancillary activities. The *principal activity* of a producer unit is the activity whose value added exceeds that of any other activity carried out within the same unit. A *secondary activity* is an activity carried out within a single producer unit in addition to the principal activity and whose output is for sale or intended to be for sale. In the SNA, secondary activities are generally separated from the principal activity. In addition to primary and secondary activities, a producer unit can undertake activities to facilitate its principal or secondary activities. These activities are carried out for own use and are called ancillary activities.

5.38. In the 1993 SNA, ancillary activities are not explicitly recorded: their cost structure and value of the output are incorporated into those of the principal or secondary activities with which they are associated. However, the update of the 1993 SNA[14], 1993 SNA Rev. 1, will recommend that ancillary units whose production costs and associated fixed assets are identifiable, be considered as separate production units forming a new establishment. The output of these units is measured at cost including capital services from fixed assets.

5.39. In the case of water abstraction and supply, there may be economic units which carry out water-related activities as a secondary activity in addition to their principal activity. The case, for example, of the mining industry in Australia which sells water as a secondary activity. Secondary activities are separated when their cost structure is distinct from that of the principal activity, and they are reclassified under the relevant ISIC category. In the example of the mining industry, if there are separate cost structures, the secondary activity of water supply would be classified under ISIC 36 and not ISIC 09.

5.40. It is very common in the case of water-related activities, that economic units carry out abstraction or wastewater treatment for own use. This would be the case of a farmer who may abstract water directly from the environment for irrigation purposes; electric power plants or other industrial establishments which may abstract directly water for their own use, etc. The same applies to wastewater treatment: enterprises and households may operate their own wastewater treatment facilities (industrial wastewater treatment plants, septic tanks, etc.). The costs associated with these activities do not explicitly appear in the accounts described in the previous section as they are incorporated with those of the principal activity.

5.41. The SEAW goes a step further as compared to the 1993 SNA Rev. 1 as it recommends, in line with the SEEA-2003, the externalisation of ancillary activities related to water even in the case in which it is not possible to identify them as separate production units. The method of identifying ancillary activities from the primary and secondary production activities is called “externalisation of ancillary activities”. An example on how to externalise these activities is provided in Box 5.3.

[14] The 1993 SNA is in the process of being updated. International agreement on the treatment of many issues has been reached. The treatment of ancillary activities is one of them.

Box 5.3: Externalisation of ancillary activity

The accounting method to record the output of ancillary activities is called 'externalisation'. Although this increases the total output of the economy, it does not modify the value added and hence the Gross Domestic Product (GDP), as this output (of ancillary activities) is offset by a corresponding intermediate (self)-consumption.

Suppose a firm purchases goods and services to the value of 1,000 to manufacture its output which it sells for 1,800. The cost of the compensation of employees is 500, consumption of fixed capital is 100 and operating surplus is 200. The standard production and generation of income account entries then appear as follows.

Uses		Resources	
Intermediate consumption	1 000	Output	1 800
Value added	*800*		
Compensation of employees	500		
Consumption of fixed capital	100		
Net operating surplus	200		
Total inputs (= total output)	1800		

Now suppose that the firm also abstracts water for its own use, the cost of abstracting water includes 100 for intermediate goods and services, 40 for compensation of employees, and 5 for consumption of fixed assets used in water abstraction. The accounts will appear as follows.

Uses	Other output	Water abstraction	Total	Resources	
Intermediate consumption				Output	
Others	900	100		- other	1 800
Water	145			- Water	145
Total	1 045	100	1 145	- Total	1 945
Value added	*755*	*45*	*800*		
Compensation of employees	460	40	500		
Consumption of fixed capital	95	5	100		
Net operating surplus	200	0	200		
Total inputs	1800	145			

The total cost of water abstraction is 145 (by convention, the output of ancillary service is the sum of costs, with zero net operating surplus). Both the value of output and the total intermediate consumption of the establishment increase by 145 but the value added and all the entries of the generation of income account are unchanged in total. At the economy-wide level, GDP and other macro-aggregates are unaltered. However, it is now possible to treat the water production activity exactly as if a separate establishment had been formed with these costs.

Source: Adapted from SEEA-2003

5.42. Table 5.6 presents the hybrid account for secondary and ancillary activities of Sewerage (ISIC 37). Similar accounts can be compiled for activities of Water collection, treatment and supply (ISIC 36) and remediation activities related to water (part of ISIC 39). Secondary and ancillary activities of sewerage are shown under the ISIC class of the principal activity but are explicitly identified. This presentation is consistent with the way information is organized in physical terms (as presented in chapters 3 and 4). The table links, for example, the cost of abstraction by industry to the volumes of water abstracted, the cost of treating wastewater with the volume of wastewater and the emission generated etc.

5.43. If a manufacturing industry (ISIC 17) treats wastewater on-site before discharging it to the environment, the activity of treating water is ancillary and is recorded under ISIC 17 in Table 5.6.

5.44. Table 5.6 includes also households as they may abstract water directly from the environment and often carry out activities of wastewater treatment through the use, for example, of septic tanks.

Table 5.6: Hybrid account for secondary and ancillary activities of sewerage

Physical and monetary units

	Industries (by ISIC categories)						
	1		…	Total industry			
	ISIC 37 as Secondary activity	ISIC 37 as Ancillary activity		ISIC 37 as Secondary activity	ISIC 37 as Ancillary activity	Own produced-consumed households	Total
1. Total output and supply (monetary units)							
of which: Sewerage services (CPC 941)							
2. Total intermediate consumption and use (monetary units)							
of which: Sewerage services (CPC 941)							
3. Total value added (gross) (= 1-2) (monetary units)							
Gross fixed capital formation for water-related infrastructure (monetary units)							
Total use of water (physical units)							
U1 - Total Abstraction							
of which: a.1- Abstraction for own use							
U2 - Use of water received from other economic units							
Total supply of water (physical units)							
S1 - Supply of water to other economic units							
S2 - Total returns							
Total (gross) emissions (physical units)							
Pollutants							

5.45. The supplementary information presented in Table 5.4 applies also to Table 5.6.

5.46. The information required for Table 5.6, in the case of secondary and ancillary activities, is likely not to be readily available in many countries. Specific surveys have to be put in place in order to estimate the costs associated with the secondary and ancillary activity of water collection, treatment and supply. Information on physical quantities of water abstracted and average costs could be used to populate the table as first step in the compilation of the table.

5.47. In the case of ancillary activities of wastewater treatment, information is generally available from established specific data collection systems such as national environmental protection expenditure surveys and other sources on environmental expenditure. Some of these sources may not provide all variables. For example, compensation of employees, intermediate consumption and taxes on production may only be available as a sum of 'current expenditure'; data on consumption of fixed capital may not be available directly and will have to be estimated using established national accounts procedures.

D. Financing

5.48. Users of water-related products do not always bear the entire costs of production. In the case of water, it is not uncommon for users to benefit from transfers from other units (generally the government). These transfers include subsidies on the production of water-related products, investment grants and other transfers that are financed either from government budgets or from specific taxes. This section describes the financing of national expenditures by identifying the financing sector (e.g. which sector is providing the financing) and the beneficiaries (e.g. which units benefit from the financing), as well as how much is being financed.

5.49. The financing table presented in Table 5.8 can be compiled for specific economic activities related to water such as Water collection, treatment and distribution (ISIC 36), Sewerage (ISIC 37) and

Remediation activities related to water (part of ISIC 39) as well as for environmental activities defined according to their purposes. Examples of activities defined according to their purposes are described in Box 5.4 and include: (i) environmental protection activities and (ii) natural resource management and exploitation expenditures. For illustration purposes, the financing table shown in this section refers to the activities of Sewerage that is collection, treatment and discharge of wastewater. Similar tables can be constructed for the other activities

Box 5.4: Environmental activities by purpose

Environmental protection expenditures are expenditures made by the economy for the protection of the environment. The term environmental protection groups together all actions and activities that are aimed at the prevention, reduction and elimination of pollution as well as any other degradation of the environment. This definition implies that, in order to be considered environmental protection, activities, or parts thereof, must satisfy the primary purpose criterion (causa finalis), i.e. that environmental protection is their prime objective. Actions and activities which have a favourable impact on the environment but which serve other goals are not classified as environmental protection.

In particular, in the domain of water resources, activities for wastewater management and for the protection and remediation of soil, groundwater and surface water are considered for the protection of the environment and are part of the Classification of Environmental Protection Activities and Expenditure (CEPA). *Wastewater management* is an activity identified within ISIC: it includes *Sewerage*, ISIC 37 (which includes the operation of sewer systems or sewage treatment facilities that collect, treat, and dispose of sewage) and *Remediation activities and other waste management services*, ISIC 39. A detailed description of environmental protection expenditure accounts (EPEA) can be found in the manuals of Eurostat (Eurostat 2002a, 2002b) and in the SEEA-2003 (UN et al. 2003)

Water management and exploitation expenditures. Management activities include research into management of natural resources, monitoring, control and surveillance, data collection and statistics, costs of the natural resource management authorities at various levels as well as temporary costs for facilitating structural adjustments of sectors concerned. Activities and transactions specifically for environmental protection are not included (they are included under environmental protection expenditure activities). In the case of water resources, water management activities include administration of water ways and water bodies, supervision, research, elaboration of plans and legislation, water policy. Exploitation activities include abstraction, harvesting and extraction of natural assets including exploration and development. In general, these accounts typically correspond to the standard economic accounts for various natural resource-related industries such as fisheries, forestry, mining and water supply (based on the SEEA-2003 paras. 5.39-5.41). In the case of water resources, water exploitation activities include exploration, abstraction, storage, treatment, and distribution.

5.50. The financing table presented in this section is based on that developed by Eurostat for environmental protection expenditure accounts (EPEA) (Eurostat 2002a, 2002b). However, some simplifications have been introduced, notably specific transfers such as implicit subsidies have been excluded on the ground that they are often relatively small as compared to the other entries in the table. It should be noted that the compilation of the financing table requires the compilation of the tables presented in sections B and C.

5.51. The starting point for compilation of the financing table is the identification of national expenditure. National expenditure for sewerage services (CPC 941 –sewerage, sewage treatment and septic tank cleaning services) consists of the sum of the following items:

- Sewerage services (CPC 941) (except by ISIC 37 to avoid double counting) which are used for intermediate and final consumption.
- Gross capital formation for the provision of the sewerage services and net acquisition of land. This corresponds to the investments made by the producers for collecting, treating and discharging wastewater.

5.52. When compiling environmental protection expenditure accounts, the national expenditure include also expenditures for the use of products which are specific for the protection of the environment. These products are referred to as adapted and connected products. Connected products are products whose use by resident units directly and exclusively serves an environmental protection objective but which are not environmental protection services produced by an environmental protection activity. Adapted (or 'cleaner') products are defined (SERIEE § 2026) as products that meet the following criteria: (a) on the one hand, they are less polluting when consumed and/or disposed than equivalent normal products. Equivalent normal products are products that provide similar utility, except for the impact on the environment. (b) on the other hand, they are more costly than equivalent normal products. Only the extra cost paid in order to make an adapted product available to the user is considered as environmental protection expenditure in the EPEA. In the case of water, septic tanks are an example of connected products.

5.53. In Table 5.7, national expenditure on sewerage services are allocated by column to specialised and other producers and final consumers. Expenditure by specialised producers (which, in this case, correspond to ISIC 37) includes investment for the production of sewerage services. Other producers use sewerage services as intermediate consumption (this includes also services produced for own use), invest in capital products and acquisition of land for generating sewerage services as secondary and ancillary activity. They could also use adapted and connected products. Expenditure by households and government corresponds to their actual consumption.

5.54. The information in Table 5.7 can be derived from the tables presented in section C with the exception of the financing from the rest of world which have to be collected.

Table 5.7: National expenditure on sewerage services

monetary units

	USERS/BENEFICIARIES					
	Producers		Final consumers			
	Specialised producers (ISIC 37)	Other producers	Households	Government	Rest of the world	Total
a. Sewerage services (CPC 941)						
Final consumption						
Intermediate consumption						
b. Gross Fixed Capital Formation and land						
c. Total domestic uses (=a.+b.)						
d. Financed by the rest of the world						
e. National expenditures (=c.-d.)						

5.55. The entry 'total domestic uses' is an intermediate aggregate from which national expenditure is obtained by subtracting the financing from the rest of the world. This financing consists of international aid for the use of sewerage services and related products.

5.56. Table 5.8 presents the financing table for sewerage services and related products. By column different categories of beneficiaries are identified: they correspond to those in Table 5.7. By row national expenditure is disaggregated according to the financing units (those actually bearing the cost) which are classified according to the institutional sectors of the national accounts: general government (which can be further disaggregated in central and local government), non-profit-institutions serving households (NPISHs), corporations, and households. The table shows how the national expenditure of the users/beneficiaries is financed.

5.57. The expenditures recorded in the first column (specialised producers) correspond to their gross fixed capital formation and land (their investments in infrastructures). Entries in the table describe how these investments are financed. In general, the producers finance their own gross fixed capital formation and land. However, the government may finance, through investment grants, a part of the capital formation of specialised corporations.

5.58. Expenditure recorded in the second column corresponds to the total of *intermediate consumption* of sewerages services including those produced by ancillary activities and connected and adapted products plus their investment in infrastructure and land for secondary and ancillary activities. In general, producers of sewerage services as ancillary and secondary activity finance themselves their intermediate consumption and capital formation.

Table 5.8: Financing of sewerage services and related products

monetary units

	USERS/BENEFICIARIES					
	Producers		Final Consumers (Actual consumption)			
FINANCING SECTORS:	Specialised producers (ISIC 37)	Other producers	Households	Government	Rest of the world	Total
General government						
NPISHs						
Corporations						
Specialised producers						
Other producers						
Households						
National expenditure						
Rest of the world						
Domestic uses						

5.59. The expenditures recorded for households correspond to their actual final consumption of environmental protection services and adapted and connected products as well as any transfers they benefit from. Entries in the column describe how this expenditure is financed. In general, households finance their final consumption themselves. However, there are two exceptions:

- Government finances the part of household consumption that takes the form of government expenditure on individual consumption goods and services. For example, where the government provides a grant (or rebate) for the purposes of installing water saving devices, such as reduced flow showerheads or dual-flush toilets.
- Government finances the subsidies that lower the price of environmental protection services or products. For example, governments may subsidise sewerage providers, thus lowering the cost of sewerage provision to households that use this service. However, when subsidies originate in earmarked taxes it is assumed that the units that pay the taxes (in general households and other producers) are the financing units.

5.60. The expenditures of the government as a collective consumer correspond to its expenditure on collective consumption services. In general, this expenditure is financed by the government from the general budget. It may happen that receipts from earmarked taxes fund some of government's provision of collective consumption services. In this case the collective services are financed by the sectors that pay the earmarked taxes. Revenues from sales of non-market services (partial payments) are not accounted in the column of government as the part of non-market output covered by partial payments does not come under collective services in the first place.

5.61. The expenditures recorded in the column of the rest of the world correspond to the transfers paid for international co-operation for environmental protection. These transfers can be financed either by the government or by households, through NGOs.

E. Taxes, fees and water rights

5.62. The issue of treatment of permits and license in the update of the 1993 SNA is currently under discussion. This section will be included in the handbook as soon as agreement is reached. Standard tables will be added.

F. Derived indicators

5.63. This section presents examples of indicators which can be derived from the monetary accounts. The first set of indicators is based on the hybrid accounts linking quantities of water used to some economic characteristics of the sector, the second is based on expenditures. This section also shows how countries have disseminated the indicators derived from the accounts. More indicators that can be derived from the accounts are presented in chapter 9.

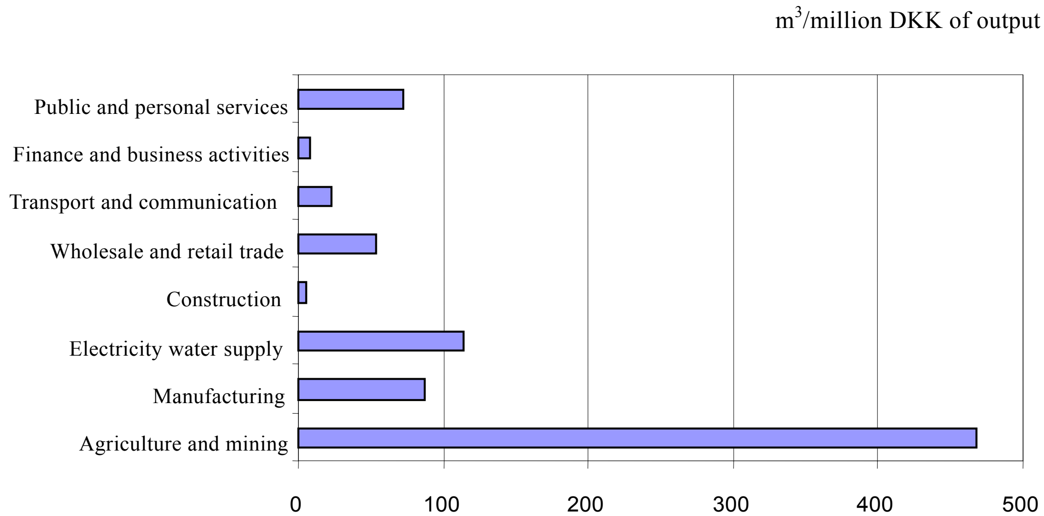
1. Indicators of water use intensity/productivity per industry

5.64. Indicators of water use intensity/productivity by sector provide information on the efficiency of water use. They provide therefore an important input when designing policies of strategic allocation of water. The economic characteristics considered most frequently in indicators of water use intensity/productivity are output, value added or number of employees. Depending on the type of analysis, these indicators may also only consider the volume of water abstracted instead of total volume water used by industry or even focus on specific uses. Water use intensity is generally defined as the ratio of the volume of water used and value added:

$$\text{Water use intensity} = \frac{\text{Volume of water used}}{\text{Value added}}$$

5.65. Figure 5.1presents an example of water use intensity for Denmark: it shows how the water supplied by ISIC 36 is used by different industries.

Figure 5.1: Water use intensity of tap water, Denmark in 2001, 1995-prices



Source: Statistics Denmark (2001) (publication in Danish)

5.66. The indicator of water productivity is similar to the "productivity" indicators used in economic analysis (e.g. capital productivity, labour productivity). It measures how much value added is generated by one unit of volume of water used. It is the reciprocal of water intensity, namely:

$$\text{Water use productivity} = \frac{\text{Value added}}{\text{Volume of water used}}$$

5.67. Table 5.9 presents a comparison of Gross Value Added (GVA) per unit of water used in Botswana, Namibia and South Africa. The differences in water productivity among the countries occur in all sectors: more income is generated for each sector in Botswana than either of the other countries. Of course, among countries that differ in water scarcity, one would expect to see such differences in water use. Where water is abundant, there is less environmental need to conserve it (although the economic argument to maximize the resource output remains valid).

Table 5.9: Water productivity by industry in Botswana, Namibia, and South Africa, 1996

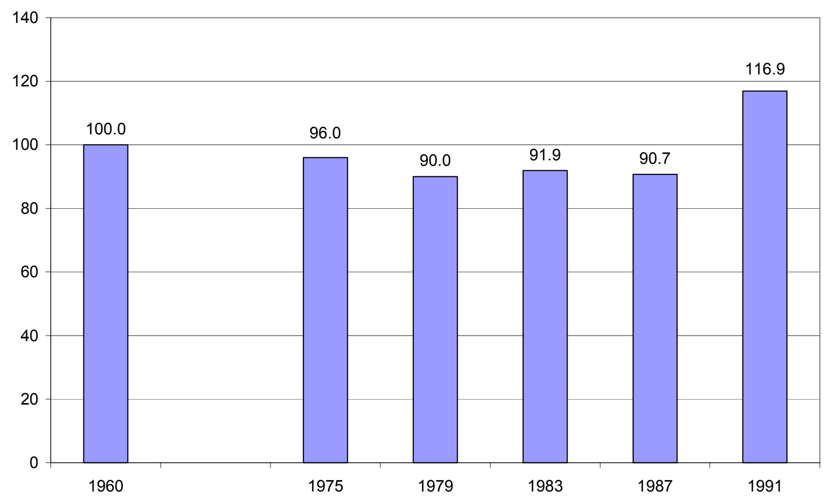
	(Pula per cubic meter of water used)		
	Botswana	**Namibia**	**South Africa**
Agriculture	9	6	2
Mining	420	54	44
Manufacturing	437	189	98
Trade, Services, Government	724	542	302
GVA per m^3 of water input	**124**	**45**	**20**

Note: the figures in Rand for Namibia and South Africa were converted to the Pula at a rate of 0.75 Pula per Rand.
Source: Lange and Hassan, 1999 and Table 5.

5.68. Figure 5.2 presents an example of how water productivity has changed over time in Germany. In the former territory of the Federal Republic of Germany, the annual abstraction of water more than doubled during the 1960 to 1991 period (increasing from 20.6 to 45.9 billion m^3). The bulk of this increase actually occurred before 1979. In terms of water productivity, it declined until 1979 which means that during this period, the water use rose more rapidly than the economic output. From 1979 to 1987 water productivity remained practically steady, and then it sharply increased in 1991.

5.69. After the reunification of the country (period not presented because of the induced break in the series), water productivity further increased another 10% between 1991 and 1995 (with abstractions declining). This gain was due to a strong rationalisation of water use: low consuming domestic equipment, re-use of water within the industries, replacement of water by other materials in certain processes and decrease in the volume of irrigation water in the new Länder.

Figure 5.2: Water productivity index, Germany (base 100 in 1960)



Source: Water flow accounts as part of material and energy flow accounts in Germany – Statistisches Bundesamt- 2000

2. Indicators of expenditures

5.70. Table 5.10 shows expenditure for environmental protection of water within the OECD. The table also displays which units in the country are the major contributors to these expenditures: public business sector and private households. Within a country, such comparisons can be undertaken at the level of the river basins.

5.71. An important indicator that should be built from the expenditure account is the rate of recovery of the costs of water services. The expenditure accounts help in the assessment of the costs and of their financing. They provide information on who finally pays for part of these costs (market water services), while the physical supply and use tables and the emission accounts will provide information on who should pay in case of a strict application of the polluter-pays principle.

Table 5.10: Investment and current expenditure in Sewerage and Remediation activities for water

		Public sector			Business sector			Private households	
Country	**Year**	**in US$ per capita***	**‰GDP**	**‰GFCF**	**in US$ per capita***	**‰GDP**	**‰GFCF**	**in US$ per capita***	**‰PFC**
Canada	1990	55.3	3.0	9.9	19.7	1.1	2.9	..	..
United States	1992	96.8	4.2	11.8	50.5	2.2	5.8	..	..
Australia	1991	44.2	2.7	12.2	..	..	..	4.1	0.4
Japan	1990	..	..	..	..	..	0.7	..	..
Austria	1991	142.1	8.2	16.9	78.1	4.5	8.5	0.3	..
Denmark	1991	56.6	3.3	10.1	..	..	..	..	..
Finland	1992	..	..	..	36.2	2.4	6.2	..	..
France	1992	86.1	4.5	9.3	23.7	1.2	1.6	11.3	1.0
Germany	1990	86.3	5.5	17.2	36.9	2.3	3.3	..	..
Italy	1989	29.5	1.9	7.9	12.8	0.8	2.1	..	..
Netherlands	1992	91.8	5.2	7.5	48.0	2.7	6.6	..	..
Portugal	1991	28.6	2.8	9.7	..	..	1.7	..	..
Spain	1991	45.8	3.6	8.6	..	..	..	..	..
Sweden	1991	63.2	3.8	8.6	..	..	4.6	..	..
Switzerland	1993	103.2	4.5	7.9	30.4	1.3	3.0	45.0	3.3
United Kingdom	1990	11.1	0.7	1.0	80.8	5.1	13.6	..	..

* at current purchasing power parities

Source: OECD PAC Expenditure – OECD – 1996.

3. Financing of expenditure for sewerage and remediation activities for water in Australia

5.72. Australia has compiled national environmental protection expenditure accounts, a component of which provides information on the financing of wastewater and water protection services.

5.73. Table 5.11 presents the financing of national expenditure on sewerage (ISIC 37) and remediation activities (ISIC 39) by sector, taking into account subsidies, grants and other transfers whenever it was possible to identify them. It was not possible to identify some transfers – these are shown as "not available" (n.a.) in the table.

Table 5.11: Financing of national expenditure for sewerage and remediation activities for water, Australia 1996-97

	Specialised producers	Other Producers	Consumers			
Financing units	Total *(AUD$'000)*	Total Industries *(AUD$'000)*	National [(a)] *(AUD$'000)*	State [(a)] *(AUD$'000)*	Households [(b)] *(AUD$'000)*	Total *(AUD$'000)*
General government						
National	10	n.a.	4 222	4 476	n.a.	8 708
State	23 827	n.a.	2 596	196 782	n.a.	223 205
Local	80 568	n.a.	-	-	n.a.	80 586
Total	**104 424**	**9 397**	**6 818**	**201 258**	**n.a.**	**321 060**
Corporations						
Environment protection industries	288 529	-	n.a.	n.a.	n.a.	288 529
Other producers	n.a.	647 761	n.a.	n.a.	n.a.	655 798
Total	**291 500**	**647 761**	**n.a.**	**n.a.**	**n.a.**	**947 298**
Households	..	..	n.a.	n.a.	1 749 900	1 749 900
National expenditure	**395 924**	**664 359**	**6 818**	**201 258**	**1 749 900**	**3 018 259**

(a) General government as collective consumer. Not collected for local government.
(b) Households as actual consumers.
Note: Sums will not necessarily equal totals as some of the breakdown was not available.
Source: Environment Protection Expenditure Australia, 1995-96 and 1996-97 (ABS cat. no. 4603.0)

5.74. The table shows that in Australia in 1996-97 households financed AUD$1750 million or 58% of total expenditure in this area. The bulk of this was paid as charges for sewage services provided by specialist producers, with very small amounts paid for septic systems (on-site treatment and storage) and urban storm water drainage. In Australia NPISH are not separated from households. The data in Table 5.11 is a rearrangement of other data presented on environmental protection expenditure published in Environment Protection Expenditure Australia, 1995-96 and 1996-97 (ABS cat. no. 4603.0) by ABS.

G. Data sources and methods

5.75. The monetary accounts presented in this chapter are an elaboration of the standard accounts presented in the 1993 SNA. The national accounts tables, if compiled at a sufficient level of detail, already include information on water collection, treatment and supply (ISIC 36) and sewerage industry (ISIC 37). Nevertheless, the compilation for example on secondary and ancillary activities as well as on financing often requires ad-hoc data collection. Data sources for compiling the tables in this chapter include special surveys and administrative data.

5.76. Specialized producers of water collection, treatment and supply (ISIC 36) and sewerage industry (ISIC 37) are surveyed on a regular basis. Through these surveys, the following variables are generally collected: sales by product according to CPC, intermediate consumption, compensation of employees, taxes paid on production, subsidies received for production, investments, employment, etc.

5.77. Surveys of producers of other classes of the ISIC could also be useful. Although the principal activity of these producers is not collection, treatment and supply of water or sewerage, they may produce these services as secondary output. Specific environment industry surveys can provide useful data on secondary output of these services as well as data on producers of equipment and facilities specific to water-related products (e.g. pipes for sewage systems, pumps, etc.) which constitute a source of data for the assessment of gross fixed capital formation on water-related products and assets.

5.78. As concerns ancillary activities, specific surveys are the main data source. These surveys provide data on investments made for the installation of equipment to abstract water and treat wastewater. Data from business associations and engineering estimates could also be a useful data source.

5.79. Government is often plays a major role in financing water supply and sewerage activities. The detailed analysis of government budgets, in particular of central, state and city, as well as government finance statistics can provide a considerable amount of information needed to compile the monetary tables.

5.80. If government finance statistics do not provide enough detail, the results of surveys of municipalities or associations of municipalities may provide data on e.g. waste and wastewater collection and treatment activities. These data may cover various variables, from the physical quantities to the prices, and the inputs used, including installations and facilities and investment.

5.81. Annual reports of government agencies dealing with water issues provide data on the activities and outlays of these agencies, as well as their receipts (either from central or local government budgets or from specific environment-related taxes, charges or fees) and the flows of funds to other units (subsidies, capital grants and other transfers).

5.82. Household surveys may constitute a source for assessing the consumption expenditure of households for waste and wastewater collection and treatment services. Expenditure on connected and adapted products (e.g. emptying services for septic tanks, etc.) will rarely be surveyed and may be estimated based on production statistics, market analysis or specific studies. The annual reports of the main non-profit institutions dealing with water issues may provide information on their activities, expenditure and receipts. Data on their financing by government may also be available.

5.83. Various other sources allow complementing the previous data. Examples are construction statistics (investments in sewerage systems, wastewater treatment plants, etc.).

Chapter 6 The asset accounts

A. Introduction

6.1. This chapter links the information on the abstraction and discharge of water with information on the stocks of water resources in the environment in order to assess how current levels of abstraction and discharges affect the stocks of water. This chapter focuses only on the quantitative assessment of the stocks and the changes in stocks which occur during the accounting period. The qualitative characteristics of the stocks are dealt with in the quality accounts presented in chapter 7. The monetary description of the assets of water resources is not dealt in this chapter: as yet there are no standard techniques to assess the economic and non-economic values of water, market prices do not fully reflect the value of the resource itself and the resource rent is often negative. There is still limited experience in the valuation of water stocks. Box 6.1 describes the experience of New Zealand in valuing water used for hydroelectric power generation. Chapter 8 of this handbook presents a discussion on various methods of valuing water.

6.2. This chapter starts with a description of the hydrological cycle which governs water movement from the atmosphere to the earth, and its links with the water asset accounts (Section B). Contrary to other natural resources such as forest or mineral deposits which are subject to slow natural changes, water is naturally in continuous movement through processes of evaporation, precipitation etc. It is important to understand the natural cycle of water not only to reflect it correctly in the accounting tables but also for analytical purposes such as, for example, how to meet water demand in dry seasons.

6.3. Section C describes how the SNA asset boundary has been expanded, presents the SEEAW asset classification, and describes the asset accounts in detail. Examples of how countries have implemented water asset accounts are presented Section D. In the cases when water resources are shared among several countries, the asset accounts can explicitly identify information on the part of the water resources belonging to each country and the origin and destination of water flows between countries. Water asset accounts could be used for the management of shared waters as they facilitate the formulation and monitoring of policies for water allocation among countries with connected water resources. Section E describes how to include information on transboundary waters in the asset accounts.

6.4. Section F presents some indicators that can be derived from the accounts and are commonly used for policy. Finally, section G briefly discusses data sources and methods.

Box 6.1: Valuation of water used for hydroelectric power generation, New Zealand

As part of the energy monetary asset accounts, Statistics New Zealand has valued water used for hydroelectric power generation. In New Zealand, water generates approximately 85 to 90 per cent of the electricity from renewable resources. It also constitutes to 60 per cent of all electricity generated (renewable and non-renewable).

The water used for hydropower generation is valued using the Net Present Value (NPV) of discounted future income stream generated from the use of the asset (resource rent, RR). Resource rent is the total revenue generated from a resource less all the costs incurred in its abstraction including a normal return to fixed assets used in the production (SEEA -2003).

In the case of water, the resource rent was calculated by deducting from the market price of hydropower, all the costs for generating it (e.g. fuel for operating the turbines, distribution costs, costs of labour etc.) as well as a normal return to capital, namely dams and turbines. The rate of return to capital chose is 8 per cent.

In the formula of the resource rent, it was assumed that water is used sustainably and thus the lifetime is infinite. The discount rate used is 4 per cent. The table below shows the time series of values of renewable sources of energy in New Zealand including water used for hydroelectric power generation from the year 1987-2001.

$million

Electrical energy	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Hydro	1,951.8	1,330.7	2,157.8	2,689.5	1,973.7	1,577.7	1,994.7	2,954.2	3,626.8	2,640.6	3,017.8	3,108.3	2,349.1	3,669.7	2,190.2
Geothermal	110.5	72.4	164.9	245.0	190.3	164.7	195.9	247.2	272.7	207.4	272.5	306.8	266.8	414.7	261.9
Biogass	10.2	7.0	9.2	14.4	7.2	10.8	11.0	15.0	20.4	19.8	42.9	61.8	57.7	89.3	59.4
Wood	30.2	19.7	32.5	39.4	29.3	25.4	28.9	38.9	44.8	31.8	39.9	52.6	44.3	67.2	35.3
Total energy	2,102.7	1,429.8	2,364.4	2,988.3	2,200.6	1,778.6	2,230.4	3,255.2	3,964.6	2,899.7	3,373.1	3,529.6	2,717.9	4,240.9	2,546.8

Source: Statistics New Zealand (2004).

B. The hydrological cycle

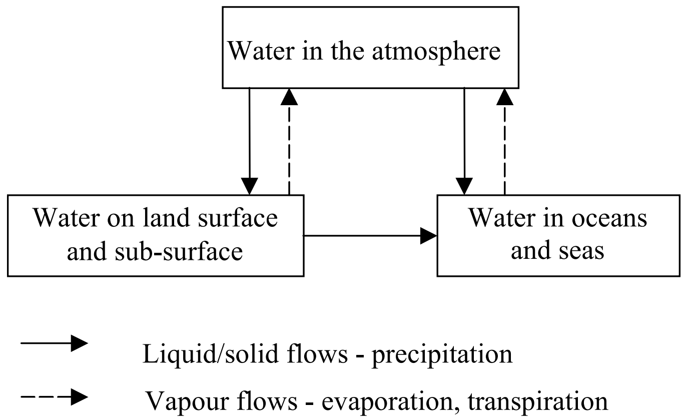
6.5. Water is in continuous movement. Due to solar radiation and gravity, water keeps moving from lands and oceans into the atmosphere in the form of vapour and, in turn, falls back again on land and oceans in the form of precipitation. The succession of these stages is called the hydrological cycle. Understanding the hydrological cycle helps to define the water asset boundary and explain spatial and temporal differences of water distribution. Figure 6.1 shows the various stages that water goes through during the natural water cycle. The figure shows land, atmosphere and sea as repositories of water. If we focus on water on land surface and sub-surface, the natural input of water is precipitation. Part of this precipitation evaporates back into the atmosphere, part infiltrates into the ground to recharge aquifers, and the remainder drains into rivers, lakes, reservoirs and groundwater and may eventually reach the sea. This cycle continues as water evaporates from land, oceans and seas to the atmosphere and falls back onto land, oceans and seas in the form of precipitation.

6.6. The natural water balance describe the hydrological cycle by relating the flows described above in the following way:

Precipitation = Evapotranspiration + runoff +/- changes in storage.

This means that precipitation either evaporates or transpires through vegetation (evapotranspiration), flows within rivers or streams (runoff), or is stored in natural or man-made water bodies (changes in storage).

Figure 6.1: Natural water cycle



Source: UNESCO (1989).

6.7. Within this natural water balance, adjustments should be made to reflect modifications to the cycle due to the human activities of abstraction-from and returns-into the environment. Water asset accounts describe this new balance by relating the storages of water (stocks) at two points in time (opening and closing stocks) to the changes in storage that occur during that period of time (flows) due to natural and human causes.

C. The water asset accounts

6.8. Asset accounts describe the stocks of water resources at the beginning and end of an accounting period and the changes in stocks that have occurred during that period. Before describing water asset accounts, this section presents the definition of assets in the SNA and how it has been expanded in the SEEA.

1. Extension of the SNA asset boundary

6.9. The 1993 SNA defines economic assets as entities:

(a) Over which ownership rights are enforced by institutional units, individually or collectively; and

(b) From which economic benefits may be derived by their owners by holding them, or using them, over a period of time (1993 SNA paragraph 10.2).

6.10. In particular, in the case of water, the 1993 SNA defines an asset of water resources as "aquifers and other groundwater resources to the extent that their scarcity leads to the enforcement of ownership and/or use of rights, market valuation and some measure of economic control". Thus only a small portion of the total water resources in a country is included in the 1993 SNA.

6.11. The SEEA extends the 1993 SNA boundary to include all water resources that provide direct use and non-use benefits. This implies that the SEEA asset category "water resources" (classified in the SEEA 2003 under the category EA.13) includes all the water resources from which water can be extracted in the current period or might be of use in the future. In practice, data are more likely to be available in cases where water is scarce and where the services to production and consumption provided by water bodies are threatened or actually diminished (SEEA para. 8.83).

2. Asset classification

6.12. Water Resource assets are defined as water found in fresh and brackish surface and groundwater bodies within the national territory that provide direct use benefits now or in the future (option benefits) through the provision of raw material and may be subject to quantitative depletion through human use. The SEEAW asset classification of water resources includes the following categories:

- EA.13 Water Resources (measured in cubic metres)
  - EA.131 Surface water
    - EA.1311 Artificial Reservoirs
    - EA.1312 Lakes
    - EA.1313 Rivers and streams
    - EA 1314 Glaciers, Snow and Ice
  - EA 132 Groundwater
  - EA.133 Soil Water

6.13. The asset classification can be adapted to specific situations depending on data availability and country priorities. For example, the classification could be further disaggregated to classify artificial reservoirs according to the type of use, e.g. for human, agricultural, electric power generation and mixed use. Rivers can be classified on the basis of the regularity of the runoff as perennial, where water flows continuously throughout the year, or ephemeral, when water flows only as a result of precipitation or to the flow of an intermittent spring. Examples of countries that used such breakdown are Namibia (Lange, 1997, Ministry of Agriculture, Water and Forestry Namibia, 2005) and the Republic of Moldova (Tafi and Weber, 2000).

6.14. Note that boundaries between the different categories in the asset classification, such as between lakes and artificial reservoirs and rivers and lakes/reservoirs, may not always be precise. This, however, is mostly a hydrological problem and does not affect the accounts. In cases where the separation between two categories (for example, the distinction between a river and a lake) is not possible, another category which would cover the "grey areas" could be introduced.

EA.131 Surface water

6.15. Surface water comprises all water that flows over or is stored on the ground surface (UNESCO/WMO International Glossary of Hydrology, 1992). Surface water includes *artificial reservoirs,* which are man-made 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 seasonal layers of snow and ice on the ground surface; and *glaciers* which are bodies of land ice that consist of recrystallized snow accumulated on the surface of the ground. Snow, ice and glaciers are measured in water equivalent.

EA.132 Groundwater

6.16. *Groundwater* includes subsurface water occupying the saturated zone (UNESCO/WMO International Glossary of Hydrology, 1992). It comprises therefore all water which collects in porous layers of underground formations known as aquifers. Aquifers may be unconfined, that is have a water table and an unsaturated zone or may be confined when they are between two layers of impervious or almost impervious formations. 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. Note that the concerns of non-renewable water applies not only to groundwater, but also to other water bodies: for example, lakes may be considered non renewable when the replenishment rate is very small compared to the total volume of water.

EA.133 Soil water

6.17. Soil water consists of water suspended in the uppermost belt of soil, or in the zone of aeration near the ground surface, that can be discharged in to the atmosphere by evapotranspiration.

6.18. The SEEA-2003 includes in its asset classification of water resources only the first three categories of surface water (EA.1311 to EA.113) and groundwater (EA.132). The SEEAW explicitly includes in the asset classification snow, ice and glaciers and soil water. While the SEEA-2003 acknowledges the importance of these resources in terms of flows (as they represent only a temporary storage of water), their explicit inclusion in the asset classification on the one side reflects the increasing importance of these resources in terms of stocks (in particular soil water) and on the other side allows for a clearer representation of water exchanges between water resources. Water in the soil, for example, is a very important resource (both in terms of stocks and flows) for food production as it sustains rainfed agriculture, pasture, forestry, etc. Most water management tends to focus water in rivers, lakes etc. neglecting soil water management, even though the management of soil water holds significant potential for water savings, increasing water use efficiency and the protection of vital ecosystems.

6.19. Glaciers are included in the asset classification even though their stock levels are not significantly affected by human abstraction. The melt derived from glaciers often sustains river flow in the driest months and contributes to water peaks. For example, without further precipitation the water stored in the Swiss glaciers is estimated to be sufficient to maintain river flows for about five years (the WWDR, 2003). Moreover, monitoring glaciers stocks is also important for monitoring climate change. Several countries including the Republic of Moldova (Tafi and Weber, 2000), Spain (Naredo and Gascó, 1995), New Zealand (2004a) and Chile (Meza et al., 1999) have compiled accounts including soil water, snow and ice.

Fresh and non-fresh water resources

6.20. The definition of water resources in the SEEA-2003 include all inland water bodies independently on their salinity level: hence they include inland fresh and brackish water. While fresh water is naturally occurring water having a low concentration of salt, brackish water has salt concentration between that of fresh and marine water. The definition of brackish and fresh water is not clear cut: the salinity levels used in the definitions vary between the countries. Brackish water is included in the asset boundary as this water can be (and often is) used with or without treatment for some industrial uses, for example, cooling water or even for irrigation purposes for some specific crops.

6.21. The asset classification of water resources can be further disaggregated to distinguish between fresh and brackish water. This would allow for a more detailed analysis of the stocks of water and their uses according to salinity level. This type of analysis can be done with quality accounts, presented in chapter 7, when the quality classes are defined according to salinity levels.

Water in oceans, seas and atmosphere

6.22. The asset classification of water resources excludes water in oceans, seas and atmosphere because the stocks of these resources are enormous compared to any level of abstraction from it thus they do not incur into depletion. However, water in oceans, seas and atmosphere is recorded in the accounts in terms of flows, in particular:

- the physical supply and use tables (see chapter 3) record: (i) water abstracted from and returned into the sea (in the case, for example, of abstraction of sea water for cooling purposes or for desalination); (ii) the precipitation directly used by the economy (in the case, for example, of rainfed agriculture); and (iii) evaporation and evapotranspiration which occur within the economic sphere (part of water consumption);
- the asset accounts record: (i) water flowing into oceans and sea (outflows from rivers); (ii) water vaporised and evapotranspired from water resources; and (iii) precipitation into water resources (flow from the atmosphere into the inland water resources).

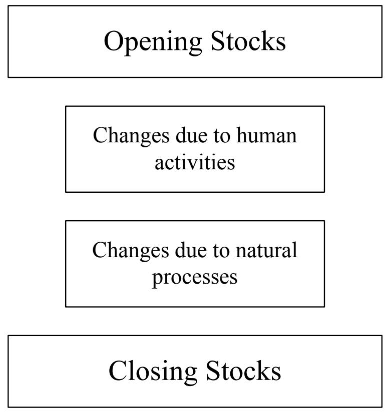
Produced versus non-produced assets

6.23. All water resource assets described in the previous paragraphs are considered in this handbook as non-produced assets, which means that they are, according to paragraph 10.6 of the 1993 SNA, "non-financial assets that come into existence other than through processes of production". It could be argued, however, that water contained in artificial reservoirs comes into existence through processes of production: first a dam has to be constructed, and, once the dam is in place, the activities of operation of the dams regulate the stock level of the water. A discussion is on-going on the treatment of water in artificial reservoirs whether it should be regarded as a produced asset instead of a non-produced one as well on its implication in the accounts.

3. Asset accounts

6.24. The water asset accounts describe how the stocks of water resources change during a period of time. Figure 6.2 presents a schematic form of an asset account: in particular, it presents (a) opening and closing stocks which are the stocks level at the beginning and end of the period of time; and distinguished between (b) changes due to human activities, which consist of abstraction and returns of water, and (c) changes due to natural causes which include flows of water between the economy and the environment and transfers of natural resources within the environment. These accounts are particularly relevant because they link water use by the economy (represented by abstraction and returns) to the stocks of water in a country.

Figure 6.2: Schematic representation of an asset account



6.25. Table 6.1 presents in more detail the structure of an asset account: the columns refer to the water resources as specified in the asset classification, and the rows describe in detail the stocks and the changes in stocks due to economic activities and natural processes.

Table 6.1: Asset accounts

physical units

		EA.131 Surface water						
		EA.1311 Reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow, Ice and Glaciers	EA.132 Groundwater	EA.133 Soil water	Total
Opening Stocks								
Changes due to human activities	Abstraction							
	of which Sustainable use							
	Returns from the economy							
Changes due to natural processes	Precipitation							
	Inflows							
	from upstream territories							
	from other resources in the territory							
	Evaporation/Actual evapotranspiration							
	Outflows							
	to downstream territories							
	to the sea							
	to other resources in the territory							
Other changes in volume								
Closing Stocks								

6.26. A*bstraction* represents the amount of water removed from water resources either permanently or temporarily during the accounting period for production activities and final consumption. Water used for hydroelectric power generation can be considered as part of water abstraction. For water allocation policies, it is often important to know how much water is used for hydroelectric power generation as this use may be in competition with other water uses. Upstream water abstraction may in fact limit the downstream use for hydroelectric power generation if a certain minimum flow is not guaranteed. However, one may argue that including water used for hydroelectric power generation inflates the figures for abstraction and hence for water use. The figures of water use for hydroelectric power generation should be separately identified so as not to obscure the analytical relevance of those indicators. In the SEEAW the definition of abstraction also includes the use of precipitation for rain-fed agriculture as this can be thought of as a removal of water from the soil as a result of human activity (e.g. agriculture). This flow is recorded as an abstraction from soil water.

6.27. *Water returns* represent the total volume of water that is returned after use into surface and groundwater during the accounting period. Returns can be disaggregated by type of water returned, for example, irrigation water, treated and untreated wastewater. The breakdown is usually the same as that used in the supply and use tables.

6.28. *Precipitation* consists of the volume of atmospheric wet precipitation (e.g. rain, snow, hail etc.) on the territory of reference during the accounting period. The majority of precipitation would fall on the soil and would thus be recorded in the column of soil water in the asset accounts. Some precipitation would also fall into the other water resources e.g. surface water. 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 would be 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. Since soil water is explicitly accounted for, this item records the total volume of precipitation before evapotranspiration takes place.

6.29. *Inflows* represent the amount of water that flows into surface and groundwater during the accounting period. The inflows are disaggregated according to their origin: (a) inflows from other territories, 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 of infiltration and seepage as well as channels built for water diversion.

6.30. *Outflows* represent the amount of water that flows out from water resources during the accounting period. Outflows are disaggregated according to the destination of the flow, namely (a) to other water resources, (b) to other territories and (c) to the sea/ocean. Outflows to other water resources 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.

6.31. “Inflows to” and “outflows from” other water resources should be measured carefully in order to reduce the risks of double counting when computing internal renewable water resources. The double counting may occur when assessing separately surface and groundwater, as the two resources are often interlinked resulting in water exchanges due to either (a) the contribution of groundwater to the surface flow or (b) the recharge of aquifers by surface runoff (FAO/AQUASTAT, 2001).

6.32. *Evaporation/Actual evapotranspiration* is the amount of evaporation and evapotranspiration that occurs in the territory of reference during the accounting period. 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, refer 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. Note that actual evapo-transpiration can only be estimated through modeling and may be a rough approximation.

6.33. *Other changes in volume* include all the changes in the stocks of water that are not classified elsewhere in the table. This item may include, for example, the amount of water in aquifers discovered during the accounting period, disappearance or appearance of water due to natural disasters, etc. Other changes in volume can either be calculated as a residual or directly.

6.34. In Table 6.1 the sustainable level of water abstraction can be specified from each water source. This variable is exogenous to the accounts and it is often estimated by the agencies in charge of water management and planning in a country. Its estimation takes into account economic, social and environmental considerations.

6.35. Table 6.2 expands the information on the inflow-to and outflow-from other water resources in the asset accounts of Table 6.1. In particular, it provides information on the origin and destination of flows between the water resources of a territory of reference allowing for a better understanding of the exchanges of water between resources.

Table 6.2: Matrix of flows between water resources

physical units

	EA.131 Surface water				EA.132 Groundwater	EA.133 Soil water	Total (Outflows to other resources in the territory)
	EA.1311 Reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow, Ice and Glaciers			
EA.1311 Reservoirs							
EA.1312 Lakes							
EA.1313 Rivers							
EA.1314 Snow, Ice and Glaciers							
EA.132 Groundwater							
EA.133 Soil water							
Total (Inflows from other resources in the territory)							

4. Definition of stocks for rivers

6.36. The concept of a stock of water is related to the quantity of surface and groundwater in a territory of reference measured at a specific point in time (beginning and end of the accounting period). While for lakes, reservoirs and aquifers the concept of a stock of water is straightforward (even though for groundwater it may be difficult to measure the total volume of water), for rivers it is not always easy to define. Water in a river is in constant movement at a much faster rate than the other water bodies: the estimated residence time of world’s water resources is about two weeks for rivers and around ten years for lakes and reservoirs (Shiklomanov, 1999).

6.37. To keep consistency with the other water resources, the stock level of a river should be 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. However, the river profile and the water depth are important indicators for environmental and economic considerations. The volume of the active riverbed has been used as a measure of stocks for rivers in Spain (Naredo and Gascó, 1995), Chile (Meza et al., 1999) and Moldova (Tafi and Weber, 2000). There might be cases, however, in which the stocks of river may not be meaningful either because the rate of the flow is very high or because the profile of riverbed changes constantly due to topographic conditions. In these circumstances, it could be avoided computing the stock of rivers (New Zealand, 2004).

Link with Supply and Use tables

6.38. Asset accounts in physical units are linked with the supply and use tables. In particular, changes due to human activities in the asset accounts, namely abstraction and returns, represent the crossing of the supply and use tables with the asset accounts (see Figure 2.4). The abstraction that appears in the asset accounts in Table 6.1 corresponds to the Abstraction from Water Resources by the economy in the physical use table. Similarly, the returns that appear in Table 6.1 correspond to the Total Returns to Water Resources in the physical supply table.

6.39. The link between physical water asset accounts and physical supply and use tables is analytically important as it provides information on the sources of water for the economy as well as destination of water discharges by the economy thus allowing for the evaluation of the pressure exerted by the economy on the environment in terms of abstraction and returns.

D. Country Examples

6.40. A number of countries have compiled asset accounts. This section presents asset accounts compiled in the Republic of Moldova, Australia and New Zealand. While the stocks of rivers are explicitly calculated in the first example, they are omitted in the others. As mentioned before, both cases are consistent with the accounting framework.

1. The Republic of Moldova

6.41. Table 6.3 and Table 6.4 show the asset accounts for the Republic of Moldova and the matrix of transfers among the various resources respectively. In Table 6.3 the stocks of rivers are computed as the volume of the active river beds.

Table 6.3: Asset account for the Republic of Moldova, 2000

Million cubic metres

		EA.131.Surface water					
		EA.1311 Reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.132 Groundwater	EA.133 Land & soil	Total
Opening Stocks			2,744	5,000	150,000	500	158,244
Changes due to human activities	Total abstraction			752	168		921
	Sustainable use						0
	Returns from the economy		0	866	74	15	955
	of which: cooling water			533			533
	losses in transport			69			69
Changes due to natural processes	Precipitation		363	290		23,516	24,169
	Inflows						
	from upstream territories			17,750	1,100		18,850
	from other resources in the territory	0	0	2,123	330	0	2,453
	Evaporation/Actual evapotranspiration		416	333		21,278	22,027
	Outflows						
	to downstream territories			19,420	1,267		20,687
	to the sea						0
	to other resources in the territory	0	0	20	134	2,299	2,453
Other changes in volume							
Closing Stocks		0	2,690	5,504	149,934	454	158,582

Table 6.4: Matrix of internal transfers, Republic of Moldova, 2000

Million cubic metres

Destination: ⇨	EA.131.Surface water					
Origin ⇩	EA.1311 Artificial Reservoirs	EA.1312 Lakes	EA.1313 Rivers and streams	EA.132 Groundwater	EA.133 Soil water	Outflow to other resources in the territory
EA.1311 Artificial Reservoirs			0			0
EA.11312 Lakes			0			0
EA.1313 Rivers and streams		0		20		20
EA.132. Groundwater			134			134
EA.133 Soil water		0	1,989	310		2,299
Inflows from other resources in the territory	0	0	2,123	330	0	2,453

2. Australia

6.42. Australia (ABS, 2000 and 2004) measure surface water assets in terms of the quantity of surface water that becomes available during a year (measured by the Mean Annual Runoff). ABS has compiled water pathways for the region of Victoria, Table 6.5, which describes how much water becomes available in the region through natural processes (in this case only precipitation), the part that is abstracted and returned by the economy (described in the rows 'changes due to human activities'), the part that evapotranspires and flows outside the region, and the part which is stored. This in short corresponds to the water balance where precipitation and inflows are equal to evapotranspiration, outflows, net abstraction and changes in storage. Note that the water pathways table corresponds to the asset account presented in Table 6.1 where the stocks are omitted.

Table 6.5: Water pathways for Victoria[a], Australia

GL

		1993-94	1994-95	1995-96	1996-97
Changes due to human activities	Total (net)	-3,914	-5,481	-4,577	-5,183
	Water used for economic purposes	8,501	9,377	7,878	9,929
	Return flow discharges	4,588	3,896	3,302	4,746
	Net water transfers	n.a.	n.a.	0	0
	Into the measurement region	n.a.	n.a.	0	0
	From the measurement region	n.a.	n.a.	0	0
Changes due to natural processes	Precipitation	174,730	133,684	152,561	134,269
	Total Outflows	79,693	79,693	79,693	79,693
	Evapotranspiration	60,243	60,243	60,243	60,243
	Basin outflow (mean annual runoff)[b]	19,450	19,450	19,450	19,450
Net changes in storage	Total	90,253	42,164	71,144	51,424
	Changes in storage in lakes and dams	-435	-3,173	1,426	1,015
	Net groundwater recharge	n.a.	n.a.	n.a.	n.a.
	Other volume changes n.e.c.	90,688	45,337	69,718	50,409

Note: (a) Totals are based on estimates and exact figures should be treated with caution.

(b) A long term average is used to define basin outflow and this has not changed during the four-year reference period.

Source: Adapted from Australian Bureau of Statistics, 2000.

6.43. The water pathways of Table 6.5 is complemented with separate tables on stocks of surface water (measured with Mean Annual Runoff - MAR) and groundwater (which are not presented here). Table 6.6 presents surface water assets in Victoria, Australia for the years 1985 and 1998: information on the MAR is presented along side with the portion allocated for economic and environmental uses.

Table 6.6: Surface water assets, Victoria, Australia

		1985 ASSESSMENT				1998 ASSESSMENT			
		Economic allocated[a]	Environmental allocated[d][e]	Environmenta l unallocated	Total assets (MAR)[c]	Economic allocated[a]	Environmental allocated[d][e]	Environmental unallocated	Total assets (MAR)[c]
River basin no.	River basin name	GL	GL	GL	GL	GL	GL	GL	GL
221	East Gippsland	1	—	379	380	1	—	379	380
222	Snowy	340	—	350	690	281	—	409	690
223	Tambo	5	—	320	325	8	—	317	325
224	Mitchell	18	—	982	1 000	21	—	979	1 000
225	Thomson	512	—	708	1 220	431	—	789	1 220
226	Latrobe	457	—	523	980	244	—	736	980
227	South Gippsland	18	—	682	700	23	—	677	700
228	Bunyip	49	—	296	345	24	—	321	345
229	Yarra	442	—	658	1 100	518	—	582	1 100
230	Maribyrnong	10	—	100	110	11	—	99	110
231	Werribee	47	—	48	95	30	—	65	95
232	Moorabool	41	—	74	115	48	—	67	115
233	Barwon	25	—	245	270	51	—	219	270
234	Corangamite	1	—	159	160	1	—	159	160
235	Otway	18	—	747	765	29	—	736	765
236	Hopkins	10	—	440	450	11	—	439	450
237	Portland	2	—	243	245	1	—	244	245
238	Glenelg	80	—	645	725	7	6	(e)712	725
239	Millicent Coast	—	—	4	4	0	—	4	4
401	Upper Murray	1 600	—	1 200	2 800	1 399	—	1 401	2800
402	Kiewa	10	—	695	705	14	—	691	705
403	Ovens	100	—	1 520	1 620	91	—	1 529	1 620
404	Broken	100	—	225	325	153	—	140	(e)(f)293
405	Goulburn	1 780	—	1 260	3 040	2005	80	(f)1 231	(e)(f)3 317
406	Campaspe	110	—	170	280	135	—	180	(e)(f)315
407	Loddon	100	—	151	251	161	28	(f)74	(e)(f)263
408	Avoca	5	—	80	85	4	—	81	85
414	Mallee	—	—	—	—	48	—	–48	—
415	Wimmera	110	—	263	373	178	11	(f)184	373
	Total	5 991	—	13 167	19 158	5 927	125	13 398	19 450

Note: (a) Average annual volume allocated for economic activity.

(b) No environmental allocations were made in the 1985 assessment (AWRC 1987a).

(c) MAR — mean annual runoff.

(d) Environmental flows in Victoria are generally made as specified flow regimes, which cannot be readily converted to an annual volume. The volumes listed are specific volumetric allocations.

(e) Reasons for change from 1985 to 1998: hydrological forecasts altered, e.g. reassessment of resources.

(f) Reasons for change from 1985 to 1998: methodological changes, e.g. new estimation techniques and methods derived for measuring water.

Source: Australian Bureau of Statistics, 2000.

3. *New Zealand*[15]

6.44. New Zealand has compiled water asset accounts yearly for the period 1995 to 2001 at national and (administrative) regional level. The accounting year used in the accounts is a 12-month period starting on 1 July. This choice was based on three considerations: (a) this period contains a whole irrigation season, (b) periods of low flows or drought usually occur entirely within that year, and (c) June/July is generally a period when storage has been replenished and water levels are stable.

6.45. Similarly to Australia, the asset accounts are in the form of a water balance, where inflows equal outflows plus changes in stored volumes. Opening and closing stocks are excluded because of difficulties in measuring volumes, particularly for rivers: many South Island rivers are braided and have riverbeds that are constantly shifting. Therefore, data were not available for the riverbed volumes in New Zealand. Supplementary tables are compiled for stocks of groundwater.

Table 6.7: Asset accounts for New Zealand, 1995-2001

	Year ended June						
	1995	1996	1997	1998	1999	2000	2001
	millions of cubic metres						
Total Inflows	*429,593*	*440,889*	*370,354*	*371,857*	*409,927*	*380,922*	*406,696*
of which: Precipitation	429,593	440,889	370,354	371,857	409,927	380,922	406,696
Total Outflows	*422,319*	*438,217*	*382,228*	*367,410*	*419,873*	*364,800*	*421,591*
Evapotranspiration	163,099	174,949	168,049	167,432	161,174	166,600	184,609
Abstraction for hydroelectricity generation	222,579	225,950	196,020	195,256	200,170	183,310	192,772
Discharge from hydroelectricity generation	-222,579	-225,950	-196,020	-195,256	-200,170	-183,310	-192,772
Outflows to sea and net abstraction(1)	259,220	263,268	214,179	199,978	258,699	198,200	236,982
Total change in storage(2)	*7,274*	*2,672*	*-11,874*	*4,447*	*-9,946*	*16,122*	*-14,895*
Soil moisture(3)	7,371	1,402	-1,958	-2,257	572	5,387	-10,519
Lakes and reservoirs(4)	-428	392	-2,222	2,322	-1,271	3,176	-4,382
Groundwater	4,220	-1,220	-2,480	-830	-1,810	820	290
Snow(5)	-6,819	3,098	-7,685	5,131	-5,998	7,778	-2,725
Ice(6)	2,930	-1,000	2,470	80	-1,440	-1,040	2,440

(1) This is a residual volume and is calculated as the inflow less other outflow and change in storage. It is the volume of water leaving the New Zealand water system, other than by evapotranspiration. Net abstraction is the difference between abstraction and discharges. It is not specifically calculated because there is insufficient data on: (a) abstraction of water for irrigation, livestock use, private domestic use, private industrial use, and geothermal electricity generation, and (b) discharges of water back into the environment.

(2) The change from the end of the previous June year to the end of the current June year.

(3) Changes in soil moisture average zero in the long-term, as presented by the average of June years 1995 to 2001.

(4) These volumes include an estimate for unavailable data.

(5) These volumes are for water stored as seasonal snow at an altitude of 900m to 2,000m. Transient snow (below 900m) and perennial snow (above 2,000m) are excluded.

(6) These volumes are for water stored in glaciers. Snow above 2,000m will largely be included here.

Source: Statistics New Zealand (2004a)

6.46. Table 6.7 presents the asset accounts for New Zealand (excluding the Chatham Islands and other outlying islands) for the years 1995-2001. Note that detailed information on abstraction and discharges were not available, thus they are included with the outflows to the sea and obtained as a

[15] Based on Statistics New Zealand (2004a).

residual item. Note that the accounts include information on water abstracted for hydroelectric power generation. Since this water is returned immediately into the environment without any losses, the discharge matches abstraction. Information on the stock levels of groundwater, snow and glaciers has also been calculated for the years 1994 to 2001 and presented in separate tables (Statistics New Zealand 2002, 2004b and 2004c).

E. Accounting for transboundary water resources

6.47. When the accounts are compiled for water resources that are shared by several countries, information can be made to explicitly identify the part of the shared resources which belongs to each riparian country as well as the origin and destination of specific flows. The two international conventions on transboundary water (The Helsinki Convention, 1996 and UN Convention on the Law of the Non-navigational Uses of International Watercourses, 1997) cover issues - related both to the quality and quantity of transboundary waters. Physical water asset accounts can provide information on the major quantitative issues of transboundary waters, such as those involving inflows coming from and outflows going to neighbouring countries, and those involving the allocation of water to riparian countries.

Table 6.8: Asset account at national level

Cubic metres

		Water Resources (classified according to the asset classification)		
		Legal quotas established by treaties	of which Transboundary waters	Total
Opening Stocks				
Changes due to human activities	Abstraction [(a)]			
	Returns [(a)]			
Changes due to natural processes	Precipitation			
	Inflows from other Water Resources in the territory	n.a.		
	Inflows from upstream territories(a):			
	From Country 1			
	…			
	Evaporation/Actual evapotranspiration			
	Outflows to other Water Resources in the territory	n.a.		
	Outflows to downstream territories			
	From Country 2			
	…			
	Outflows to the sea	n.a.		
Other Volume changes		n.a.		
Closing Stocks				

(a) Each of these flows may be subject to quotas established in treaties and agreements between riparian countries

6.48. Table 6.8 presents an example of how information on transboundary waters can be made explicit in the asset account: inflows and outflows are further disaggregated according to the country they originate (in the case of inflows) and arrive at last (in the case of outflows). In addition, since some flows may be subject to agreements between riparian countries, information on the established quotas is reported along side with information on the actual flows. If there is an agreement that establishes the part of the transboundary waters that belong to the country, the opening and closing stocks are measured by the quota established in the agreement.

6.49. If the territory of reference of the accounts is a river basin which extends beyond the boundary of a State, the opening and closing stocks of water resources can be disaggregated according to the country the water resources belong to. Similarly, information on abstraction and returns is disaggregated according to the country responsible for those flows. Table 6.9 presents an example of an asset account for a river basin shared by two countries. Note that the same structure can be used in the case that there are more riparian countries sharing waters.

6.50. The opening and closing stocks of the water resources in the basin are disaggregated according to the country according to the quotas established in treaties if they exist. Abstraction and returns are further disaggregated according to the country abstracting and returning water. In principle, a country can abstract water only from its part of the asset. However, there may be cases that a country abstracts more than the part of the stock that is assigned by a treaty. In this case, there is a transfer of water from one country to the other.

Table 6.9: Asset Accounts for a river basin shared by two countries

<table>
<tr><th colspan="2" rowspan="2"></th><th colspan="2">Water Resources (classified according to the asset classification)</th><th rowspan="2">Total</th></tr>
<tr><th>Country 1</th><th>Country 2</th></tr>
<tr><td colspan="2">Opening Stocks</td><td></td><td></td><td></td></tr>
<tr><td rowspan="6">Changes due to human activities</td><td>Abstraction[(a)]:</td><td></td><td></td><td></td></tr>
<tr><td>By Country 1</td><td></td><td></td><td></td></tr>
<tr><td>By Country 2</td><td></td><td></td><td></td></tr>
<tr><td>Returns[(a)]:</td><td></td><td></td><td></td></tr>
<tr><td>By Country 1</td><td></td><td></td><td></td></tr>
<tr><td>By Country 2</td><td></td><td></td><td></td></tr>
<tr><td rowspan="9">Changes due to natural processes</td><td>Precipitation</td><td></td><td></td><td></td></tr>
<tr><td>Inflows from other resources[(a)]:</td><td></td><td></td><td></td></tr>
<tr><td>Country 1</td><td></td><td></td><td></td></tr>
<tr><td>Country 2</td><td></td><td></td><td></td></tr>
<tr><td>Evaporation/Actual evapotranspiration</td><td></td><td></td><td></td></tr>
<tr><td>Outflows to other resources in the country[(a)]:</td><td></td><td></td><td></td></tr>
<tr><td>Country 1</td><td></td><td></td><td></td></tr>
<tr><td>Country 2</td><td></td><td></td><td></td></tr>
<tr><td>Outflows to the sea</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Other Volume changes</td><td></td><td></td><td></td></tr>
<tr><td colspan="2">Closing Stocks</td><td></td><td></td><td></td></tr>
</table>

Note: (a) Each of these flows may be subject to quotas established in treaties and agreements between riparian countries. Information on these quotas should be reported in a separate column when available.

6.51. Established quotas for abstractions and returns (merely in physical terms) as well as on other flows can be included in the tables in a separate column to monitor the compliance to the treaties as in Table 6.8. However, for sake of simplicity of presentation, this information is not included in Table 6.9.

F. Derived Indicators

6.52. The accounts can be used for the derivation of indicators. Since asset accounts link information on abstraction from and returns to water resources with information on water resources in the environment, a number of indicators on the status of water resources in the environment as well as on the pressure of human activities (through activities of abstraction and return) on the resource can be derived. Most of the indicators presented in this section can be directly derived from the accounts; others are based on supplementary information. The indicators presented next are presented into two separate groups: indicators on the status of water resources in the environment and indicators on the pressure exerted by human activities.

Indicators on water resources in the environment

6.53. Indicators on the status of water resources in the environment can be used to assess and monitor water resources in a territory and compare them with those of other territories. These indicators allow for the evaluation of some natural characteristics - climatic, geographic and topographic – of a region. It is important to look at these indicators in addition to those on pressure caused by human activities in order to link water demand with water supply from the environment. Box 6.2 presents some indicators commonly used for the assessment of the status of water resources in the environment. Note that these indicators do not provide information on the qualitative status of water resources, which are discussed in Chapter 7.

6.54. *Internal Renewable Water Resources* (IRWR) gives an indication of the amount of water that is internally produced through precipitation. IRWR is computed by adding up average annual surface runoff and groundwater recharge occurring within a country's borders. A method has been developed by AQUASTAT to improve consistency in global data sets by avoiding double counting of the overlap between surface and groundwater. This indicator can be computed from the matrix of flows between water resources in Table 6.2.

6.55. *External Renewable Water Resources* provides information on the amount of renewable resources that are generated outside the territory of reference. These resources consist mostly of river runoff but, in arid regions, they may also include groundwater transfers between the countries. This indicator corresponds to inflows from other territories as illustrated in Table 6.1. In the definition, external inflows are classified as natural or actual depending if upstream water consumption due to human activities is excluded or not. Since the accounts record stocks and flows that occurred during the accounting period, the indicator derived from the accounts correspond to the Actual External Renewable Resources.

Box 6.2: Selected indicators on water resources in the environment

Indicator	Definition
Internal Renewable Water Resources	"Average annual flow of rivers and recharge of groundwater generated from endogenous precipitation." (FAO/AQUASTAT)
External Renewable Water Resources	"Part of the country's renewable water resources shared with neighbouring countries. Total external resources are the inflow from neighbouring countries (trans-boundary groundwater and surface water inflows), and the part of the shared lakes or border rivers. The assessment considered the natural resources generally; if there are reservations in neighbouring countries, they are called actual resources." (FAO/AQUASTAT)
Total Natural Renewable Water Resources not directly derivable	The sum of internal and external renewable water resources. It corresponds to the maximum theoretical amount of water available for a country on an average year over a long reference period." (FAO/AQUASTAT)
Total Actual Renewable Water Resources	"(Fresh water resources total) The sum of internal and external renewable water resources, taking into consideration the quantity of flow reserved to upstream and downstream countries through formal or informal agreements or treaties and reduction of flow due to upstream withdrawal. cf. external surface water inflow actual or submitted to agreements. It corresponds to the maximum theoretical amount of water actually available for a country at a given moment. The figure may vary with time. Their computation is referring to a given period and not to an inter-annual average. " (FAO/AQUASTAT)
Exploitable water resources (Manageable resources)	"Part of the water resources which is considered to be available for development under specific technical, economic and environmental conditions." (FAO/AQUASTAT)
Dependency ratio	"Ratio between the external renewable resources and total natural renewable resources. This indicator describes the part of the total renewable water resources originating outside the country." (FAO/AQUASTAT, WWDR 2003, Margat 1996)
Per capita renewable resources	Ratio between total renewable water resources and population size. (WWDR 2003, Margat 1996)
Density of internal resources	Ratio between the average internal flow and area of the territory (Margat, 1996)

6.56. *Total Actual Renewable Water Resources* provides an indication of the amount of water that is generated through natural processes in a territory because of internal precipitation and inflows from other territories. This quantity can be derived from Table 6.1 and Table 6.2 or obtained as a sum of the previous two indicators. Asset accounts generally do not explicitly show the inflows subject to formal or informal agreements between riparian territories. However this information can be added to specify the part of inflows from other territories subject to international agreements. Another useful indicator is the *Total Natural Renewable Resources*, which represents the amount of water that would be available in a territory if in the upstream territories there were no human induced water consumption – water abstracted from water resources and not returned into water resources. Should this quantity be available, this indicator can be derived by combining information on total actual renewable resources and water consumption in upstream countries. If asset accounts are compiled for an international river basin, as described in Table 6.9, this indicator could be obtained from the table.

6.57. *Dependency ratio* provides information on the reliance of a country to water resources generated outside its territory. This indicator is computed as the ratio of external renewable resources over total natural renewable resources. It can be derived from the asset accounts as both numerator and denominator of the ratio can be derived from the accounts (see previous indicators).

Table 6.10: Indicators of water resources for selected countries, 2000

	Total internal renewable water resources (km^3/year)	Water resources: total renewable (km^3/year)	Water resources: total renewable per capita (m^3/capita year)	Dependency ratio (%)	Land area (km2)	Population in 2000 (1000 inh)
Greenland	603.00	603.00	10,767,857	0	341,700	56
Alaska	800.00	980.00	1,563,168	18	1,481,353	627
French Guiana	134.00	134.00	812,121	0	88,150	165
Iceland	170.00	170.00	609,319	0	100,250	279
Guyana	241.00	241.00	316,689	0	196,850	761
Suriname	88.00	122.00	292,566	28	156,000	417
Congo	222.00	832.00	275,679	73	341,500	3,018
Papua New Guinea	801.00	801.00	166,563	0	452,860	4,809
Gabon	164.00	164.00	133,333	0	257,670	1,230
Solomon Islands	44.70	44.70	100,000	0	27,990	447
Canada	2,850.00	2,902.00	94,353	2	9,220,970	30,757
New Zealand	327.00	327.00	86,554	0	267,990	3,778
Norway	382.00	382.00	85,478	0	306,830	4,469
Belize	16.00	18.56	82,102	14	22,800	226
Liberia	200.00	232.00	79,643	14	96,320	2,913
Bolivia	303.53	622.53	74,743	51	1,084,380	8,329
Peru	1,616.00	1,913.00	74,546	16	1,280,000	25,662
Laos	190.42	333.55	63,184	43	230,800	5,279
Paraguay	94.00	336.00	61,135	72	397,300	5,496
Chile	884.00	922.00	60,614	4	748,800	15,211

Source: Reported by United Nations and the World Water Assessment Programme (2003) and computed by FAO/Aquastat.

6.58. The dependency ratio varies between 0 and 1. It increases as the amount of water received from neighbouring countries increases as compared to the total natural renewable resources. Margat (1996) presents also a complementary indicator - *indicator of independence*, which measure the degree of autonomy of a country from resources generated outside its borders. This indicator is obtained as the ratio of internal over total natural renewable resources.

6.59. It is often important to relate information on water resources with economic, demographic and social information such as population size and total land area. Comparing, for example, total renewable water resources to the population size would provide information on the natural ability of a territory to generate water resources as compared to the population size. In other words, this indicator would indicate if the natural water supply, measured in terms of renewable water resources, is sufficient to meet the demand of the current population. If over-exploitation occurs and there is an increase pressure on the resource due to an increase in population, alternative sources of water supply may have to be developed in order to reduce the stress on water resources. Comparing internal (or total) renewable water resources with the area of a territory would provide some information on the geography of the water resources.

6.60. Table 6.10 presents some of the indicators discussed above for selected countries from the World Water Development Report (United Nations and the World Water Assessment Programme, 2003). Information on the dependency ratio and the land surface provide some indication of the countries' spatial characteristics of water resources. Although such tables can be compiled without having in place an accounting system, designing integrated policies requires an information system such as the one provided by water accounting.

6.61. Water availability is an indicator that is often mentioned, but rarely defined. It is often used as a synonym of renewable water resources. This follows from the idea that abstracting water at the same rate as the recharge would not lead to the depletion of water resources. This is, however, a simplified view. Firstly, depletion of water resources is a long term concept and it is not simply linked to renewable water and abstraction in one year. Moreover, water availability is linked to existing technologies in place for the abstraction, treatment and distribution of water. In some cases, even marine water may be considered available water, if the technology for desalinating the water is in place.

6.62. The concept of water availability is related to the ability of a country to mobilize water. It includes therefore factors such as the economic feasibility and the level of technology for storing part of the flood water in artificial reservoirs, extracting groundwater and desalinating water. For water stressed countries, water of low quality (requiring extensive treatment before use) may be considered available, while in countries where water scarcity is not an issue the same type of water may be not considered available for abstraction. Similarly, the level of technology has a big impact on the water that can be considered available. For these reasons comparing countries on the basis of this indicator is very difficult and total actual renewable resources is often used as a proxy of water availability.

6.63. FAO/AQUASTAT suggests the use of an indicator of exploitable (or manageable) water resources defined as the part of the water resources considered to be available for development under specific technical, economic and environmental conditions. This indicator is the result of several considerations such as the dependability of the flow, extractable groundwater, minimum flow required for environmental, social and non-consumptive use, etc. (FAO/AQUASTAT Online Glossary). This indicator therefore is directly related to sustainable water use, which appears in Table 6.1.

Example of measuring water availability in Namibia[16]

6.64. In Namibia water availability has been calculated taking into account the different sources of water and the capacity to mobilize water. In addition, in order to give an indication of the amount of water that would be available if all potential sources were developed, information on the potential amount of available water is also computed. Table 6.11 summarizes the information on available water for Namibia for the year 2000 (Ministry of Agriculture, Water and Forestry, Namibia, 2005): by column information on the actual and potential water availability is shown. By row the different sources of water are identified: they include dams and ephemeral rivers, perennial rivers, groundwater and other water.

6.65. The distinction between ephemeral and perennial rivers is due to the fact that in Namibia all except two rivers (the Kwando and Okavango rivers) that flow within Namibia's border are ephemeral that is they run only after periods of substantial rain. Dams are therefore built in order to store this water which would otherwise flow away or evaporate. Water availability from dams and ephemeral rivers is based on the long term availability from the dams measured by the 95 per cent safe yield. Note that the yield is the amount of water that can be supplied from a reservoir or catchment during a specified time period and the 95 per cent safe yield is the yield that can be expected 95 per cent of the time. The table shows that Namibia can be guaranteed an amount of at least 100 millions of cubic metres of water in one year from dams in 95 per cent of the years (or in other words there is a chance of one shortfall in 20 years).

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[16] Based on Ministry of Agriculture, Water and Forestry, Namibia, 2005

Table 6.11: Total annual available water, Namibia

Millions of cubic metres per year

Water sources:	Annual Amount of Water Available with Installed Capacity	Potential Amount Available (Total Source)
Dams and ephemeral rivers	100.0	200.0
Perennial rivers	170.0	1,105.0
Groundwater	150.0	300.0
Other water (Recycled)	7.5	10.0
Total	427.5	1,615.0

Source: Ministry of Agriculture, Water and Forestry, Namibia, 2005.

6.66. The availability of water from perennial rivers (namely, rivers which flows continuously all through the year) is based on the installed capacity to abstract water which refers to the maximum amount of water that can be abstracted with the abstraction infrastructure in place.

6.67. The availability of groundwater in Namibia is based on the long-term sustainable yield. The long-term sustainable yield refers to the amount of water that can be abstracted from an aquifer on a long term basis without causing a significant fall in the water table. When water is either abstracted at a greater rate that the sustainable yield or from an aquifer which does not receive any recharge, the stock reserve of groundwater diminishes and the water table falls.

6.68. The last source of water considered in Table 6.11 is Other water which consists mainly of re-used water and wastewater. The Municipality of Windhoek has a reclamation plant which received treated households wastewater from the City, treats it to potable quality and supplies it for further use. The annual amount of water available from this plant is based on the capacity of the plant. Other municipalities, like Windhoedk, Walvis Bay, Swakopmund and Otjiwarongo, also reuse purified water effluent to irrigate sports fields, cemeteries and parks and in some cases even for crop production.

Indicators on the pressure exerted by human activities

6.69. The previous set of indicators describes the structural characteristics of the water resources in a territory by looking at water generated internally and externally and linking it to the land surface and population size. However, it does not provide a direct indication of the pressure exerted by the economy on water resources. Table 6.12 presents some of the indicators that can be derived from the asset accounts and that are commonly used to link abstraction and returns to water resources in the environment. These indicators show, in quantitative terms, the extent to which water resources are being exploited or used to meet country's water demands.

Table 6.12: Selected indicators on the pressure exerted by human activities

Annual Withdrawals of Ground and Surface Water as a Percent of Total Renewable Water / Exploitation index	The total annual volume of ground and surface water abstracted for water uses as a percentage of the total annually renewable volume of freshwater. (UN, 2001)
Consumption Index	Ratio between Water Consumption and Total Renewable Resources. (Margat, 1996)

6.70. *Annual Withdrawals of Ground and Surface Water as a Percent of Total Renewable Water* shows the degree to which total renewable water resources are being exploited to meet the country's water demands. It is a measure of a country's vulnerability to water shortages. This indicator is sometimes referred to as *exploitation index* (Margat 1996, Redaud 1998). To assess the magnitude of water stress an indicative scale is often used: if this indicator is less than 10%, there is no pressure on water resources; if it is between 10% and 20%, there are pressures on water resources; if it is between 20 and 40% control systems need to be established to conserve water; and finally if it is over 40% the pressure endangers renewable water resources (Redaud, 1998).

6.71. The exploitation index can be computed from the asset accounts, Table 6.1, as total water abstraction for the economy and Total Renewable Resources (see previous indicators).

6.72. While the exploitation index provides information on the removals of water as compared to renewable resources, it does not take into consideration the fact that most of the water used is returned back to the inland water system thus making it potentially available for further uses downstream. Therefore it is useful to complement this indicator with the *Consumption Index* which describes the part of abstracted water that is not returned to water resources as a percentage of renewable water resources.

6.73. The Consumption Index is defined as the ratio between water consumption and renewable water resources, where water consumption is the difference between abstraction and returns. It is important however to define clearly abstraction and returns as in some context abstraction includes only the removal of water from freshwater resources. In the accounting terminology, abstraction includes the removals of water from any source, hence the consumption index derived from the asset accounts in Table 6.1 corresponds more to a 'Water Resources Consumption Index' as the consumption derived from the table is the difference between Abstraction from Water Resources (as defined in the asset classification) and Returns to Water Resources.

6.74. In water accounting the term Water Consumption is used to describe the loss of water that occurs during use either because water is evaporated, incorporated into products or otherwise lost during use. This indicator is computed from the physical supply and use tables (see chapter 3).

6.75. Depending on the analysis, these indicators can also be computed in relation to internal renewable water resources (FAO/AQUASTAT, WRI) or they can be further broken down according to the abstracting industry. In order to show spatial variability these indicators could be computed at a finer regional scale.

6.76. It should be noted that both these indicators - exploitation and consumption indices - compare abstraction and consumption to renewable resources leaving out non-renewable resources. It therefore is important to look also at other indicators which link abstraction to non-renewable resources.

G. Data sources and methods

6.77. Data necessary for the compilation of water asset accounts are generally collected by a diverse range of institutions within a country: hydrological, meteorological institutes or agencies in charge of water management at local, regional or national level. For example, meteorological institutes are typically in charge of collecting, storing and managing information on precipitation. Information on river flow, inflows and outflows are generally collected in hydrological, hydro-geological institutes.

6.78. The compilation of asset accounts requires the identification of the agencies and institutes responsible for the collection and elaboration of information relevant to the accounts. Once the data sources within a country have been identified, data can be gathered from the relevant agencies. It is important, however, that, when using available data, the consistency with concepts and definitions used in the accounts is insured. This includes also ensuring that the spatial and temporal reference of the data is the same as the one used for the accounts.

6.79. The accounts are fundamental to identify potential inconsistencies among data from different sources and validate data through the inherent checks of the accounting identities. In case of inconsistencies, it is often necessary to go back to the data source to reconcile data.

Part II

Chapter 7 Quality accounts

A. Introduction

7.1. The use one can make of water depends crucially on its quality. Pollution creates health hazards, affects biodiversity in a negative way, increases the costs of treating water and increases water stress. Pollution of groundwater aquifers can be almost irreversible if not detected at an early stage.

7.2. In Europe, the Water Framework Directive (WFD) of the European Parliament and of the Council, requires EU countries to establish water policies so as to ensure that all water meet "good status" by 2015 (see Box 7.1). According to the Dublin Statement "measurement of components of the water cycle, in quantity and quality, and of other characteristics of the environment affecting water are an essential basis for undertaking effective water management" (Dublin, 1992). Agenda 21 states a growing concern that "at the time when more precise and reliable information is needed about water resources, hydrological services and related bodies are less able than before to provide this information, especially information on groundwater and water quality" (Agenda 21, para 18.23). It has therefore become increasingly important to account for water quality.

7.3. While in previous chapters the focus was on water in terms of input into the production process and water availability, this chapter looks at water quality and its link to various uses. It is therefore a first step towards ecosystem accounting and its variants.

7.4. Quality accounts do not have a direct link to the economic accounts, as changes in quality cannot be attributed to economic quantities using a linear relationship, as in the case of the water asset accounts, in volume terms. However, since quality is an important characteristic of water and limits its use, the SEEAW covers the quality accounts. Further, the SEEAW covers driving forces in terms of the structure of the economy and population, pressures in terms of abstraction of water and emission, responses in terms of environmental expenditures and taxes and fees charged for water and sanitation services. The state and impacts are represented in terms of quality accounts.

7.5. Quality accounts describe in qualitative terms the stocks of water, which are described in volume terms in the asset accounts as presented in chapter 6. The structure of the quality accounts is similar to that of the asset accounts. The quality accounts however look much simpler than the asset accounts, as changes in quality are the result of non-linear relationships. Therefore, it is not possible to distinguish changes in quality due to human activities from changes in quality due to natural causes.

7.6. Although constructing quality accounts may be simple from a conceptual point of view, there are numerous issues with its implementation. The most obvious one is how to define quality classes. Most countries use definitions according to their own particular interests, and there is little standardisation of concepts and definitions or aggregation methods. Aggregation can be over different pollutants, to reach one index, which measures the combined impact of pollutants on water resources; over time – to address seasonal variations – as well as over space, to reach a single quality measure for measurements at different locations.

7.7. Because of the issues outlined above, and a lack of a sufficient number of country experiences, this chapter is presented in terms of issues and lessons learnt from trial implementations instead of ready-made solutions. In section B we will look at basic concepts of water quality accounting, including the difficulty of defining quality in the presence of multiple uses. Section C discusses the structure of quality accounts. In section D we will look at two outstanding issues, the choice of determinands and the 'rule of the worst'. After looking at two indices that are used when aggregating over space in section E, section F describes the exercise currently under way in the European Environment Agency of constructing quality accounts for rivers.

Box 7.1: The European Water Framework Directive 2000/60/EC

The Water Framework Directive (European Parliament and Council, 2000) that came into force on 22 December 2000 has the following key elements:

- It expands the scope of water protection to all waters. A distinction is made between surface waters (rivers, lakes, transitional and coastal waters), groundwater and protected areas i.e. areas that are designated for water abstraction, protection of aquatic species or have recreational purposes.
- It sets the deadline in 2015 for achieving "good status" for all waters. For surface water this comprises both "good ecological status" and "good chemical status". The former is defined in Annex V in terms of the biological community, hydrological characteristics and chemical characteristics. Member States will report the ecological quality for each surface water category into five classes ranging from high to bad. The boundary values will be established through an intercalibration exercise. Chemical status is reported as good or failing to achieve good. For groundwater, as the presumption is that it should not be polluted at all, the approach is slightly different. There is a prohibition on direct discharges and a requirement to reverse any anthropogenically induced upward pollution trend. Besides reporting the chemical status, quantitative status is reported as either good or poor, depending on the sustainability of its use.
- It calls for economic analysis in Annex III: the costs of water services should be recovered, taking long-term forecasts of supply and demand for water in the river basin district into account, in accordance with the polluter pays principle; the cost-effectiveness of measures in respect of water uses should be analyzed.
- It endorses a "combined approach" of emission limit values and quality standards. In a precautionary sense it urges all existing source-based controls to be implemented. At the same time a list of priority substances, Annex X, will be defined prioritised on risk whose load should be reduced based on an assessment of cost-effectiveness.
- It recognizes the river basin – being the natural hydrological and geographical unit - as the most suitable basis for water management instead of administrative or political demarcations. Member States will produce and update every 6 years "river basin management plans" containing all the above mentioned measures as detailed in Annex VII.
- Besides streamlining existing legislation, it urges for close cooperation as well as consultation of the users. In line with the subsidiarity principle, decisions should be taken as close as possible to the locations were water is used.

Source: European Parliament and Council, 2000.

B. Basic concepts of water quality accounting

7.8. Natural waters exhibit a wide variety of chemical (e.g. nitrate, dissolved oxygen, etc.), physical (e.g. temperature, velocity, etc.) and biological (e.g. bacteria, fish, etc.) characteristics that result from natural processes and anthropogenic activities. Water quality is described by all these characteristics.

7.9. Quality applies to both water bodies proper and waterbeds, which contain or transport this water. The quality of water running through a river could be very pure, whereas the riverbed could be severely polluted with heavy metals that have sunk into its sediment in previous decades. In this chapter we will restrict ourselves to the former, i.e. to the quality of water flowing into water bodies, e.g. rivers, lakes, etc.

7.10. Quality describes the current status of a certain water body in terms of certain characteristics, which are called "determinands" (i.e. "what helps determining"). The term "determinand" is chosen over pollutant, parameter or variable (Kristensen and Bogestrand, 1996), to underscore the fact that a determinand describes a quality characteristic of a waterbody, and is not exclusively associated with human activities. Examples of determinands, as used in the French SEQ-eau system (System for the Evaluation of the Quality of Water, Oudin 2001), are depicted in Table 7.1.

Table 7.1: Indicators and parameters included in the 1st version of Water-SEQ

Indicators	Determinands*
Organic and oxidizable matter	O_2d, $\%O_2$, DCO, DBO_5, COD, NKJ, NH_4^+
Nitrogen (except nitrates)	NH_4^+, NKJ, NO_2^-
Nitrates	NO_3^-
Phosphorus	PO_4^{3-}, total P
Suspended Matter	Suspended solids, turbidity, transparency
Colour	Colour
Temperature	Temperature
Salinity	Conductivity, Cl^-, SO_4^{2-}, Ca^{2+}, Mg^{2+},K^+, TAC, hardness
Acidity	pH, dissolved Al
Phytoplankton	$\%O_2$, and pH, chlorophyll a + pheopigments, algae, ΔO_2 (24 hours)
Micro organisms	Total coliforms, faecal coliforms, faecal streptococci
Mineral micro pollutants in water	Arsenic, mercury, cadmium, lead, total chromium, zinc, copper, nickel, selenium, barium, cyanides
Metal with bryophytes (moss)	Arsenic, mercury, cadmium, lead, total chromium, zinc, copper, nickel
Pesticides in water	37 substances are concerned
Organic pollutants (except pesticides) in water	59 substances are concerned

Source: Le-SEQ-eau Souterraines (Oudin 2001).

Note: *The original does not use the word determinand but the word parameter.

7.11. The selection of determinands used to assess the quality of a certain water body, is linked to its use and functions. There is however no standard classification of water uses. Most classifications recognize the following uses: drinking water, leisure, irrigation, and industry. The French (Oudin, 2000) distinguish for example, aquatic life, drinking water, leisure, irrigation, livestock and aquaculture. Australia and New Zealand (ANZECC/ARMCANZ 2000) mention aquatic ecosystems, primary industries, recreation and aesthetics, drinking water, industrial use as well as cultural and spiritual values (although for the latter two categories no quality guidelines are provided).

7.12. For policy purposes it is important to define the suitability of water for a certain use or water body function by specifying series of normative values for the determinands, which represent the requirements for these uses (Train, 1979). For reasons of practicality, ease of reporting as well as the inherent uncertainty, water quality is eventually reported in the form of classes. For instance, the European Water Framework Directive (see text box) defines five ecological quality classes: high, good, moderate, poor and bad. Each class is defined according to three types of classifications: biological quality, hydro-morphological quality, and physico-chemical quality, as illustrated in Table 7.2. The worst class obtained in any of the three classifications (physico-chemical, hydrological and biological) determines the global class.

7.13. Once quality classes are defined for each particular water use, the next question that comes to mind is, whether it is possible to define quality classes that are detached or independent from use or function? This would allow for comparable figures across countries.

7.14. There is no single answer to the question above. Different countries have chosen different approaches. In some cases countries have chosen to assign one single use to water bodies, and the quality class is defined on the basis of this use. In case of multiple uses, water quality is defined on the basis of the most sensitive or stringent use. In other cases quality classes are defined by combining thresholds of determinands for different uses.

7.15. In Australia, the approach chosen to define quality classes of groundwater, is on the basis of salinity, measured by the total dissolved solids. It consists of defining four classes directly linked to the use of water. Four classes have been defined: “fresh” (salinity<500 mg/l), “marginal” (500<salinity<1 500), “brackish” (1 500<salinity <5 000) and “saline” (salinity>5 000 mg/l). These categories correspond to potential limitations for economic uses: “Fresh” quality is recommended for human drinking, “marginal” quality can be used for irrigation and, at the end of the range, some industrial processes are able to use very saline water, including sea water (the salinity of which is about 35 000 mg/l).

7.16. The United States use the first approach in defining quality classes. According to the USA Clean Water Act (known under this name since 1977) states must take three major, interrelated actions. They must designate a specific use or uses for each water body, set quality criteria accordingly, and implement antidegradation policies. Standards are water body-specific. In case of multiple uses water quality could be defined in terms of its most sensitive or stringent use. This is for example the case of Australia: “Where two or more agreed uses are defined for a water body, the more conservative of the associated guidelines should prevail and become the water quality objectives” (ANZECC/ARMCANZ, 2000).

Table 7.2: Physico-chemical classification: elements for the ecological quality classes of rivers

Element	High status	Good status	Moderate status
General conditions	The values of the physicochemical elements correspond totally or nearly totally to undisturbed conditions. Nutrient concentrations remain within the range normally associated with undisturbed conditions. Levels of salinity, pH, oxygen balance, acid neutralising capacity and temperature do not show signs of anthropogenic disturbance and remain within the range normally associated with undisturbed conditions.	Temperature, oxygen balance, pH, acid neutralising capacity and salinity do not reach levels outside the range established so as to ensure the functioning of the type specific ecosystem and the achievement of the values specified above for the biological quality elements. Nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific synthetic pollutants	Concentrations close to zero and at least below the limits of detection of the most advanced analytical techniques in general use.	Concentrations not in excess of the standards set in accordance with the procedure detailed in section 1.2.6 without prejudice to Directive 91/414/EC and Directive 98/8/EC.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific non-synthetic pollutants	Concentrations remain within the range normally associated with undisturbed conditions.	Concentrations not in excess of the standards set in accordance with the procedure detailed in section 1.2.6 without prejudice to Directive 91/414/EC and Directive 98/8/EC.	Conditions consistent with the achievement of the values specified above for the biological quality elements.

Waters achieving a status below moderate shall be classified as poor or bad.

Waters showing evidence of major alterations to the values of the biological quality elements for the surface water body type and in which the relevant biological communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions, shall be classified as poor.

Waters showing evidence of severe alterations to the values of the biological quality elements for the surface water body type and in which large portions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent, shall be classified as poor.

Source: European Parliament and Council (2000).

7.17. The approach followed by France (called the System for the Evaluation of the Quality of Water or SEQ-eau, Oudin 2001) consists of distinguishing different main types (rivers, groundwater, etc.) of water bodies. Accordingly for each main type, different uses and functions are defined. Determinands having comparable impact together are grouped to form indicators (see Table 7.1), for example, forming the indicator nitrates. Determinands are not aggregated variables. From a list of in total 15 indicators, depending on use, a subset is selected. For example, for the use ‘industry’ only two indicators are selected (corrosion[17] and suspended matter), but for drinking water 13 out of 15 are selected. A final quality class for a certain use can then be defined by taking the worst score obtained for any indicator.

7.18. In the French approach it is also possible to derive a global quality index of a water body. This is not done by taking the worst of the worst score obtained for the different uses, but by combining

[17] Not an indicator in Table 7.2, but corrosion is recognized as separate indicator in a later version of SEQ which recognizes 17 indicators.

threshold values for the indicators. For instance, quality classes for nitrate are defined by choosing the two most restrictive uses (in this case drinking water and aquatic life), and combing their threshold values, making sure always to choose the most restrictive of the two. The global quality index is the worst score obtained for any indicator.

7.19. The WFD does not mention a specific classification for different uses. As is explained in Box 7.1, it distinguishes between several types of water (groundwater, surface water and protected areas). The rational for this may be understood as stemming from different uses, as protected are areas designated for water abstraction, protection of aquatic species or recreational purposes.

7.20. Whether a global quality class is defined by the most sensitive use as in the first approach, or by combining threshold values as exemplified by the second approach, both approaches assess the overall quality as the worst result of all use focused quality assessments. This method that defines quality according to 'the rule of the worst', has important drawbacks that will be discussed in detail in section D. Its main advantage is that it does provide a rule of choice that designates a quality class for each water body independent of use.

C. The structure of the accounts

7.21. The general structure of the quality accounts is the same as that of the water asset accounts in volume terms. The only difference is the addition of the quality dimension, which describes the volume of water. The accounts show the opening and closing stocks together with the changes in stocks during the accounting period for each quality class. Table 7.3 shows the general structure for quality accounts as presented in the SEEA 2003.

Table 7.3: Quality accounts

physical units

	Quality classes				
	Quality 1	Quality 2	Quality 3	Quality n	Total
Opening stocks					
Changes in stocks					
Closing stocks					

Source: SEEA 2003.

7.22. Each cell shows the volume of water of a certain quality class at the beginning and end of the accounting period. The column "total" represents the stock of the water body at the beginning and the end of the accounting period as defined in chapter 6. The row "changes in stocks" is derived as a difference between closing and opening stocks.

7.23. Table 7.3 can be compiled for the following water resources: lakes, rivers, reservoirs and groundwater. Two steps are generally used to compile water quality accounts:

- Defining quality and quality classes (see section B),
- Defining units that enable the aggregation of water volumes sorted by quality classes.

It should be noted that in the case of rivers, the aggregation of water volume requires special attention.

7.24. In the case of rivers, quality is a characteristic of a given volume of water at a given point in time and location and it is difficult to aggregate such measurements to represent large regions such as lakes and rivers. This is particularly difficult for rivers due to the flowing nature of the water. A specific standard unit of account has been introduced that represents a river stretch of one kilometre with a water flow of one cubic meter per second, called the "standardized river-kilometre" (Heldal and Østdahl, 1984) later changed into *standard river unit* (SRU):

$$SRU_i = L_i \times q_i$$

where i is the ith stretch (the part of a river that lies between monitoring points), L its length (in kilometres) and q the reference rate of flow, for example, the long-term yearly average. This measure entails multiplying each stretch of a river containing a certain quality of water by its flow. The river is thus divided in different sections with different quality classes, whose water flow can be aggregated without double counting (SEEA 8.128). The SRU allows the aggregation of stretches of watercourses that are of different size.

7.25. In the case of France, the water system comprises on average 10.8 million SRU for its approximately 85,000 km of main courses, disaggregated into 55 catchments. The minimum size of rivers to be considered impacts the final quantity of SRU in a basin. Because of lack of adequate data, the marginal contribution of the smallest rivers is unknown. Estimates from the Insititut français de l'environnement (Ifen, 1999) suggest that considering all rivers existing at the 1:50,000 scale would increase by 2,5 the total SRU registered at the 1:1,400,000 scale.

7.26. With the introduction of the SRU, quality accounts for rivers can be compiled by assessing the quality index or class for each stretch, computing the SRU value for each stretch, and summing the corresponding SRU per quality class to populate the stock table.

7.27. Table 7.4 shows the quality accounts for rivers as compiled in France for the years 1992 and 1994. 5 Quality classes are selected, 1A (best one), 1B, 2, 3 and NC (not classified, worst one). The description of stocks according to quality was available for two years and the figures are comparable as they are obtained from comparable assessment methods. The quality accounts show that there has been an improvement between the two years: there are more and more SRU in good quality classes (1A and 1B) and less and less in bad quality classes (3 and NC).

Table 7.4: Quality accounts of French watercourses by size class (organic matter indicator - in 1000 SRU)

	1992 state					*Changes by quality class*					1994 state				
	1A	1B	2	3	NC	1A	*1B*	*2*	*3*	*NC*	1A	1B	2	3	NC
Main rivers	5	1253	891	510	177	*3*	*336*	*9*	*-183*	*-165*	8	1583	893	358	12
Main tributaries	309	1228	1194	336	50	*16*	*464*	*-275*	*-182*	*-22*	325	1691	919	154	288
Small rivers	260	615	451	128	47	*44*	*130*	*-129*	*-17*	*-28*	306	749	322	110	188
Brooks	860	1464	690	243	95	*-44*	*176*	*228*	*15*	*-23*	810	1295	917	258	72

Note: The figures in the middle column (in italics) do not in all cases match precisely the calculated difference between the 1992 and 1994 states of the rivers in question. This is because of difficulties in comparing certain groups of watercourses in some watershed basins between the two points in time.

The classification of watercourses into main rivers, main tributaries, small rivers and brooks follows from the scale of the used map.

The 'organic matter indicator', considers the following parameters: dissolved oxygen, BOD5 (biochemical oxygen demand at 5 days), COD (chemical oxygen demand) and ammonium (ions NH4+). It also looks at eutrophication and nitrates.

Source: The Accounts of the quality of the watercourses - Implementation of a simplified method, on-going development, Institut Français de l'ENvironnement, August 1999.

7.28. In the case of groundwater quality, since flow is very low, quality accounts can directly be constructed in volume (m^3).

7.29. Table 7.5 provides an example of quality accounts for groundwater in Australia, using salinity levels for defining quality classes. Although complete accounts could not be established in 1998 (only groundwater in so-called "groundwater management areas" was monitored), the study of the major differences between the two assessments shows a shift from the "fresh" to the "marginal" water quality category. The number of m^3 of brackish water also increased between the two years.

Table 7.5: 1985 and 1998 accounts of the groundwater quality in Victorian provinces (Australia)(in million m^3)

	Fresh	Marginal	Brackish	Saline	Total
1985	477.5	339.2	123.3	32.3	972.3
1998 (incomplete)	(39.1)	(566.6)	(141.1)	(n.a.)	(746.8)

Source: Water Account for Australia – 1993-94 to 1996-97 - Australian Bureau of Statistics, May 2000.

7.30. Quality accounting is a useful tool to follow the evolution of the quality of water resources and provide an indication of the efficiency of the measures taken in order to protect or improve the state of water bodies. The comparison of changes in 'stocks of quality' is expected to provide an assessment of the effectiveness of protective and restoration measures.

7.31. There is a complication however. Changes in water quality can have different causes. They could result from emissions of pollutants, self-purification, changes in dilution factors because of increased abstraction of water, increased run-off due to uncontrolled events or new regulations restricting emissions and so on. Each of these events has an effect, positive or negative, on the change of water quality. This is illustrated in the conceptual scheme below. For instance, Δ*(uncontrolled events)* signifies the change in water quality that occurred between t_0 and t_1 that cannot be related to any event out the accounting sphere:

Water quality t_1 = *Water quality* t_0 + Δ*(uncontrolled events)* + Δ*(abstractions)* + Δ*(emissions)* + Δ*(expenditure)*

Suppose that global quality at t_0 was 6.6, there were no major natural events during the accounting period, and no abstractions on this particular stretch. If measuring the quality at t_1 shows that it has increased to 7.0 we could attribute this change of 0.4 to the environmental expenditures that were made, and derive a cost-effectiveness estimate. However, in practice we know that water quality is the result of an unknown function *f* of causes (including the interactions), and quality at t_1 can be more accurately represented as:

Water quality t_1 = *f(Water quality* t_0 + Δ*(uncontrolled events)* + Δ*(abstractions)* + Δ*(emissions)* + Δ*(expenditure))*

As a consequence, it is difficult to attribute changes in 'stocks of quality' to its direct causes. Technically speaking, the causes are non-additive, and therefore we cannot construct stock tables from all the individual flows alone. Because of this, quality accounts have a much simpler structure than the asset accounts of the 1993 SNA and SEEA.

7.32. The better water quality as well as pressures from economic activities and expenditures for protecting water resources are monitored in a common framework, the more policy relevant will the information be for achieving "good status of water resources". Quality is very much linked to the location of the monitoring station as well as to the time of measurement. The information on water quality is usually available in great detail of spatial and temporal disaggregation. For these reasons, it is recommended to calculate quality accounts at the level of river basins and administrative regions as well as quarterly.

D. Issues

1. The choice of determinands

7.33. Different countries use different determinands as illustrated by Table 7.6. There are large differences in both number and choice of determinands used per chemical group when comparing different quality assessment systems between countries. The number of common determinands is very low. This variety reflects primarily different concepts and understandings of local problems. The large difference in pesticides, for instance, reflects the existence of different agricultural practices.

Table 7.6: Number of determinands per chemical group in different assessment systems

	Number of determinands				
Determinand group	**Total**	*of which:* Specific to Canada	*of which:* Specific to France	*of which:* Specific to South Africa	*of which:* Common determinands
Biological information	5	1	1	2	
Environmental	10	1	1	1	6
Gases dissolved	5		2	1	1
Metals (and metalloids)	24	3	2	1	9
Nutrients	5		1	1	1
Organic matters	7		4	1	
Other	1			1	
Pathogenic germs	8	1		3	2
Pesticides	68	22	23	6	4
Radioactivity	26	26			
Salinity	14		1	3	4
Toxics (n-metal, n-pesticides)	104	36	38	3	2

Note: The *total number of determinands* reflects the number of determinands used at least by one country. *Common determinands* refers to the number of determinands used by the three countries in their guidelines. *Specific to country X* refers to the number of determinands used only by country X in its guidelines (and not by the other countries in the table). .

Source: Philippe Crouzet (based on Canadian Council of Ministers of the Environment, 2001 and 2003, Oudin and Maupas, 1999a, Department of Water Affairs and Forestry, 1996).

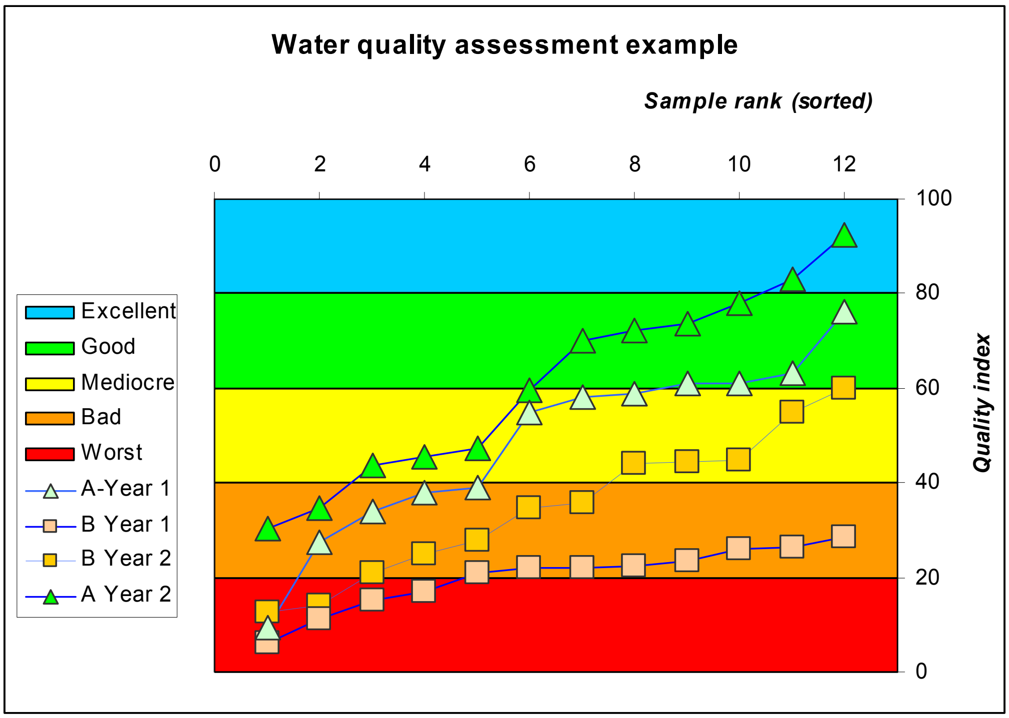
7.34. The choice of determinands is the outcome of a scientific, practical, economical and political compromise. Some important determinands cannot be reliably and affordably monitored because they have special behaviour (e.g. liquid - sediment quick exchange) or because no routine determination method exist. This is especially the case for pesticides, of which a few dozens can be accurately quantified among several hundreds of active substances that are marketed. The same problem occurs when considering biological toxins (with special mention to cyanotoxins) and endocrine disruptors. Large numbers of chemicals, for example toxic hydrocarbons derivatives, are hardly soluble in water and pose considerable problems when attempting to make reliable samples.

7.35. Due to the experimental status of most quality accounts, there has been little or no standardisation of determinands, methods to measure them, as well as threshold values to define quality classes. The main consequence of this lack of standardisation has been the problem of comparability of quality accounts across countries. In the context of the WFD, attempts are under way to standardize both the choice of determinands as well as threshold values for assessing quality classes.

2. The choice of assessment method

7.36. As mentioned in section B, most water quality assessments evoke a form of the 'rule of the worst' i.e. the rule of always choosing the lowest or most detrimental value from a certain set. This rule can be applied at the level of determinands (choosing the worst measured value in a time series for a determinand at a monitoring point), at the level of indicators (choose the quality class of the worst performing indicator), at the level of classifications (choosing the worst class obtained in any classification albeit biological, hydrological or chemical, as recommended by the WFD) or a combination. Figure 7.1 shows the result of applying the "rule of the worst" to arbitrary values.

Figure 7.1: Comparison of assessment rules for two different sets of data



Source: Philippe Crouzet.

7.37. Figure 7.1 represents a hypothetical situation in which 12 measurements are obtained from two locations (A and B) in year 1 and 2. Each point represents the quality index resulting for each sample, and is plotted in the figure in which also the 5 quality classes are represented as shades of grey. Location B shows a significant improvement of quality for 5 samples during year 2. However, since 2 measurements are in the worst class, year 2 is classified identically as year 1. The case of location A is slightly different: it is classified as worst in year 1 and bad in year 2, despite the fact that the results suggest a significant improvement of quality.

7.38. There are several issues with the "rule of the worst". Extreme values, as illustrated in Figure 7.1 can have a significant impact on the eventual classification of the water body. A water body is classified as bad regardless of whether it has only a single trespassing value, or has permanent bad quality status. Furthermore, the improvement of monitoring often results in the apparent worsening of quality indexes (a larger number of measurements of a larger number of determinands increases the probability to monitor extreme values). Finally, the "rule of the worst" tends to hide seasonal variations.

7.39. One possible solution to deal with extreme values is to smooth the effect. As an example, according to the French SEQ-eau approach, the score for each indicator is determined by the most downgrading sample observed in at least 10% of the samples analysed during the period (Oudin 2001). This way of smoothing is of course only possible when there are more than 10 measurements a year.

7.40. An alternative for the 'rule of the worst' is exemplified by the Canadian federal system (CCME) (Canadian Council of Ministers of the Environment, 2001). The principle is based on the weighting of three factors of trespassing values at each site. It takes into account the number of determinands beyond their threshold ("scope" S = number of failed determinands / total number of determinands monitored), the frequency of trespassing during the assessment period ("frequency" F = number of failed tests / total number of tests) and the distance between the threshold and the observed value ("excursion" E = [observed value / target value]-1). All factors are normalised as to fall in the range 0-100.

$$CCMEWQI = 100 - \sqrt{\frac{S^2 + F^2 + E^2}{3}}$$

7.41. The final CCME Water Quality Index (CCMEWQI) is the length of the 3 dimensional vector [S,F,E] normalised to 0-100. For presentational purposes, the length 0 is given the index 100 (best quality). By construction, the index can be applied to different sets of determinands (and therefore different uses of water), as long as annual series exist in order to assess frequency. The authors recommend that datasets should have at least 4 values per year. The overall quality is classified in one of 5 classes: excellent (100-95); good (94-80); Fair (79-65); marginal (64-45) and poor (44-0).

E. Water quality indices

7.42. Due to the experimental nature of developing water quality indices, this section is limited to discussing two indices constructed for rivers. These indices have been used for aggregation, and each corresponds to a different need.

The River Quality Generalised Index (RQGI) aggregates water quality over river basins. Water quality accounts could be used to measure the efficiency of water management programmes that often exist at the basin level. The results of measures taken or the expenditures incurred should be readable through an improvement of the water quality. It is therefore important to be able to aggregate water quality over river basins.

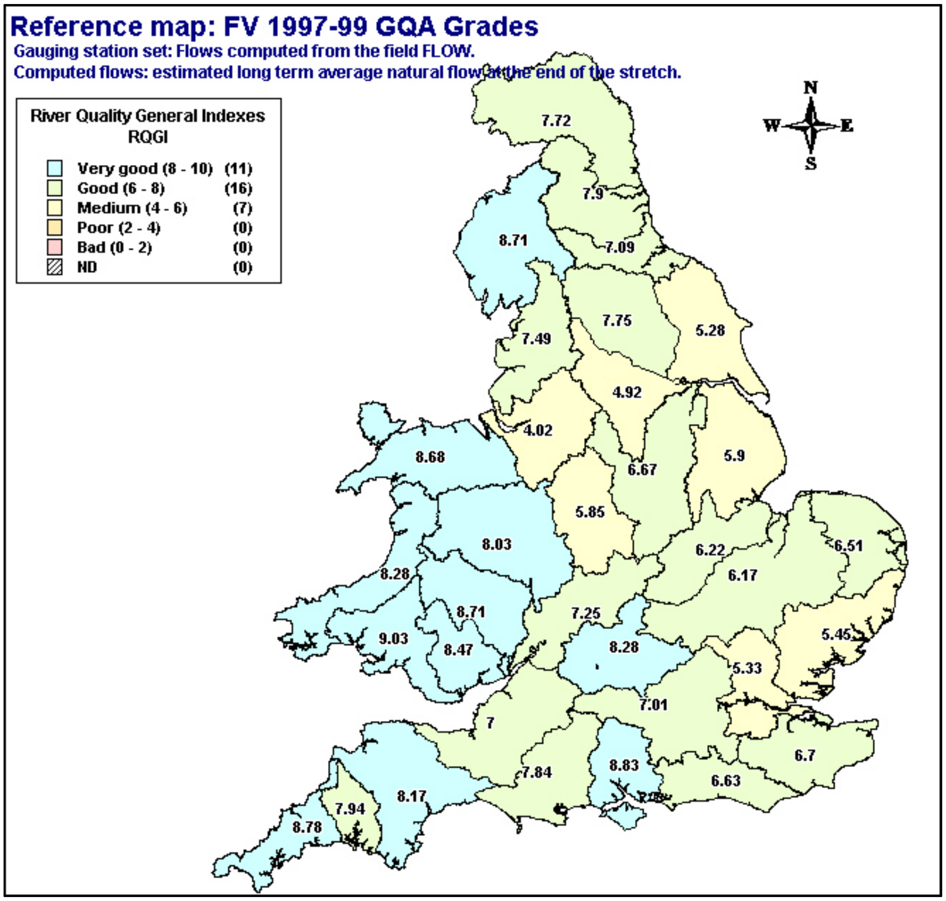
The Pattern Index measures the variance in the quality classes of the stretches that underlies a particular RQGI score for a river basin. It allows for differentiating between basins where water is of a uniform quality and basins where it results from certain "hotspots" or occasional exceeding. Improving the quality of a water body that results from a "hotspot" requires less effort than purifying water that is permanently polluted by numerous chemicals.

7.43. The River Quality Generalised Index (RQGI) is a weighted average of SRU, S_j, according to quality class G_j. It results in a value between 0 (worst) and 10 (best), equally spaced.

$$RQGI = \frac{10}{n} \times \frac{\sum_j S_j \times G_j}{\sum_j S_j}$$

Where n is the range of the quality grades of the assessment system.

Figure 7.2: Global river quality in England and Wales in 1997-1999

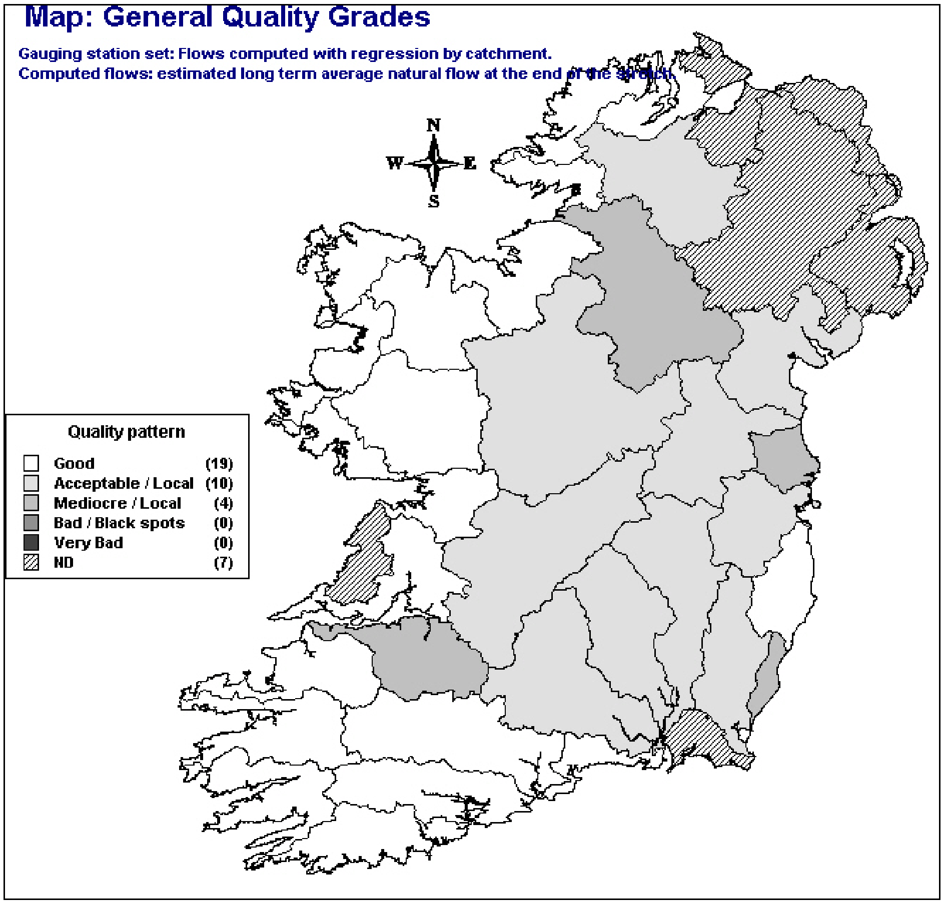


Source: Data collected by EPA England and Wales (EEA, 2001b). Original data published in (Environment Agency, 1998)

7.44. As an application, Figure 7.2 shows RQGI score per river basin in England and Wales in 1997/1999 (EEA, 2001b). The overall index for all the reviewed catchments improved from 6.50 in 1990 up to 7.47 in 1997/1999.

7.45. As an application of the pattern index, Figure 7.3 shows the aggregated map of Irish basins with potentially mediocre quality of waters. These basins, although not showing a high proportion of bad quality, record a low proportion of good quality. Due to their low variance in quality per stretch, they could be confronted with severe water quality problems.

Figure 7.3: 1990 proportion of good or bad biological quality SRUs in the Irish river basins (top) and resulting patterns (bottom)



Source: Data provided by Irish EPA, processing reported in (EEA, 2001c).

F. Implementation

7.46. There is at the moment little experience with the implementation of quality accounts. Most of the experience is concentrated in European countries.

7.47. A project to match economic data and physical accounts was started by Ifen (Ifen and Beture-Cerec, 2003) and resulted in the development and validation of the basic methodology on the Rhin-Meuse area.

7.48. The basic methodology uses detailed quality monitoring data, assesses quality indexes, builds linear maps of quality and run-off (these can be substituted by drained area proxies if run-off data is not available) and computes accounts, either by basin or by administrative unit. It requires a structured river geographical information system (or GIS), in which each stretch can be populated with run-off and quality values, that are obtained from extrapolation modules based on monitoring data.

7.49. The EEA plans to implement this basic methodology, based on the current EuroWaternet, the EEA Water Monitoring and Information Network for Inland Water Resources, which aims at collecting harmonized quality data at different locations throughout Europe. This database, together with the

European delimitation of river basins and the hydrographical maps of the different watercourses that are currently being constructed jointly by four European bodies (Joint Research Centre, Eurostat, DC Environment and the EEA), will constitute the basis to characterize stretches of rivers with quality classes. The actual implementation will be carried out from 2005 onwards, starting with volunteer countries.

7.50. On the basis of the limited country experiences in the implementation of quality accounts, a series of steps can be identified for the quality accounts. These include:

- The precise identification of the water body to be accounted: rivers, lakes and reservoirs, or groundwater. This requires decisions on the minimum size of rivers and lakes to include, on the basis of a statistical assessment of the consequences of leaving out water bodies below the chosen threshold.
- The objectives of the reporting. Are quality classes compiled for indicator production only or should detailed tables, to be analyzed in conjunction with expenditures, be compiled? Should the results be reported at river basin level or administrative region?
- Accurate information on the quality assessment methods in use in the country. Does the assessment method provide classes, indexes, annual or seasonal results? Are raw data available to re-assess quality or are only final results available?
- Information on run-off for rivers, replenishment and residence time for lakes and groundwater.
- A GIS that includes river stretches, internal transfers, position and volumes of lakes and reservoirs, area and capacity of groundwater.
- The organization of data and the availability of ad hoc software, hardware and expert availability to carry out calculations and production of accounts.

Chapter 8 Valuation of water resources

A. Introduction

8.1. The national accounts treat water like all other products: water is valued at price of its transaction. Unlike many other products, however, the prices charged often provide only a poor, inadequate indicator of water's economic value, a situation arising from certain unique characteristics of water:

- Water is a heavily regulated commodity for which the price charged (if any) often bears little relation to its economic value or even to its cost of supply. This situation is sometimes most severe in water-scarce developing countries where water may be provided to some users at no charge. Administered prices occur in part because the natural characteristics of water inhibit the emergence of competitive markets that establish economic value. (For a more detailed exploration of this topic, see Easter et al., 1997; Young, 1996.);
- Water supply often has the characteristics of a natural monopoly because water storage and distribution are subject to economies of scale;
- Property rights, essential for competitive markets, are often absent and not always easy to define when uses of water exhibit characteristics of a public good (flood mitigation), a collective good (a sink for wastes), or when water is subject to multiple and/or sequential use;
- Water is a 'bulky' commodity, that is, its weight-to-value ratio is very low, inhibiting the development of markets beyond local area;
- Large amounts of water are abstracted for own use by industries other than ISIC 36, such as agriculture or mining. Abstraction for own use is not recorded explicitly as an intermediate input of water; hence, the use of water is underestimated and the value of water's contribution, for example to agriculture, is not explicit but accrues to the operating surplus of agriculture.

8.2. The need to treat water as an economic good has been recognized as an essential component of sustainable water management. Integrated Water Resources Management (IWRM), a globally endorsed concept for water management, identifies maximizing economic value from the use of water and from investments in the water sector as one of the key objectives along with equity and environmental sustainability (Global Water Partnership, 2000). This principle was reconfirmed at the 2002 World Summit on Sustainable Development in Johannesburg, the 2003 Third World Water Forum in Tokyo, and the 2005 Millennium Project Report to the UN. The prices charged for water recorded in the national accounts often do not reflect its full economic value.

8.3. The economic value of water can be useful for many policy areas, for example, to assess efficiency in the development and allocation of water resources. Efficient and equitable allocation of water takes into account the value of water used by competing end-users in the present generation, the allocation of resources between present and future generations, and the degree of treatment of wastes discharged to water or other activities that affect water quality. Water valuation can also be useful in setting water pricing policy and in the design of economic instruments to achieve better use of water resources. Instruments for water include property rights, tradable water markets, taxes on water depletion and pollution, and subsidies for water demand management.

8.4. Economists have developed techniques for estimating the value of water. This chapter reviews the techniques for valuation and discusses their consistency with the 1993 SNA valuation. It does not provide recommendations on which valuation technique to use and it should be seen as an overview of existing practices. Further, because there is no consensus on the valuation techniques to use nor on the inclusion of these techniques in the SEEAW because of their lack of consistency with the 1993 SNA valuation principle, this chapter is presented as an add-on to the water accounts for its policy relevance.

8.5. The valuation techniques reviewed include those commonly used for the water goods and services presently included in the water accounts:

(i) Water as an intermediate input to production in agriculture and manufacturing

(ii) Water as a final consumer good

(iii) Environmental services of water for waste assimilation

8.6. Other water values, notably for recreation, navigation and biodiversity protection, and water qualities, such as reliability and timing of water availability, are not addressed.

8.7. Section B discusses some issues that arise in valuing water such as aggregation of water values from the local to national level. Section C describes some background concepts in the economic valuation of water and the valuation principle of the 1993 SNA. Sections D provides an overview of the valuation techniques and section E discusses the strengths and weakness of each water valuation technique through empirical examples.

B. Issues in the valuation of water

8.8. This section briefly presents some issues that arise for the valuation of water goods and services: namely, the scaling and aggregation of water values, the risk of double counting as some value of water is already captured in the accounts and the types of measures of value and their implications.

National and local valuation: scaling and aggregation of water values

8.9. Water valuation has a long history in economics, mostly at the project or policy level. Projects and policies are often implemented for a designated water management area, such as a river basin. There has been little experience of aggregating these localized values to the national level.

8.10. Because water is a bulky commodity and the costs of transporting and storing water are often high, the value of water is determined by local and regional site-specific characteristics and options for use. For example, the value of water as an input to agriculture will often vary a great deal by region because of differing factors that affect production costs and product value, including soil, climate, market demand, cost of inputs, etc. In addition, the timing of water availability, water quality and reliability of supply are also important determinants of water value. Consequently, the value of water can vary enormously within a country even for the same sector.

8.11. The site-specific nature of water values means that water values estimated for one area of a country cannot be assumed to hold in other areas. This poses a problem for constructing accounts for water value at the national level, because the method commonly employed for national accounts - scaling up to the national level from sample data - cannot be as readily applied. It is more accurate and useful for policymakers to construct water accounts at the level of a river basin or an accounting catchment for which economic information can be compiled, and aggregate them at national level to obtain national water accounts. River basin accounts will also be more useful for policymakers because many water management decisions are taken at the river basin level, and even policy at the national level must take into account regional variations in water supply, demand and value. Furthermore, in some countries, there may be extensive transfers of water between river basins. Inter-basin transfers are often valued according to the use made of the water in the receiving river basin.

Double-counting

8.12. In interpreting accounts for the value of water, care must be taken to avoid double counting. The value of water as an intermediate input is already fully included in the 1993 SNA, although it is rarely explicitly identified:

- For industries purchasing water from ISIC 0161 and 36, the water value in the 1993 SNA is spread out among three components of an industry's production costs: the service charge paid, any additional current and capital costs (purchases of equipment, energy, labour, and other inputs) incurred by a company for treatment, storage, or transport of water, and industry value-added where any residual water value accrues.
- For industries abstracting water for own use, the value of water is split between costs incurred for abstraction, transport, treatment, or storage of water; and the industry's value-added.
- For households, water value in the 1993 SNA includes the portion paid to water utilities or incurred by self-providers for abstraction.

8.13. The value of wastewater treatment may be partly reflected in the costs of services provided by ISIC 37 and the costs for self-treatment by industry and households. Damages from changes in water quality to industrial productive capacity or industries' costs of averting behaviour are already included in the 1993 SNA as part of the affected industries' costs of production. Some consumer averting behaviour and health costs may be included in the 1993 SNA as part of consumer expenditures, but others may not be, or may not be easy to identify. The value of recreational or aesthetic water services to consumers may also be at least partly reflected in the market prices of land, housing, or tourism facilities.

8.14. In summary, most values for water are already included in the 1993 SNA, but not explicitly attributed to water. The role of water valuation is to make those values explicit, but they should not be interpreted as additional values not included in the 1993 SNA. The value of water as a consumer good, even if not paid by the users, should in principle be included in the 1993 SNA.

Valuation techniques; marginal *vs*. average value

8.15. There are many valuation techniques for various water uses and, because of their foundation in cost-benefit analysis and its emphasis on economic welfare, they can produce three conceptually different measures of 'value:'

- Marginal value, the price the last buyer would be willing to pay for one additional unit. This value corresponds to price in a competitive market, and in principle is compatible with the 1993 SNA valuation.
- Average value, the average price that all buyers would be willing to pay, including a portion of consumer or producers' surplus, which is the maximum amount that each buyer would be willing to pay, even though he is not actually charged that price. Average value can

be quite different (higher or lower) from the marginal value. For example, the *average* damage from a heavy load of pollution into a lake may be substantially lower than the *margina*l damage that would result from a small increase in load.

- Total economic value, a measure of total economic welfare that includes consumer surplus and producer surplus, that can be used to estimate average value.

8.16. These concepts are defined and explained in section C; their implications for valuation are described further in Section D. Because average value includes consumer/producer surplus, a concept that is not compatible with the concept of value in the 1993 SNA, it would certainly be preferable to use techniques that measure marginal value, but often it is not possible to measure marginal value (see sections C and D). Nevertheless water valuation is useful in its own right, but attention should be paid when comparing water value with national accounts aggregates as the underlying valuation principles are not the same.

8.17. When economic values are intended to contribute to a discourse on valuation, evaluation and policy, then it may be appropriate to include all values for which there are reasonable estimates, regardless of whether they are average or marginal values. In any case, there are very few point estimates of value, whether marginal or average, that can be provided with great certainty. Valuation studies often provide a range of values because of the uncertainty and considerable amount of judgment underlying the method and its implementation. The annual report on cost-benefit analysis of federal regulations in the United States, for example, reports a range of values, sometimes quite large, and guidelines specify some of the alternative assumptions and parameters to be used, such as discount rates (OMB, 2003).

8.18. A useful approach to the valuation challenge would be to include values for all water services that can be estimated with fairly reliable data and techniques, and to identify whether the values are marginal or average so that the user is aware of how this may distort policy analysis.

C. Economic approach to the valuation of water

8.19. In economic terms, water is an essential commodity so the value (willingness-to-pay) for a basic survival amount is infinite. Once basic needs are met, economic valuation can make an important contribution to decisions about water policy. A commodity has economic value when users are willing to pay for it rather than do without. The economic value of a commodity is the price a person would pay for it (or, on the other side of the transaction, the amount a person must be paid in compensation to part with it). Economic values can be observed when people make a choice among competing products available for purchase (or for barter trade - values need not be expressed only in monetary units). In competitive markets, the process of exchange establishes a price that represents the marginal economic value, that is, the value of the last (marginal) unit sold. In the absence of water markets or where markets function poorly, valuation techniques can be used to estimate the economic value of water. One of these techniques is called a 'shadow price' (see Box 8.1).

Box 8.1: Shadow Prices

In economic analysis, such as an evaluation of alternative allocations of water among competing users, it is necessary to express the benefits and costs in monetary terms using prices and quantities. Often observed prices are used. However, observed prices sometimes fail to reflect true economic values. Examples include government regulation that sets prices for commodities like water and energy, taxes or subsidies that distort market prices of agricultural commodities, minimum wage that is set above market clearing prices, or trade restrictions that increase the price of domestically produced goods. In such cases, it is necessary to adjust the observed market price for these distortions. In other cases, there may be no market price at all, and the price must be estimated. The resulting adjusted or estimated price is called a 'shadow price.'

8.20. Economists have many techniques for estimating shadow prices, and a great deal of practical experience applying these techniques. Most techniques were typically developed for cost-benefit analysis of projects and policies, and other applications whose requirements and purposes are quite different from those of the national accounts. Consequently, the application of these techniques for valuation of water in the water accounts, which, as satellite accounts to the 1993 SNA, should be based on the same valuation principles as the 1993 SNA, is not entirely straightforward.

8.21. Water valuation can be quite complex: data are often not available and expensive to collect, water values are usually very site-specific and benefits transfer (a method of applying values obtained from one study site to other sites) is not well developed for many aspects of water, methods and assumptions are not standardized, and uncertainty may be quite high. In addition, many valuation techniques depart from the concept of value in the 1993 SNA, raising major challenges to monetizing water accounts in a manner that is consistent with the 1993 SNA.

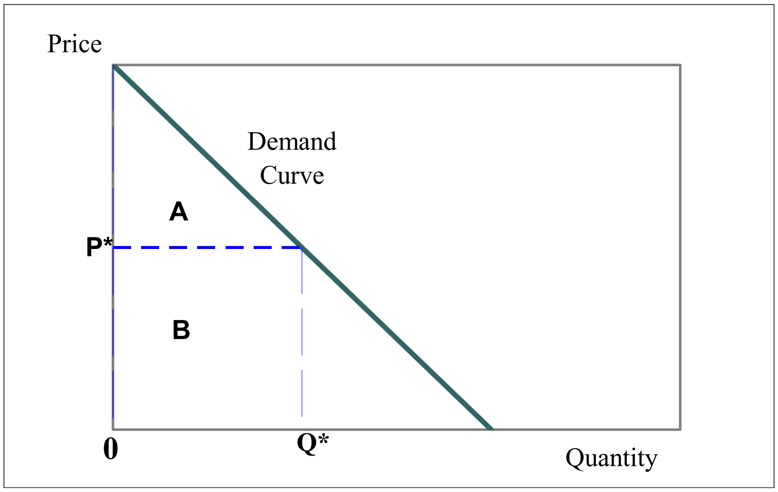
8.22. The 1993 SNA records actual market (and near market) transactions, and the 1993 SNA-value of a product is its market price. In competitive markets, prices represent marginal values of goods and services. There are many instances, however, in which observed prices may differ from marginal values, sometimes significantly, due to factors such as market failure, administered prices, taxes and subsidies, and trade protection. Sometimes these distortions may be large, sometimes small.

8.23. Non-market valuation techniques estimate either marginal value, average value or total economic value (TEV), which includes 'consumer surplus' in addition to the market price paid. Consumer surplus is the difference between what an individual is willing to pay and the price that the individual actually pays. The difference arises because the same price is charged to all consumers in a given market regardless of what the consumer is willing to pay. Prices in the 1993 SNA may be quite different from marginal values, but the 1993 SNA does not include measures of consumer surplus. The relationship among these three concepts of economic value is illustrated in Figure 8.1.

- Total economic value of water is measured as the sum of total willingness-to-pay of all consumers, and is typically displayed as the area under the demand curve. For quantity Q*, *total economic value* is the area A+B. This measure is appropriate in applications such as cost-benefit analysis when the purpose is to measure the total change in economic welfare.
- The figure (A+B)/Q* represents the *average value* of a unit of water when Q* units of water are used. The average value is larger than marginal value (by the amount A/Q*) because it includes a portion of consumer surplus, the difference between consumers' willingness-to-pay (the demand curve) and market price.

- P* represents the *marginal value* of a unit of water at Q*. For an individual, the marginal value represents the benefit from the use of one more unit of water. For a business, the marginal value represents the increase in net revenue made possible by increasing water input by one unit. The marginal value is relevant for assessing the economic efficiency of the allocation of water among alternative uses. Competitive market prices equal the marginal value.

Figure 8.1: Demand curve for water



Note: The value of water for human survival is likely to be infinite and is not included in this graph.

8.24. In some instances it is easier to measure total and average values than marginal values, but the consequences for valuation can be large. For example, it is not uncommon for practitioners to estimate the total damages from water pollution, then divide by the tons of pollutant emitted to obtain average damages per ton of pollutant. This average value is likely to differ significantly from marginal values if the dose/concentration-response function is nonlinear. It can be quite misleading to apply the average value obtained from one study in one location to another location, or even the same location at a different point in time. As mentioned earlier, water services are often provided and acquired without trade or through trade in imperfect markets and hence information is not available for specification of proper demand functions and calculation of marginal or total economic values. In such cases cost rather than benefit-based measures are commonly used to value water.

D. Overview of valuation methodologies

8.25. People value an environmental good such as water for many purposes, which economists classify into use values and non-use values (see Box 8.2). (Note that for the purposes of the following discussion, only water beyond the amount necessary for survival is considered because only this amount of water has a finite value.) Use values refer to the use of water to support human life and economic activity. They include (i) the direct use of water as a resource, (ii) the indirect support provided by water ecosystem services, and (iii) the value of maintaining the option to enjoy direct or indirect use of water in the future (option values). Non-use values include the value of knowing that water and water ecosystems will be available to future generations (bequest value) and the intrinsic value of water ecosystems (existence value).

Box 8.2: Categories of economic values for water

Use Values

Direct use values: The direct use of water resources for consumptive uses such as input to agriculture, manufacturing and domestic use, and non-consumptive uses such as hydropower, recreation, navigation and cultural activities.

Indirect use values: The indirect environmental services provided by water such as waste assimilation, habitat and biodiversity protection, hydrologic function.

Option value: the value of maintaining the option for use of water, direct or indirect, in the future.

Non-Use Values

Bequest value: the value of nature left for future generations.

Existence value: the intrinsic value of water and water ecosystems, including biodiversity, the value people place simply on knowing that a wild river, for example, exists even if they never visit it.

8.26. An estimate of the total value of water should include all use and non-use values. While in many early water valuation studies, only tangible use values were included, in recent decades the value of other uses has been recognized and included to the extent possible. Even where monetary values cannot be reliably estimated, many official government guidelines for cost-benefit analysis require that some physical indicator of values be included. Valuation techniques for most direct uses are relatively well developed, mainly because they are closely related to market activities. The valuation of some indirect uses, like waste assimilation services, is also fairly well developed. However, the valuation of other indirect services (such as habitat protection and cultural values associated) and the non-use values are more controversial and not as well developed. Since these services are not yet included in the water accounts, they will not be discussed further.

8.27. Table 8.1 shows the valuation techniques that have been most often applied to the water uses included in water accounts. All except contingent valuation are based on what economists call 'revealed preference' methods, that is, water value is derived from observed market (revealed) behaviour toward a marketed good related to water. Contingent valuation is a 'stated preference' technique based on surveys that ask people to state (stated preferences) their values. Economists are often more comfortable with estimates derived from actual market behaviour, but for some water services, even indirect market information may not be available such as protecting wetlands or endangered species. Each technique is described in greater detail in the next section. A more detailed discussion of valuation methodologies for water with references to many studies in the literature can be found in (Gibbons, 1986, Turner, et al., 2004; and Young, 1996). Frederick et al. (1996) provide an exhaustive review of water valuation studies in the United States.

Table 8.1: Valuation techniques for water

Valuation techniques	Comments
1. Water as an intermediate input to production: agriculture, manufacturing Residual value Change in net income Production function approach Mathematical programming models Sales and rentals of water rights Hedonic pricing Demand functions from water utility sales	Techniques provide average or marginal value of water based on observed market behavior
2. Water as a final consumer good Sales and rentals of water rights Demand functions from water utility sales Mathematical programming models Alternative cost Contingent valuation	All techniques except contingent valuation provide average or marginal value of water based on observed market behavior. Contingent valuation measures total economic value based on hypothetical purchases
3. Environmental services of water: waste assimilation Costs of actions to prevent damage Benefits from damage averted	Both techniques provide information on average or marginal values

E. Empirical applications of water valuation

8.28. This section presents valuation techniques organized by the major categories of uses addressed in the water accounts: water as an intermediate input to agriculture and manufacturing, water as a final consumer good, and environmental services of water for waste assimilation.

8.29. Examples are also presented to illustrate some of the problems that arise when applying these techniques and how different practitioners have solved them. The majority of water valuation studies have addressed water value for irrigation, waste disposal and recreation (Frederick et al., 1996; Gibbons, 1986; Young, 1996). The reader should keep in mind that some important attributes affecting water quality cannot be dealt with in such a brief overview. For example, the value of water is likely to change with location and the season (irrigation water has low value outside the growing season). The value of water in a particular use will also be affected by the quality of water and the reliability of supply.

1. Valuing water as an intermediate input to agriculture and manufacturing

8.30. The most commonly used valuation techniques for water as an intermediate input into agriculture and manufacturing are the residual value and its variants, mathematical programming and hedonic pricing applications.

8.31. Irrigation is the single largest use of water in the world (Gleick, 1993), but it is also among the lowest-valued uses of water (Gibbon, 1986). Production decisions in agriculture are highly complex and filled with uncertainties. In a review of irrigation water valuation studies, Young (1996) finds most of them flawed, with a tendency to overestimate the value of water. The most commonly applied valuation technique is the residual valuation approach and its variations, change in net income and the production function approach.

8.32. In some countries with relatively little irrigated agriculture, industry is the major user of water. For example, in Sweden, two industries alone, Pulp & paper and Chemicals, accounted for 43% of total freshwater water use in 1995 (Statistics Sweden, 1999). It is often assumed that industrial value of water is relatively high, compared to agriculture, but this use of water has received much less attention than other uses (Wang and Lall, 1999). In a review of valuation of water studies in the United States, Frederick et al. (1997) found 177 estimates for irrigation water, 211 estimates for the recreational value of water, and only 7 estimates for industrial water value.

Residual Value, Change in Net Income, and Production Function Approaches

8.33. Residual value and its related techniques of change in net income (CNI) and production function approach, are techniques applied to water used as an intermediate input to production based on the idea that a profit maximizing firm will use water up to the point where the net revenue gained from one additional unit of water is just equal to the marginal cost of obtaining the water. Residual valuation assumes that if all markets are competitive except for water then the total value of production exactly equals the opportunity costs of all the inputs. When the opportunity costs of non-water inputs are given by their market prices (or their shadow prices can be estimated), the shadow price of water, then, is equal to the difference (the residual) between the value of output and the costs of all non-water inputs to production:

$$TVP = \sum p_i q_i + VMP_w q_w$$

$$VMP_w = \frac{TVP - \sum p_i q_i}{q_w}$$

where

TVP = total value of the commodity produced;

$p_i q_i$ = the opportunity costs of non-water inputs to production;

VMP_w = value of marginal product of water;

q_w = the cubic meters of water used in production.

8.34. Although the literature terms the shadow price of water its ‘value marginal product’, the residual value actually measures average value because VMP is measured for the total amount of production and total non-water inputs, rather than marginal output and marginal costs of non-water inputs. Average and marginal values are identical only in cases where production functions exhibit constant returns to scale. Whether average value diverges significantly from marginal values depends on the nature of the production function, which is an empirical question.

8.35. In applying this technique to water accounts it should be noted that, as formulated above, the value of water includes some costs incurred by the user for abstracting, transporting and storing water, as well as water tariffs. These costs are already included in the national accounts and should not be double-counted.

Box 8.3: Calculating residual value: and example from Namibia

The residual value technique was applied to agricultural production in the Stampriet region of Namibia, where farmers abstract groundwater to raise cattle and irrigate crops including lucerne for their livestock (Lange et al., 2000; Lange, 2002; 2004). A survey was undertaken in 1999 and data for farm income and costs were obtained for 16 of the 66 farmers in the region. The data about some items are considered reasonably accurate, notably farm income, inputs of most goods and services, and compensation of employees. Fixed capital costs, one of the largest cost components, were difficult to estimate because farmers often did not keep good records. Farmers also do not always meter their water and the estimates of water use must be treated with caution. From the survey, average farm income and costs were calculated. Average residual value was calculated as Gross farm income – Inputs of G&S – Compensation of employees – Farmers' imputed income – Capital costs (depreciation, working capital, cost of fixed capital).

Despite the weakness of the data, the results are useful to illustrate the sensitivity of the residual method to the assumptions made. The table shows the costs of production and residual value of water under different assumptions about the cost of capital. Assuming a 5% cost for capital investments, the residual value of water was Namibia $0.19 per cubic meter. But if the real cost of capital, rose to 7%, farmers would not even earn enough to cover all the capital costs and the value of water would be negative.

Farm revenue & costs (in 1999 Namibia $)		Data source
Gross farm income	$ 601,543	Output x market prices from survey
Inputs of goods and services	$ 242,620	Inputs x prices from survey
Value-added, of which:	$ 358,923	
Compensation of employees	$ 71,964	Wages paid + in-kind payments from survey
Gross operating surplus, of which:	$ 286,959	
Imputed value of farmers' labour	$ 48,000	Imputed based on average salary of hired farm manager
Depreciation	$ 66,845	Standard depreciation rates x farmers' estimated historical cost of capital in survey
Cost of working capital	$ 17,059	Imputed as % of the value of fixed capital
Cost of fixed capital including land, 3% -7%	$75,739 to $176,724	Based on farmers' estimated historical cost of capital reported in survey
Residual value of water	$79,316 to -$21,669	
Amount of water used (m3)	154,869	Farmers' "best guess;" water is not metered
Residual value N$/m3	$0.51 to -$0.14	

Source: adapted from Lange (2004) and Lange et al. (2000).

8.36. The residual value method has been widely used for irrigation because it is relatively easy to apply, but is quite sensitive to small variations in the specification of the production function and assumptions about market and policy environment. If an input to production is omitted or underestimated, its value is wrongly attributed to water. In some cases, researchers conduct extensive farm surveys of crop production and inputs. In other cases, secondary data are used to derive average crop yields and production costs. Secondary data may differ considerably from actual inputs and yields of the farming area being assessed. Box 8.3 demonstrates this method using a case study from Namibia.

8.37. Assuming the model specification is accurate, the prices for all inputs and products must be reviewed because some inputs, notably family labour, may not be paid, and the prices of other commodities may differ significantly from their marginal values due to taxes, subsidies for energy, trade protection, etc. Water is a major input to irrigation and its unit value is extremely sensitive to the volume of water used for production. Yet, in many countries, irrigation water is not metered and only estimates are available, based on 'rules of thumb' applied to hectares under irrigation and the type of crop cultivated (Johansson, 2000). In the Namibian case study described in the Box 8.3, farmers' own estimate of the water used was at least 50% higher than the guidelines used by water management authorities (Lange, 2006; 2002).

8.38. Labour is a significant input to agriculture, and often at least some portion of this labour is unpaid. In the 1993 SNA, this is recorded as mixed income together with operating surplus. Unless a value is estimated for this input, the value of water will be overestimated. Family labour is often unpaid in both developed and developing countries and in the 1993 SNA should be estimated on the basis of prevailing wages rather than in terms of the opportunity costs of workers. Farm management is a distinct contribution of the farmer and sometimes less easy to value unless there is comparable farms which hire manager.

8.39. It is not uncommon for governments to subsidize the costs of critical inputs to agriculture, notably fertilizer and energy. Some developing countries also fix the price paid for major agricultural crops, often below their marginal value. In other countries, the price of agricultural commodities may not be directly subsidised, but trade protection is used to maintain high crop prices. In applying the residual value technique these distorted input and output prices must first be corrected.

8.40. Box 8.4 shows two examples of residual value adjusted for trade protection: the United Kingdom and Jordan. In the example of the United Kingdom, the authors did not have information about the amount of water used for each crop, so the residual value is given as the value per hectare, meaning for the total amount of water required to cultivate a hectare's worth of a given crop. After correcting for trade protection, only one crop, potatoes, would generate a positive return to water.

8.41. For irrigation farming, capital can be a substantial component of costs, and the correct costing of capital raises several challenges. In some studies, fixed capital may be omitted entirely or in part (e.g., Al-Weshah, 2000). This may be appropriate in situations of short-term disruption of water supply such as a drought, where the objective is to maximize profits by allocating water to higher value crops under unusual short-term conditions. But these short-term values of water do not reflect the long-term values and are not appropriate for long-term water management because they are overestimated.

8.42. Residual value as described above is suitable for a single crop or single product operation, but for multiple products, a slightly different version is used, the change in net income (CNI) approach. CNI measures the change in net income from all crops resulting from a change in the water input, rather than the value of all water used in production. It is often used to compare the value of water under present allocation to the value that would be obtained under an alternative allocation of water. For example, it might be used to assess a farmer's response to a policy change intended to bring about a change in crop mix or production technology. In contrast to residual value, by measuring the impact of a change, CNI measure the marginal value of water rather the average value obtained with the residual value approach.

Box 8.4: Adjusting the residual value of water for market distortions

The case studies for UK and Jordan show the importance of adjusting for market distortions from trade protection. In both cases, the residual value of water is calculated with and without the effective subsidies from trade protection and substantial differences occur.

Case 1. United Kingdom. Bate and Dubourg (1997) estimated the residual value of water used for irrigation of 5 crops in East Anglia from 1987 to 1991 using data from farm budget surveys. However, data about actual water use was not available so the residual value is calculated for the amount of water needed to cultivate a hectare of a given crop. When the effective subsidies from the EU's Common Agricultural Programme are taken into account, the residual value is negative for all crops except potatoes.

	£ per hectare*	
	Not adjusted for CAP subsidies	Adjusted for CAP subsidies
Winter wheat	101.12	-176.48
Barley	13.45	-164.70
Oilseed rape	220.04	-146.48
Potatoes	1428.84	880.04
Sugar beet	327.93	-3565.10

*Actual amount of water used per hectare of a crop is unknown.

Source: Adapted from (Bate and Dubourg, 1997)

Case 2. Jordan. Schiffler (1998) calculated residual value for fruit crops (apples, peaches, olives, grapes) and vegetable crops (tomatoes, watermelon, cucumbers, squash and wheat) in 1994 based on data from farm surveys. Values were calculated with and without trade protection. The difference was small (7%) for fruit crops, but nearly 50% for vegetables.

	Jordanian dinar per m^3 of water input	
	Not adjusted for trade protection	Adjusted for trade protection
Fruit crops	0.714	0.663
Vegetable crops	0.468	0.244

Source: Adapted from Schiffler (1998)

8.43. Young (1996) notes that the change in net income approach is used more often than the single-crop residual value approach. CNI faces the same problems in correctly specifying the production function and correcting for missing or distorted prices. Since CNI is essentially a comparison of existing production to a hypothetical change, it faces additional data challenges in correctly specifying the resulting income and costs of production for the alternative.

8.44. The *production function approach* uses regression analysis, usually to a cross-section of farmers or manufacturers, to estimate a production function, or, equivalently, a cost function which represents the relationship between inputs and outputs, specifically water and crop yields. The functions are developed from experiments, mathematical simulation models, and statistical analysis of survey or secondary data. The marginal value of water is obtained by differentiating the function with respect to water, that is, measuring the marginal change in output (or reduction in costs) that results from a small change in water input.

8.45. The production function approach and mathematical programming (see below) are the most widely applied techniques for water valuation in manufacturing. The residual value method has not been used for industry water valuation because the cost share of water is quite small in most industrial applications and the residual value method is very sensitive to the quantity of water input. Renzetti and Dupont (2003) used a production function approach to measure the marginal value of water in manufacturing (see Box 8.5). A similar study was undertaken in China by Wang and Lall (1999), using data for about 2,000 firms, mostly medium and large state-owned enterprises, in 1993.

Box 8.5: Marginal value of water by industry in Canada, 1991

Using a production function approach, Renzetti and Dupont (2003) estimate the marginal value of raw water for 58 manufacturing industries in Canada over three years, 1981, 1986, and 1991. Assuming firms minimize their costs, they formulate a translog cost function based on the quantity of output, the quantity of water, the price of capital, labour, energy, materials, water re-circulation, in-plant water treatment, as well as several dummy variables that take into site-specific and industry-specific characteristics such as the aridity of a province and the share of raw water that is used for industrial processes. In the cost function approach, the shadow price of water is estimated as the marginal change in costs resulting from an incremental change in the quantity of raw water intake. The mean shadow value across industries was C$ 0.046/m3 in 1991 prices. In very dry provinces the shadow value was higher than in water-abundant provinces, C$0.098 and C$0.032, respectively.

Industry	Shadow price of water C$/1000m^3
Food	17
Beverages	38
Rubber	6
Plastic	32
Primary textiles	14
Textile products	5
Wood	20
Paper and allied products	31
Basic metals	107
Fabricated metal	48
Transport equipment	25
Non-metallic minerals	23
Refined petroleum/coal	288
Chemicals	72

Source: Adapted from Renzetti and Dupont (2003).

Mathematical programming models

8.46. Various forms of *mathematical programming models* have been developed to guide water allocation and infrastructure development decisions. These models specify an objective function (such as maximizing the value of output) subject to production functions, water supply, and institutional and behavioral constraints. These models may be applied to one sector, such as agriculture to determine the optimal mix of crops, to a watershed to determine the optimal allocation of water among all users, or to a national economy. These may be linear programming models or, simulation models, or more commonly for economy-wide analysis, computable general equilibrium (CGE) models.

8.47. The models calculate shadow prices or marginal value of all constraints including water. Optimisation models, as the name implies, estimate marginal values for water based on an 'optimal' allocation of water and the corresponding reconfiguration of economic activity and prices. An example of a linear programming approach to agriculture in Morocco is given in Box 8.6. An economy-wide approach may use linear programming, simulation, or, more commonly, a CGE (computable general equilibrium) model. Diao and Roe (2000) use a CGE model of Morocco to determine the impact of trade reform on the shadow value of water in agriculture. The long-term change in shadow prices (the shadow prices themselves are not reported) range from –22% for wheat to +25% for fruits and vegetables.

Box 8.6: Linear programming approach to valuing irrigation water

Shadow price of water in selected sectors in Morocco, 1995

Bouhia (2001) develops a linear programming model for Morocco to assist in water management and water policy design. The economic part of the model is based on the Moroccan Social Accounting Matrix, expanded to include 13 irrigated crops and one rainfed agricultural sector. Four types of water are distinguished: water inputs from a network, groundwater, precipitation, and return flows.

	dirham/m^3
Sugar cane	2.364
Other cereals	3.013
Sugar beat	3.042
Fodder	3.047
Barley	3.291
Maize	3.426
Citrus	3.692
Legumes	5.603
Sunflower	6.219
Wheat	7.498
Vegetables	12.718
Livestock	25.019
Industrial crops	48.846
Industry and services	92.094

Source: Adapted from Bouhia (2001).

Hedonic pricing

8.48. Hedonic pricing is based on the idea that the purchase of land represents the purchase of a bundle of attributes that cannot be sold separately, including water services. For agriculture, the bundle includes such things as soil quality, existing farm infrastructure, and water resources. Regression analysis of land sales (or reasonably assessed values of land) on the attributes of the land, both positive and negative, reveals the amount that water services contributes to the total value of land. The marginal value of an attribute of land, such as water quantity or quality, is obtained by differentiating the hedonic value function with respect to that attribute. This technique has been most widely used to estimate recreation values of water and to a lesser extent to estimate the value of water for agricultural. Box 8.7 provides an interesting example of hedonic pricing that combines both water quantity and water quality in Cyprus. Many similar studies have been carried out throughout the world where water quality is an issue.

2. Water as a final consumer good

Markets for water and tradable water rights

8.49. A few water-scarce countries have instituted markets for trading water or water rights either on a temporary or permanent basis, notably Australia, Chile, Spain, and parts of the United States. (See Garrido, 2003 for an overview of these markets and how they have functioned.) Trading in a competitive market could establish a price that represents the marginal value of water. In the countries that have established water markets, market trades have generally increased the efficiency of water use by providing strong incentives for allocating water to higher-value uses and for water conservation. However, evidence suggests that the transactions prices do not represent the marginal value because the conditions necessary for a competitive market are not present (Young, 1996).

Box 8.7: Hedonic valuation of irrigation water quantity and quality

Koundouri and Pashardes (2002) use hedonic pricing to estimate the value of water for irrigation use in Cyprus where saltwater intrusion is occurring in coastal areas. The authors must address an additional challenge to hedonic modelling: land can be used for either agriculture or tourism. Land that is closer to the sea is less productive for agriculture due to saltwater intrusion, but increases in value for tourism. The authors regress land values (from a 1999 survey of 282 land owners) on a number of variables reflecting existing infrastructure, location, quality of land and the salinity of the underlying groundwater, which was represented by proximity to the coast. The sample selection included only agricultural land users, excluding land used for tourism so that the value of land would not be affected by tourism land demand. The farmers' marginal WTP for avoiding saline groundwater was £10.7 per hectare.

8.50. A competitive market requires, among other things, a large number of buyers and sellers and frequent transactions. In Chile, water trades accounted for only 1% of total abstractions by the mid-1990s and prices ranged from US$250 to $4,500 a share (4,250 m3) (Brehm and Quiroz, 1995; Hearne and Easter, 1995). Development of water markets was greatest in areas with effective water-use associations, well-defined property rights and good irrigation infrastructure (large reservoirs, adjustable gates with flow meters); in areas without these characteristics, high transactions costs limited water market development. In a few countries tradable water rights may provide a basis for water valuation in the future, but this technique has not been applied yet.

Consumer and municipal water use

8.51. Municipal water use includes a number of distinct groups: households, government, and sometimes commercial and industrial use. Most studies focus on household demand when it can be readily separated from other users. The two most common approaches to valuing domestic use of water, above a basic survival amount, involve estimation of the demand curve either from actual sales of water (revealed preference), or using contingent valuation approach (stated preference). Both approaches estimate the average value of water.

Demand functions estimated from water sales

8.52. This approach uses econometric analysis to measure total economic value (consumer surplus), which is then used to calculate average value, based on an estimate of what the average consumer would pay. The conditions under which a demand curve can be derived are rather stringent and are often not obtained, even in developed countries. (See Walker et al. (2000) for more detailed discussion). Water use must be metered to provide accurate data about volume consumed and water charges must be based on volume consumed, because when consumers pay a lump sum, the marginal cost is zero and their consumption does not reveal marginal value. Demand curves cannot be estimated where water is rationed or where a single marginal price is charged to all consumers. Where a single price is charge, a less reliable alternative sometimes used is to trace the real tariff over time and changes in water consumed. Walker et al. (2000) also point out that the water demand function of households with piped water differs substantially from those relying on unpiped water supply, a common situation in most developing countries. An accurate estimate of consumer demand must include both types of households. Appropriate sales data will provide two or more points to which a demand curve is fitted, usually assuming a semi-log demand function. The value of water is highly sensitive to the functional form assumed for the demand curve.

Contingent Valuation Method

8.53. The contingent valuation methodology (CVM) differs from all the previous methods in that it does not rely on market data, but asks individuals about the value they place on something by asking them how much they would be willing to pay for it. This is particularly useful for eliciting the value of environmental goods and services for which there are no market prices, such as recreation, water quality, and aquatic biodiversity. CVM was first used several decades ago, but became a much more popular technique after 1993 when standardized guidelines for CVM applications were set out by a prestigious panel of economists following a disastrous oil spill off the Alaskan coast (NOAA, 1993). The technique has some application to consumer water demand, in which consumers are asked how much they would be willing to pay for water. CVM typically measures total economic value from which an average value can be estimated.

8.54. Box 8.8 discusses a case where consumer demand curves are derived using both methods, CVM and estimated demand functions. Although the results are similar in some cases, they are quite different in others. The authors consider the demand function approach more reliable because it is based on actual market behaviour. They conclude that for estimating consumer water demand CVM is not a good substitute for revealed preference (Walker et al., 2000). A comparison of values derived from CVM and revealed preference studies for a wider range of environmental services show a similar disparity (Hanley and Spash, 1993).

3. Valuing the environmental services of water for waste assimilation

8.55. The SEEA identifies two principles for the direct valuation of environmental degradation: cost-based and damage-based. The former is based on the cost of preventing environmental degradation and has been referred to in the past as the 'maintenance cost' approach. The latter is based on the benefits of averting damage incurred from environmental degradation.

Benefits from Averting Damage from Water Degradation

8.56. This approach measures the value of water's waste assimilation services in terms of the benefits from averting damages resulting from loss of this service. Damages include human illness and premature death, increased in-plant treatment of process water required by industry, increased corrosion or other damage to structures and equipment, siltation of reservoirs, or any other loss of productivity attributable to changes in water quality.

Box 8.8 : Two approaches to measure the value of domestic water in Central America

Walker et al. (2000) used two different methods to estimate the value of water, revealed preference and contingent valuation. The revealed preference approach derived a demand curve based on surveys of household water consumption and expenditure from 1995-1998 in 7 cities in Central America. The survey distinguished households with piped and unpiped water. The price paid for a cubic meter of water is different for households with piped and unpiped water, and a demand curve could be derived from the 2 points. For households relying on unpiped water, water expenditure included both cash payments for water plus the opportunity cost of the time required to haul the water, so there were further variations in the cost per cubic meter of water depending on the distance to water source.

The contingent valuation survey asked households how much they would be willing to pay for improved service with monthly consumption of $30m^3$. Each household was given only one price to respond to and could answer yes or no. Different households were given different prices and the distribution of yes and no answers for the different prices was used to derive a demand curve. In 4 cities, the revealed preference and CVM estimates were fairly similar, but in the other 3 cities, the two approaches differed by 100%. The authors conclude that the variation is too great to use CVM when good revealed preference data are available.

	Price at which consumers would demand 30 m^3 (US$/$m^3$)	
	CVM	**Revealed preference**
Sand Pedro Sula, Honduras	0.13	0.49
Intermediate cities, Honduras	0.10	0.14
Managua, Nicaragua	0.16	0.23
Sonsonate, El Salvador	0.32	0.16
Santa Ana, El Salvador	0.21	0.19
San Miguel, El Salvador	0.49	0.17
Panama and Colon, Panama	0.51	0.40

Note: figures represent average value

Source: Adapted from Walker et al. (2000).

8.57. The first task in providing this value is to identify standards for the waste assimilation capacity of a water body. Water standards have been established by international organizations like World Health Organisation (WHO) as well as by national agencies in terms of concentrations of substances. These concentrations are often grouped according to the maximum level acceptable for a particular use, with human consumption requiring the highest standard. Recreational water usually does not have to meet such a high standard. Some industrial processes require extremely clean water while others may not, e.g., water used for cooling, although polluted water may damage or corrode equipment. Water for irrigation also does not have to meet the highest standards.

8.58. The next step is to determine the extent of damage caused by a change in water quality. For human health damage, a 'dose-response' function is used, which relates a change in a specific aspect of water quality to the incidence of human illness and death. Engineering studies provide similar concentration-response functions for damage to land, buildings, structures and equipment, and the environment. These damages must then be valued.

8.59. The value of clean drinking water can be measured, for example, as the value of waterborne disease and premature deaths averted. The value of health risks averted usually includes the cost of medical treatment and value of lost work time, but not the value of social disruption, loss of educational opportunities for children, personal suffering and loss of leisure time. Damage to land and property includes, for example, the cost of declining agricultural productivity, the loss in hydroelectric power resulting from accelerated siltation of a dam, or the cost of accelerated corrosion of structures from increased salinity.

8.60. Measuring and valuing damage can be particularly challenging: damages may not occur during the same accounting period as the change in water quality, there may be great uncertainty about the degree of damage caused by a change in water quality, or damages may occur further downstream, even in another country. Even when damages can be measured, it is not easy to value them, particularly environmental damages. In most instances, total damages are estimated and an average damage cost per unit of pollutant is estimated. A great deal of effort has gone into estimating marginal damage functions, although these estimates are more widely available for air pollution than for water pollution.

Costs of Averting Damage from Water Degradation

8.61. Like the damage-based valuation approach, the maintenance-cost approach is also based on environmental degradation, but rather than looking at the cost of damages caused, it is based on the cost of actions to prevent damage. It is based on the premise that, for actions by individuals (such as purchasing bottled water), an individual's perception of the cost imposed by adverse environment quality is at least as great as the individual's expenditure on goods or activities to avoid the damage. Actions taken by society, such as regulation and collective treatment of waste water, represent a social perception of relative costs and benefits. As in the damage-based approach, information needs include: the assimilative capacity of water bodies, the emission of pollutants by specific activities (including consumption), the relationship between concentrations of pollutants and environmental function, and the relationship between levels of activities and emission of pollutants. Since these relationships are likely to be non-linear, they pose a significant challenge for the policymaker.

8.62. The cost-based approach has three variants: structural adjustment costs, abatement cost and restoration cost. *Structural adjustment costs* are those costs incurred to restructure the economy (production and/or consumption patterns) in order to reduce water pollution or other forms of environmental degradation to a given standard. It addresses both production activities and consumption. The level of specific activities may be reduced or entirely eliminated. Measuring the cost of structural change often requires complex economy-wide modelling.

8.63. The *abatement cost approach* measures the cost of introducing technologies to prevent water pollution. Technologies include both end-of-pipe (e.g., filters that remove pollutants from the wastewater stream) or change in process (e.g., substitution of less polluting materials) solutions. At the consumer level, it includes expenditures for substitute goods, such as buying bottled water instead of using tap water, or the cost of activities like boiling water for drinking. *Restoration cost approach* measure the costs of restoring a damaged water body to an acceptable state. The abatement cost approach is the most widely used of the cost-based approaches.

8.64. The cost of preventing emission of pollutants was used to value loss of water quality in some of the early water degradation accounts in developing countries like the Philippines (NSCB, 1998) and Korea (KEI, 1998). Pollution abatement costs were estimated using benefits transfer, which is a process of adjusting parameters, cost functions, damage functions, etc. developed at one time in one setting for use in another context. In principle, marginal abatement curves should be applied to estimate the marginal and total costs of pollution reduction in each plant. In practice, an average figure per unit of pollutant was used because information about specific plants was not available. The advantage of this valuation approach is that, at the time, it was easier to obtain estimates of the costs of technologies used to reduce pollution emissions than to estimate the benefits from reduced pollution. There is a growing body of literature on the health and industrial production impacts of pollution, which now makes it easier to estimate the damages averted from changes in water quality, although many of these damages are average rather than marginal values.

8.65. The benefit from damages averted is a widely used approach in the cost-benefit literature and the preferred technique for the SEEA. Often, the results are reported as the total benefit from costs averted or average cost per statistical life saved (or illness prevented). Marginal costs, which relate potential damages averted to marginal changes in water quality (measured as the concentration of substances), are not often reported. One study that does use marginal damage cost functions is *Value of Returns to Land and Water and Costs of Degradation* by CSIRO, a report to the Australian National Land and Water Resources Audit. Part of the results is shown in Box 8.9.

Box 8.9: Marginal cost of water degradation

In a report to the Australian National Land and Water Resources Audit, Hajkowicz and Young (2002) estimated the value of water in different uses, and the costs of water degradation nationwide. The latter includes water degradation due to salinity, erosion, sedimentation, and turbidity. They estimated marginal damage costs using cost functions derived from engineering studies. With salinity, the major problem is corrosion of equipment. The marginal damages from a unit increase in salinity are shown below. Households use the most water (85%) and suffer the highest costs from a marginal increase in salinity, mainly from damage to plumbing systems, hot water heaters and rain tanks. For industry, the major damages are to cooling towers and boiler water feeders.

Marginal damage costs from a unit increase in salinity for urban and industrial water users, Murray River (1999 Australian $ per unit of EC*)

	Marginal cost of salinity	Share of total water use
Households	111,270	85%
Industrial	54,780	12%
Commercial	7,400	4%

*EC = electrical conductivity units, a measurement of water salinity roughly equivalent to 1.6 x Total Dissolved Solids in water (mg/L).

Source: Adapted from Hajkowicz and Young (2002).

Chapter 9 Examples of policy uses and applications of water accounts

A. Introduction

9.1. Global freshwater resources are under pressure from ever-increasing demand for human activities, contamination from pollution, increasing incidence of water-related disease, loss and degradation of freshwater ecosystems, and global climatic change that affects water supply and demand. As the limits of domestic water resources are reached, countries are increasingly dependent on shared international water resources, raising the potential for conflict. These concerns affect both industrialized countries with highly developed water and sanitation infrastructure as well as developing countries where many people still do not have access to basic services. Social disruption, premature death and lost productivity from water-related illness impose a heavy cost on developing countries. Under these growing pressures, water management has become increasingly difficult.

9.2. Most water statistics focus on hydrology and water quality, but have not paid much attention to economic and social aspects (Vardon and Peavey, 2004). Ssome critical policy questions require linking data about water with economic data, for example:

- the consequences for water resources of economic growth, and patterns of household consumption and international trade;
- the social and economic impacts of water policy instruments such as regulation, water pricing, and property rights;
- the contribution of specific economic activities to pressure on water resources and options for reducing pressure.

Water accounts provide a unique tool for improved water management because they integrate data about both the environmental and economic aspects of water supply and use.

9.3. The ability to address jointly the environmental, economic, and social aspects of water policy is central to Integrated Water Resources Management (IWRM), a widely accepted approach to water management adopted by Agenda 21, the EU Water Framework Directive (Directive 2000/60) and the 2003 Third World Water Forum in Tokyo. IWRM has also been identified as one of the immediate actions countries should take for achieving the Millennium Development Goals, which has been widely adopted as the framework for development (MPTFWS, 2003).

9.4. IWRM is based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good, whose quantity and quality determine the nature of its utilization.

9.5. Water accounting has a unique contribution to make to IWRM because it is the only approach that integrates economic accounts with accounts for water use and supply in a framework that supports quantitative analysis. Water managers often have information about water use by broad groups of end-users, but this data cannot be easily used for economic analysis because the classification of end-users rarely corresponds to the classification of economic activities used for the national accounts. The water accounts, in contrast to other water databases, links water data (use, supply, resources, discharge of pollutants, assets etc.) directly to economic accounts. They achieve this by sharing structure, definitions and classifications with 1993 SNA; e.g. water suppliers and end-users are classified by the same system used for the economic accounts, that is the International Standard Industrial Classification of all Economic Activities (ISIC) (UN, 2006b).

9.6. The first part of this chapter focuses on the policy uses of water accounts with examples drawn from countries that have compiled water accounts. The water accounts, like other environmental accounts and the economic accounts, provide (i) indicators and descriptive statistics for monitoring and evaluation, and (ii) detailed statistics for policy analysis. Section B describes the most common indicators used to evaluate the current patterns of water use and supply, and pollution. It begins with macro-level indicators that provide 'warning' signs of a trend that may be unsustainable or socially undesirable, often at the national level. It then progresses to more detailed indicators and statistics from the water accounts that shed light on sources of pressure on water resources, opportunities for reducing the pressure, and contribution of economic incentives (such as pricing) to the problem and possible solutions. These indicators can be compiled directly from the water accounts without requiring much technical expertise.

9.7. The Annex addresses more thoroughly the link between indicators that can be derived from the water accounts and sets of indicators and index numbers developed by international organizations, such as the Millennium Development Goals, UN Commission on Sustainable Development (Sustainable Development Indicators) and OECD (Environmental Indicators).

9.8. This information sets the stage for analysis of more complex water policy issues, mostly based on economic models that incorporate the water accounts. Rather than attempting a comprehensive review, section C seeks to demonstrate the use of water accounts for several critical policy issues such as projecting future water demands or estimating the impact of water pricing reform. Generally, these applications require cooperation between statisticians and economists and other specialists with expertise in various analytical techniques.

9.9. Countries generally do not embark in the compilation of all the modules of the water accounts at once rather they start with those modules that address more directly the country's policy concerns. Virtually all countries begin with physical supply and use tables for water and emissions, viewing these tables as the most important for improved water management. Countries add monetary accounts for water and accounts for pollution depending on the policy concerns and data availability. Asset accounts have been generally compiled at a later stage of implementation. Most examples of policy applications utilize accounts for the supply and use of water and generation of pollution described in Chapters 3 and 4.

9.10. Although the water accounts are usually compiled at the national level for an accounting period of one year, this is often not so useful for water managers because water availability and use often vary among regions, and from one season to the next within a year. Section D addresses this problem by describing the development of water accounting on a regional basis - often for river basins or the 'accounting catchment' defined earlier in the manual. Several countries now compile water accounts on a regional basis (e.g., Australia, France, Netherlands and Sweden). The possibility of introducing more flexible temporal dimensions is also discussed.

9.11. IWRM is based on the concept that water resources (rivers, groundwater, lakes, wetlands, etc.) are linked to each other, to human activities and to other resources such as forests and land use. Improved water management requires taking into account all related resources. Section E describes some of the links between water accounts and other resource accounts in the SEEA that would be useful for IWRM and a more comprehensive approach to sustainable development.

B. Indicators for water management

9.12. The first step toward improved water management is usually to obtain a good understanding of current patterns of use, supply and pressure. Descriptive statistics and indicators from the accounts provide information on:

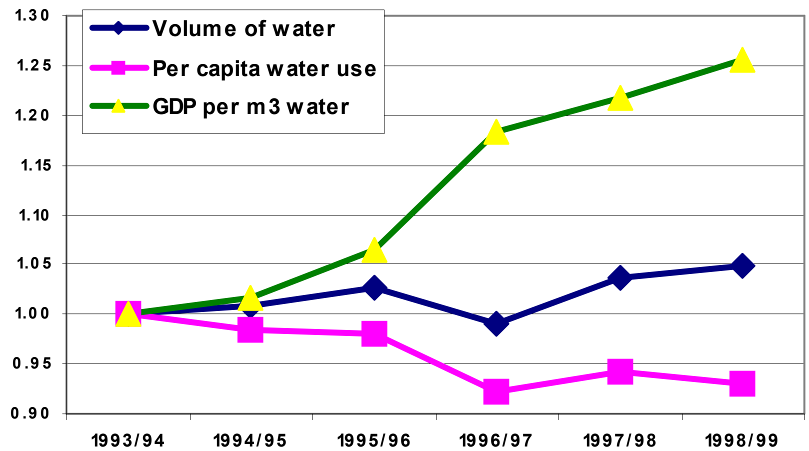
- *Sources of pressure on water resources*: how much does each sector contribute to particular environmental problems, such as overexploitation of groundwater or water pollution?
- *Opportunities for improving water productivity*: Is water being allocated to the highest value users? What opportunities exist to increase water efficiency and productivity? How extensive are losses?
- *Water pricing policies*: are water providers achieving full cost recovery? Is pricing equitable across different users? Do pricing policies provide incentives for water conservation and pollution prevention, or do they encourage excessive use of water resources?
- *Sustainability of water use*: comparing water resources and water use

9.13. This section discusses how the water accounts contribute to each one of these areas of information. The indicators presented have all been introduced and defined in Chapters 3-5; notes to each table and figure identify the relevant chapter.

1. Sources of pressure on water resources

9.14. Simple time trends of total water use and pollution reveal changing pressure on water resources and indicators of 'decoupling,' that is, separating economic growth from increased use of resources. For example, in Botswana, per capita water use and water productivity (measured by GDP per cubic meter of water used) both declined from 1993 to 1998, so that the volume of total water use increased only 5% (Figure 9.1) even though GDP grew more than 25%. For a water scarce country, this is a positive trend. Statistics Netherlands constructed a similar set of indicators for wastewater and water pollutants (nutrients and metals) over the period 1996 to 2001 (van der Veeren at al., 2004): even though GDP has grown considerably, the Netherlands managed to reduce the volume of water pollutants substantially (Figure 9.2). Of course, to assess the pressure on water, either as a source or a sink, these trends must be evaluated against water availability in specific places and seasons. Most countries have not integrated this step with their water accounts, an issue taken up later in this part of the chapter.

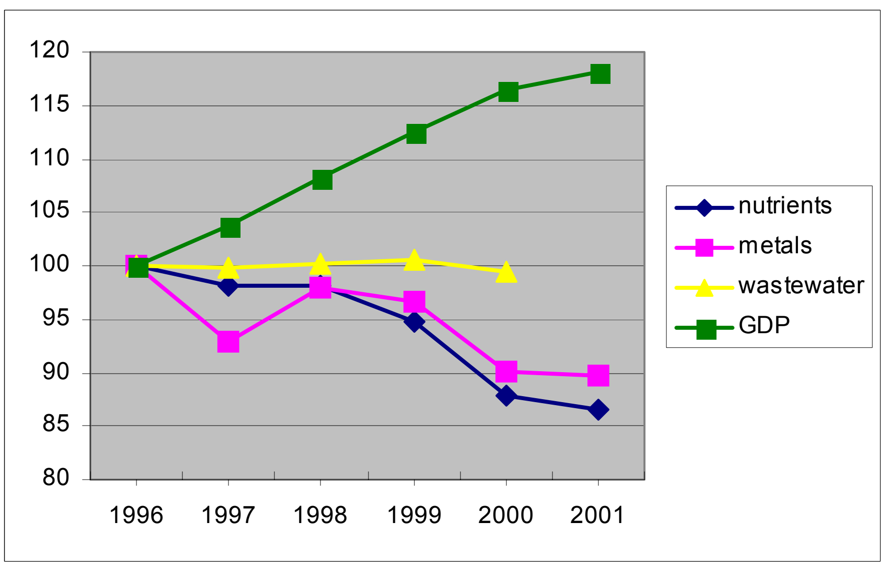
Figure 9.1: Index of water use, population and GDP in Botswana, 1993 to 1998 (1993 = 1.00)



Note : These indicators can be derived from the physical supply and use table described in Chapter 3

Source: Based on Lange et al., 2003

Figure 9.2: Index of growth of GDP, wastewater, and emissions of nutrients and metals in the Netherlands, 1996 to 2001 (1996 = 1.00)



Note : These indicators can be derived from the physical supply and use table and the emissions table described in Chapters 3 and 4

Source: Figure 25, van der Veeren et al. (2004)

9.15. Even at the macroeconomic level, the water accounts typically make further distinctions based on characteristics of water to provide a more thorough and useful assessment of trends. Some of the most common characteristics include:

- Volume of water used disaggregated by purpose such as cooling, industrial process, cleaning, etc. This is useful for identifying the potential for water conservation and improvements in water efficiency. In Denmark, for example, 79% of water was used for cooling (Table 9.1, Statistics Denmark, 1999).

- Volume of water provided by water utilities compared to water abstracted for own use and reuse of water. Nearly half of Australia's water use in 2000-01 was abstracted directly by end-users, with the remaining provided through water mains or by reuse of water (Table 9.2). This distinction is important because in some countries there are significant differences among these sources in terms of water regulations, the capacity for monitoring may differ, and investment strategies for the future are affected by the source of water.
- Volume of abstracted water by natural source. Overexploitation of groundwater, for example, may be a critical issue in some countries so water managers need accounts that identify trends in groundwater abstraction and the users of groundwater. Similarly, it may be very useful to identify use of water from shared international water resources when allocations from such resources are restricted.
- Similar measures can be compiled for wastewater (e.g., shares that are treated and untreated) and pollution.
- Quality status of water bodies by catchment and size class, leading to apportioning causes between point, non-point, domestic, and other sources. Identifying the roles of different sources allows identification of sound investment in corrective measures.

Table 9.1: Water use by purpose in Denmark, 1994

	1000 m^3	Percent
Tap water**	434,400	6%
Cooling	5,356,157	79%
Production processes	58,276	1%
Added to products	3,996	*
Other purposes	885,896	13%
Total	6,738,725	100%

*less than 1%

** Tap water refers to water distributed by the water supply industry, ISIC 36

Note: This table can be derived from the physical supply and use table described in Chapter 3

Source: Adapted from Statistics Denmark (1999).

Table 9.2: Water use by source in Australia in 2000-01

	GL (10^9 liters)	**Percent of total water use**
Abstraction for own use	11,608	47%
Water received from ISIC 36	12,784	51%
Reuse	527	2%
Total	24,919	100%

Note: This table can be derived from the physical supply and use table described in Chapter 3

Source: ABS (2004).

Comparing environmental and socio-economic performance of industries

9.16. The economy-wide indicators discussed above provide an overview of the relationship between economic development and water use, but information about water use at the industry level is required to understand the trend and prioritise actions. Environmental-economic profiles are constructed to compare the environmental performance of industries, or individual companies within an industry, among each other and over time. These profiles include indicators that compare the environmental burden imposed by an industry to the economic contribution it makes. For a simple water profile, an industry's environmental burden is represented by its share of water use and/or pollution generated, and its economic contribution is represented by its share of value-added. Water profiles may be used for "benchmarking" industry performance in order to promote water efficiency and water conservation.

9.17. In Australia, for example, Agriculture accounts for 67% of total water use, but less than 2% of GDP (Table 9.3), indicating that its burden on water is greater than its economic contribution—but how much greater in comparison to other industries? Water productivity combines the two elements, economic contribution and environmental burden, into a single number by dividing industry value-added by water use (see Chapter 5 for a precise definition and derivation of this indicator).

Table 9.3: Water profile and water productivity in Australia, 2000-2001

	Water consumption (Megalitres)	Percent distribution of water consumption	Percent of Industry Gross Value-added	A$ VA/m3 water consumption
Agriculture, total	16,660,381	66.9%	1.8%	0.58
Livestock	5,568,474	22.4%	0.3%	0.27
Dairy farming	2,834,418	11.4%	0.3%	0.53
Vegetables	555,711	2.2%	0.3%	3.27
Fruit	802,632	3.2%	0.3%	1.98
Grapes	729,137	2.9%	0.3%	1.86
Sugar	1,310,671	5.3%	0.1%	0.22
Cotton	2,908,178	11.7%	0.2%	0.42
Rice	1,951,160	7.8%	0.1%	0.18
Forestry & fishing	26,924	0.1%	0.3%	57.42
Mining	400,622	1.6%	6.3%	84.81
Manufacturing	866,061	3.5%	13.6%	84.70
Electricity and gas supply	1,687,778	6.8%	2.1%	6.59
Water supply	1,793,953	7.2%	0.8%	2.35
Other industries	832,100	3.3%	75.2%	487.65
Households	2,181,447	8.8%	Na	Na
Environment	459,393	1.8%	Na	Na
Total	**24,908,659**	**100.0%**	**100.0%**	

Na: not applicable

Note: This table can be derived from the physical supply and use table described in Chapter 3

Source: Based on ABS (2004).

9.18. Water productivity is the most widely used indicator from the water accounts for cross-sector comparisons. It provides a first approximation of the potential gains and losses from a reallocation of water - an issue taken up in more detail in Section C. Water productivity is also interpreted as a rough approximation of the socio-economic benefits generated by allocating water to a particular industry (and is sometimes mistakenly confused with water value - see Chapter 8 for a discussion of this distinction). As shown in Table 9.1, Australia's water accounts reveal that water productivity in agriculture (A$0.58 of VA/$m^3$ of water) is orders of magnitude less than services (Other industries, A$487.65).

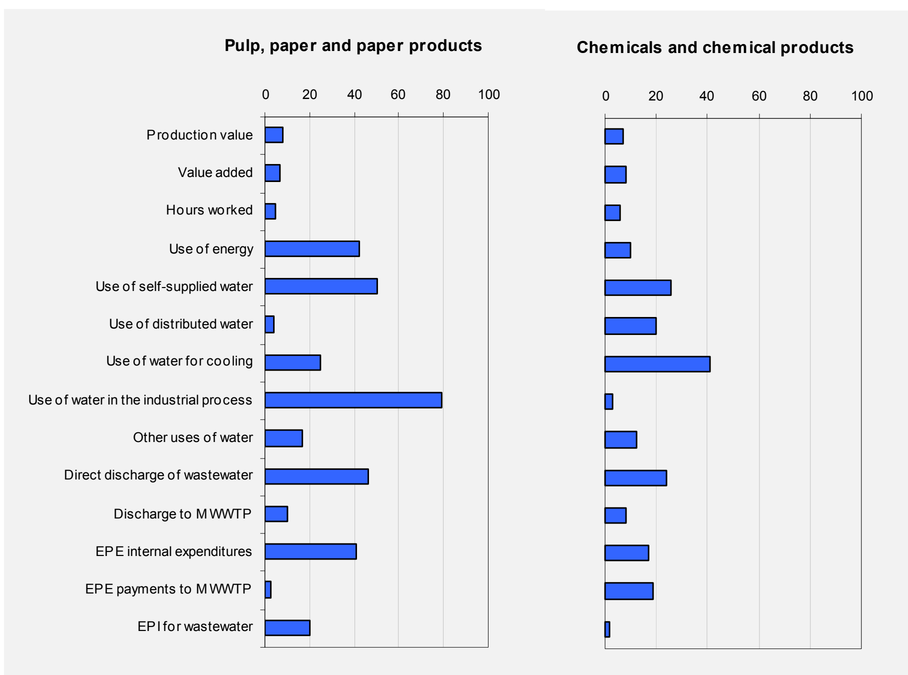
Table 9.4: Water profile for Namibia, 1997 to 2001

(Namibia $ of value-added per m^3 of water use, constant 1995 prices)

	1997-98	1998-99	1999-2000	2000-01	2001-02
Agriculture	5.5	5.6	5.5	5.2	4.5
Commercial Crops	0.8	0.8	0.7	0.8	1.0
Commercial Livestock	18.5	18.6	19.2	22.2	20.9
Traditional agriculture	7.5	8.4	8.1	6.2	4.6
Fishing	14,352.5	1,573.9	936.2	983.3	991.3
Mining	130.3	132.9	172.1	174.4	167.0
Manufacturing	227.7	205.9	228.5	223.9	226.6
Services	547.7	535.9	582.7	590.2	575.3
Government	211.1	211.8	236.7	216.6	234.2

Note: This table can be derived from the physical supply and use table described in Chapter 3
Source: Based on DWA, 2005 and Lange forthcoming 2006

Figure 9.3: Environmental-economic profiles for some Swedish industries, 1995



Notes: The values are percentages of the total for manufacturing enterprises recorded against each variable. The indicators for this profile are obtained from the physical supply and use table (Chapter 3), the emission accounts (Chapter 4), and the tables for environmental protection expenditures and investment (Chapter 5)
EPE = Environmental protection expenditure; EPI = Environmental protection investment
Source: Statistics Sweden, 1999.

9.19. It is quite useful to compile a times series of environmental-economic profiles over time, such as the water productivity time series for Namibia in Table 9.4. Water profiles can also be much more extensive, as shown in the example for two industries in Sweden (Figure 9.3) using 14 measures of performance: three measures of economic contribution (production, value-added, hours worked), one non-water environmental factor (energy use), and 10 factors related to water use and wastewater treatment.

9.20. For effective water management, one must understand the reasons for large differences in water use and pollution emissions from different industries. A country's water use or pollution depends on several factors: size and structure of the economy, technology, and population. Size is indicated by total GDP, structure by each industry's share of GDP, and technology by water intensity of each sector (see chapter 5 for more detailed discussion of the derivation of water intensity indicators).

Table 9.5: Water intensity and total domestic water requirements by industry in Namibia, 2001-2002

	Percent of water use	Water intensity (direct): Litres/N$output	Total domestic water requirements: litres/N$ output
Commercial crops	42.5%	326.56	350.7
Commercial animal products	9.0%	17.55	35.7
Traditional agriculture	23.1%	117.7	156.8
Fishing	0.2%	0.04	21.8
Mining	2.5%	0.96	16.9
Meat processing	0.5%	1.29	31.5
Fish processing	0.3%	0.72	18.6
Grain milling	0.1%	0.26	33.6
Beverages and other food processing	0.4%	0.42	27.4
Other manufacturing	1.4%	0.68	1.24
Electricity	*	0.17	16.3
Water	*	0.19	18.4
Construction	0.1%	0.10	31.9
Trade; repairs	0.7%	0.38	22.0
Hotels and restaurants	0.6%	1.26	21.7
Transport	0.2%	0.14	23.7
Communication	0.0%	0.05	15.9
Finance and insurance	0.2%	0.24	22.3
Business services	0.1%	0.11	18.2
Other private services	1.1%	1.95	31.8
Government services	5.0%	1.67	24.3
Households	11.9%	Na	Na
Total	100.0%	Na	Na

Note: Total domestic requirements are calculated from the physical supply and use table (Chapter 3) coupled with an input-output table. They do not include water embodied in imports.

*less than 0.1%

Na: not applicable

Source: Based on DWA, 2005 and Lange forthcoming 2006.

9.21. Table 9.5 shows the distribution of water use by industry in Namibia and the water intensity of each industry. In 2001-2002, Commercial crop farming accounted for 43% of total water use and had a "water intensity" of 327, that is, Commercial crops require 327 litres of water to generate a dollar of output. Within the agricultural sector, water intensities vary a great deal; commercial livestock farming has water intensity of only 18 litres per dollar of output. As in most countries, Agriculture is the most water-intensive sector; all other sectors are an order of magnitude or more lower in water intensity. Even a small increase in Agricultural production would have a substantial impact on water use because of its relatively high water intensity, whereas, the same increase in Service sector production, or even Mining and Manufacturing, would have a much smaller impact on water use.

9.22. Water productivity could be increased within an industry by introducing more water efficient technology or changing the product mix from lower-value to higher-value products. It can also be increased by reallocation of water from high- to low-water-intensive industries. For a water scarce country, a fundamental message from such analysis is:

- sustainable economic growth may be limited if based on water-intensive sectors, or,
- measures must be introduced to reduce water intensity if economic growth is to be based on water-intensive sectors like Agriculture.

This does not mean, of course, that agriculture-led development is not feasible, rather, it indicates that considerations on the higher-value, less water-intensive agricultural subsectors, accompanied by incentives to increase water efficiency and conservation should be taken into accounts when design development policies..

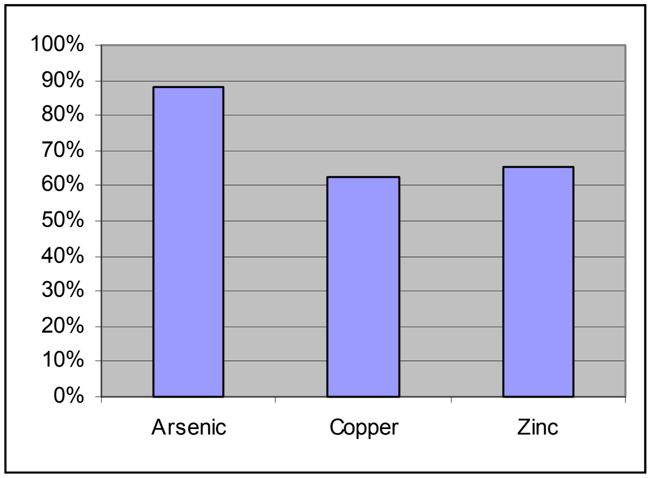
9.23. The assessment of water intensity tells water managers why water use or pollution is so high, but it is also important to understand the *driving forces*, that is, the forces that determine the level and structure of industry production. For example, Australian households used 1800 GL directly in 1994-1995, but they consume many goods and services, which require water to produce. When all the water - direct and indirect - required to meet household demand is taken into account, total water use rises almost nine-fold to 16,172 GL (Lenzen and Foran, 2001).

9.24. This principle of measuring the ‘upstream’ water requirements can be applied to each product or category of final demand using hybrid input-output tables, which are input-output tables augmented by water accounts (described in Chapter 5). The hybrid input-output tables can be used to calculate the Total water requirement per unit of industry output can be compared to the direct requirement (water intensity). In the previous example for Namibia, total domestic water requirements (shown in column 3 of Table 9.5) are considerably higher than direct water requirements in most instances. This important indicator is on the border of water statistics and more complex policy analysis and will be taken up again, in relation to trade, in the next section.

International transport of water and pollution

9.25. For countries sharing international water resources, actions by one country often affect others, and water management in one country may require accounting for the volume and quality of water flows from other countries. For example, the rivers in the Netherlands have their origin in other countries and carry pollutants emitted by upstream countries. Table 9.4 shows the significance of this problem for the Netherlands: most of the arsenic (88%), copper (62%) and zinc (65%) has its origins abroad and is ‘imported’ into the Netherlands. In such cases, even the most stringent national policy for pollution control may have only a limited impact on the load of pollutants in a river at the country level. For shared international water resources, only a regional approach to water and pollution policy will be effective.

Figure 9.4: Percentage of metal emissions to rivers in the Netherlands originating abroad in 2000



Note: These indicators can be obtained from the supply and use table for emissions (Chapter 4).

Source: Adapted from van der Veeren et al. (2004)

2. Opportunities for improving water productivity

9.26. Water supply and water productivity are not determined solely by natural conditions and driving forces. The way that water is managed affects the amount of water that can be utilized by end-users and the productivity of water. The effective supply of water can be increased by:

- *Increasing water efficiency by individual users*. Domestic water requirements can be met with very different volumes depending on consumer behavior and technology: shower *vs* bath, toilet flush volumes, improved technology of washing devices, pressure washers, temporized taps, etc. In industrial processes, changes in technology, sometimes very simple, may simultaneously reduce both water use and pollution as well as provide recyclable water. A simple and effective example is the dry recovery of animal droppings in the stall areas of slaughterhouses.

- *Reducing system losses*. Losses can result from leakages due to poor infrastructure maintenance and other causes such as illegal connections, faulty water meters, and so on. In many industrialized countries, losses are fairly low. In Australia, for example, losses as a percent of total supply range from a low of 3% in Australian Capital Territory to 17 % in Victoria (ABS, 2004). In developing countries, losses can be much higher. Among the 29 municipalities in Namibia's water accounts, 3 had losses between 11-15% of supply in 2001; 12 towns, accounting for 21% of municipal water supply, had losses of 20-39%; and the rest has losses 40% or greater (Lange, 2005).

- *Increasing reuse of water* and use of return flows by directing water to storage or other uses and minimizing pollution and salinity of return flows. Reuse of water has been identified as one of the most cost-effective ways to provide water, and has been increasing steadily in water scarce countries (ABS, 2004).

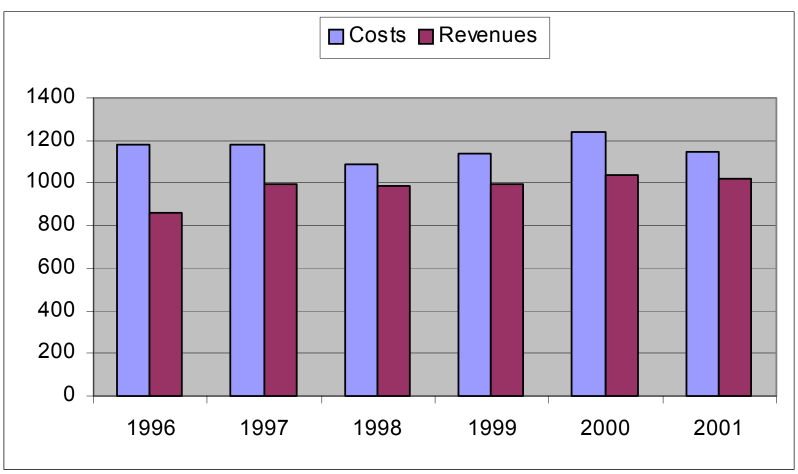
3. Water pricing and incentives for water conservation

9.27. Water pricing is important for financial sustainability - a system must be able to recover its costs - and also for environmental sustainability because of the incentives pricing provides for resource utilization. Except for the minimum amount of water necessary for human survival, people will generally use less water the higher its price. Conversely, where water prices are low, there is little incentive for conservation. It is not unusual for water scarce countries to subsidize the use of water, even for low-value production in commercial agriculture.

9.28. Accounts that would reveal cost recovery - the cost of supply and water tariffs - are not compiled in many countries, or are compiled for only part of water use, mainly because of a lack of data. For water supplied by utilities through water mains, it is usually possible to compile accounts for the average cost of supply, but little data is available for abstraction for won use (for example, Statistics Sweden, 2003). On the pricing side, municipalities may apply a single price for combined water and wastewater services, making it difficult to estimate the charge for each service.

9.29. In countries with full-cost recovery (which may be defined differently in each country), the average price should equal the average cost of supply, although it is unlikely to match precisely in any given year, and sometimes researchers use this shorthand method to estimate implicit unit price and supply cost (Chapter 5). However, many countries, especially developing countries, do not have full-cost recovery pricing, so the price and supply cost will differ. Furthermore, even with full-cost recovery, unit supply costs may vary significantly within a country due to differences in regional water resource availability. For example, Namibia's bulk water supply is based on a system of nearly 200 water schemes and unit supply costs range from a low of N$0.27/m3 to more than N$500.00/m3 (Lange, 2004). Prices will vary by customer where water fees are a combination of fixed fees plus variable fees based on the volume and/or type of customer.

Figure 9.5: Costs and revenues for wastewater treatment services in the Netherlands, 1996 to 2001 (in million euros)



Note: Data are compiled only for households and companies connected to municipal sewer systems. These figures can be compiled from the monetary supply and use tables presented in Chapter 5
Source: van der Veeren et al. (2004).

9.30. Once supply costs and price have been calculated, the implicit subsidy by sector can be calculated. A similar set of indicators can be compiled for wastewater treatment as well. Similar calculations can be made for wastewater treatment supply costs and pricing. In the case of the Netherlands, full cost recovery has been achieved for drinking water, but not for wastewater (van der Veeren et al., 2004)

4. Sustainability: comparing water resources and water use

9.31. In assessing sustainability of water use, the volume of water use must be compared to the renewable supply of water, based on an assessment of stocks or estimated renewable supply. However, few countries compile water asset accounts that are as comprehensive as their water SUT. In some countries, water quality is a greater concern than water volume, so stocks that measure volume may not be a high priority. In other countries, water managers recognize the importance of stock accounts, but do not have comprehensive data, particularly for groundwater stocks. An example is provided for Namibia in Table 9.6. Water authorities acknowledge that the national-level figures for water availability shown in the table are mainly useful for building public awareness, but that national figures may hide relative surpluses and shortages among sub-national regions. Water management requires similar figures at a more spatially disaggregated level within water management areas.

Table 9.6: Water use in 2001 compared to estimated availability of water resources in Namibia

	Estimated long term available water resources* (Mm3 per annum)	Water use, 2001 (Mm3)
Dams on ephemeral rivers	100	85
Perennial rivers	170	90
Groundwater	159	106
Other (recycled)	8	1
Total	**437**	**282**

*Based on currently installed capacity

These figures are obtained from water asset accounts (Chapter 6) and physical supply and use tables (Chapter 3)

Source: Department of Water Affairs, 2005

C. Water management and policy analysis

9.32. Under IWRM, decision-makers no longer rely primarily on conventional supply-oriented approaches to water management. Rather, water management analyzes the benefits of current allocations of water, anticipates future water demands, and evaluates different policy options for meeting those demands. Options include increasing the effective supply of water from efficiency improvements, wastewater reuse, demand management, and other measures. Policy analysis using the water accounts can address a very broad range of issues. Some of the most critical policy issues for water managers include:

- What are the likely future water demands under alternative economic development scenarios and are they sustainable? How do changes in agricultural, energy, forestry and other policies affect water supply and use?
- What is the impact of trade on water use and pollution?
- What are the opportunities for, costs and benefits of water demand management and other water conservation measures? Can economic growth be 'decoupled' from growth in water use?
- What would be the social and economic impact of pricing reform for water and wastewater?

- What are the costs and benefits of treating different sources of water pollution?
- What is the highest value allocation of water among countries sharing an international river or lake?
- How will external phenomena, like climate change affect water resources and how can the economy best prepare for these impacts?

9.33. The water accounts provide detailed information that can be used to analyze pressure on water resources, formulate long-term water management strategies and design effective policies for implementing a given strategy, such as appropriate water pricing and effluent taxes. These applications typically require linking the water accounts described in Chapters 3-5 to economic models, and integrating the input-output (IO) table with water accounts is an essential step in building many of these models (See Box 9.1). The consistency between national accounts and water accounts allows the easy incorporation of water accounts in many different kinds of economic models.

Box 9.1: Water accounts and input-output analysis

There are many tools for economic analysis and those taking a multi-sectoral approach are often built around input-output tables. Multi-sectoral models include standard input-output analysis as well as other modeling approaches, notably computable general equilibrium modeling (which uses a Social Accounting Matrix, an IO table expanded for institutions) and econometric models. Various partial equilibrium models, such as those developed for Life-Cycle Analysis also use IO.

The water supply and use tables (SUT), described in chapters 3-5, are directly linked to the national accounts supply and use tables; just as the IO table is constructed from the SUT, water IO accounts can be derived from the water SUT. In modeling, water in physical units is included in the IO table as a primary input of production. IO analysis of the water accounts themselves provides very useful information regarding the structure of the economy, driving forces, and water use & pollution, as described in the previous section. IO-based, multi-sectoral models are also widely used for projecting future water demands, or analyzing different policy options and the economic instruments for achieving them. Statistics Denmark notes that their water accounts are most extensively used for IO analysis (Statistics Denmark, 2004).

9.34. The number and range of potential policy applications of water accounts are vast and it is not possible to provide a comprehensive review in this chapter; rather, a selection of examples based on water accounts is provided. These examples address projecting future water demand, the socio-economic benefits from water policy reform, assessing the costs and benefits of water treatment, and analyzing links between trade and water use.

1. Meeting future water demand

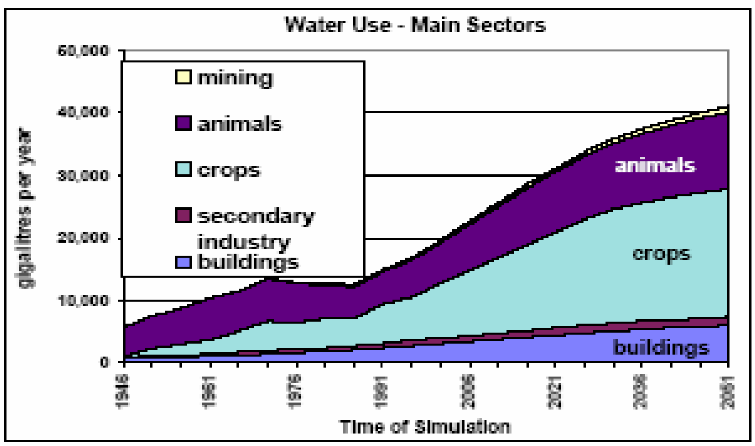
9.35. Projecting future water demand is essential for water management. For example, future water and sanitation requirements depend on many factors, including population growth, the volume and composition of economic growth, and technological change. How the requirements are met depends on available technologies, including innovative ones like water demand management and reuse of water, and water policies such as pricing and other incentives for water conservation. Scenario modeling designed to incorporate some of these factors, especially for influencing water demand and unconventional water supply, are useful tools for water managers. They require sophisticated economic models, often built around water accounts integrated with IO tables (Box 9.1).

9.36. In Australia, the water accounts have been used extensively for water planning at the regional and national levels (see Vardon and Peavey, 2004). For example, Appels et al. (2004), on behalf of the

Australian Productivity Commission, projected impacts on water demand under different scenarios for irrigated agriculture in the Murray-Darling Basin. CSIRO used the water accounts (along with other data) to project water requirements for Australia in the year 2050 under a range of alternative scenarios about population growth, growth of irrigated agriculture, technological improvements in water efficiency, and measures to improve or compensate for declining water quality (Box 9.2). An example of projecting water use at the regional level is described for Sweden in section D.

Box 9.2: Projecting water use in Australia

CSIRO, a major Australian research center, undertook a study of water use in 2050, considering options for improved technology, as well as population and income growth and the expansion of irrigated agriculture. Using a range of data, including those from the Australian water accounts, in a simulation model, total managed water usage was projected to expand from a 24,000 gigalitres in 2000-2001 to more than 40,000 gigalitres per year by 2050. This is due to a major expansion of irrigated agriculture in northern Australia as constraints on the availability and quality of water are experienced in the south. The model assumes widespread introduction of best practice technology in non-agricultural sectors. The water requirements for industry, mining and domestic use represent about 20% of the total. The water use by animals reflects the growth of the dairy industry in particular, which is relatively water-intensive. The authors note the importance of international trade in driving water use: Australia exports an estimated 4,000 gigalitres of embodied water more than it imports. This is about the same amount used each year by urban Australia.



Source: Foran and Poldy (2002).

2. Social and economic gains from water policy reform

9.37. To evaluate the present distribution of water and the social and economic gains from policy changes, criteria for evaluation need to be designed, and tools to measure them need to be developed. Water policy concerns economic issues such property rights and water allocation, investment in infrastructure and pricing. Among the many possible analyses, two important applications of water accounts to water policy are described here: (i) social and economic benefits of present water allocation and alternative allocations; and (ii) consequences of water pricing reform.

Social and economic benefits of water reallocation

9.38. Water consumption for production purposes, such as agriculture and industry, provide economic benefits such as incomes, employment, and foreign exchange earnings. Although these benefits do not measure the exclusive contribution of water to economic value (see discussion in Chapter 8), they are often used as indicators of broadly defined socio-economic benefits from the use of water in one industry relative to another, or in one region of a country relative to another. This indicator was introduced in Section A as the 'water productivity' indicator.

9.39. Water productivity measures the *direct* income and employment generated by water use in a sector, but there may be significant additional benefits, upstream and downstream from the direct user. It is often argued that agriculture generates relatively little direct income per unit of water input, but supplies food processing industries that in turn generate additional income and employment. An analysis of forward and backward linkages using the input-output approach described for trade and the environment provides a more comprehensive picture of the socio-economic benefits of water use in a particular activity, or a particular region. Box 9.3 describes an example of this analysis for South Africa. A great deal of similar analysis has been undertaken for Australia using the water accounts (e.g., CIE, 2004; Lenzen and Foran, 2001).

9.40. In many countries, water is often not allocated efficiently from an economic perspective, that is, to the uses that would generate the highest net economic returns. While economic efficiency is not the only consideration in water policy, it is an important aspect. Even when economic criteria are not used for water allocations, water managers would benefit from an understanding of the potential economic gains from improving the efficiency of water allocation.

9.41. The partial equilibrium approach of input-output may indicate the relationship between the present allocation of water and incomes and employment, but a different modeling approach is needed to determine what the optimal allocation of water in an economy would be. Optimization models for water (see Chapter 8 for a discussion of different modeling approaches) estimate the potential gains from reallocating water to the highest value users. All optimization models require a database for water use that could be provided by the water SUT described in Chapters 3 and 5. The results include projected water demands by industry, the value of water, and the resulting structure and level of economic activity (GDP). If pollution and pollution abatement costs or damage costs are included, the levels and costs of pollution are also calculated.

Water pricing reform

9.42. In many countries, even water-scarce developing countries, the price charged for water does not reflect its true financial cost, let alone the full economic cost. Where the costs are subsidized, there is little incentive for resource conservation. Subsidies, if any, can be calculated for each industry from information in the water SUT by subtracting the supply cost from the payment for water. Monitoring subsidies is clearly important both for sustainable management of resources as well as for equity by identifying which groups in society receive the greatest subsidy. In addition to monitoring, however, policy-makers need to know the potential consequences of water pricing reform: what would be the net gain or loss to national income and employment, and what industries or social groups would be most hard hit.

Box 9.3: Evaluating agricultural water use on a catchment basis in South Africa

Water resources are under increasing pressure in post-apartheid South Africa for several reasons, notably improved access to safe drinking water for millions of previously excluded households, and the emphasis on economic growth and job creation, often in water-intensive industries. An evaluation of the socio-economic benefits generated by each economic activity relative to its water use is an essential input into good water management. Hassan (2003) provided such an evaluation for different agricultural activities within the Crocodile river catchment for the Water Research Council of South Africa. He measured the *direct* value-added and employment generated per cubic meter of water used in each activity. He also extended the analysis to consider the *indirect* benefits by measuring the value-added and employment generated by upstream and downstream linkages to each agricultural activity.

Upstream linkages consist of inputs to agricultural activities, such as fertilizer and agricultural chemicals, fuels, etc. Downstream linkages consist mainly of food processing industries, and the wood processing industries including paper and pulp, wood products, furniture, etc. These linkages are measured using a well-established economic tool, input-output analysis. The analysis revealed that a simple comparison of benefits across sectors did not provide an accurate picture of the full, economy-wide benefits.

Considering only the direct effects, both the income generated (value-added) and employment are highest for mangoes, but when indirect effects are added, pine appears the best. This is largely because there is very little additional processing that adds value for mangoes, while pinewood is used in many wood products. At the opposite end, sugar cane appears to be the least beneficial crop when only the direct income and employment are considered, but taking into account the indirect effects, sugar moves to third place.

Socio-economic benefits from water use for different agricultural activities in the Crocodile River catchment, South Africa, in 1998

Value-added (Rands/m3 water input)				Employment (1000 Person days/m3 water)			
Direct		Total (direct + indirect)		Direct		Total (direct + indirect)	
Mangoes	2.8	Pine	21.3	Mangoes	20	Pine	114
Oranges	1.9	Eucalyptus	13.3	Oranges	18	Eucalyptus	78
Avocados	1.7	Sugar cane	9.9	Grapefruit	13	Sugar cane	44
Eucalyptus	1.5	Mangoes	8.9	Eucalyptus	12	Oranges	39
Grapefruit	1.5	Oranges	6.6	Bananas	7	Mangoes	37
Bananas	1.3	Grapefruit	4.9	Pine	6	Grapefruit	28
Pine	1.2	Avocados	3.4	Avocados	5	Bananas	12
Sugar cane	0.9	Bananas	3.2	Sugar cane	2	Avocados	7

Source: Adapted from Hassan (2003).

Box 9.4: Impact on GDP of water price increases in Australia

Since 1996-1997, water charges across Australia have, on average, doubled, and water trading has been introduced in part of the Murray-Darling River Basin, resulting in a significant improvement in water use efficiency (Centre for International Economics, 2004). The Centre for International Economics has developed a model to simulate over a 5-year period the impact on GDP of water pricing changes through induced changes in water use efficiency (WUE) that result in more water efficient technology and reallocation of water among sectors. For irrigated agriculture, they found that WUE would have to increase 1.5% annually to counterbalance the impact of increased water charges.

CIE then considered the impact of reducing current water diversions to increase environmental flows through alternative economic instruments: administered reduction applied proportionately to all users is considerably more costly than allocating the cuts through a market-based method of tradable of water rights.

Impact on GDP of improvements in water use efficiency under a doubling of water charges in Australia (million A$)

	Percent annual increase in water use efficiency (WUE)	
	1% annual increase	2% annual increase
Irrigated agriculture	-24	78
Dryland agriculture	-51	-112
Food and fibre processing	44	97
Other industries	262	410
Total impact on GDP	253	521

Source: Based on CIE (2004).

9.43. Economic models, such as those used for assessing the optimal allocation of water can introduce water price accounts to estimate the economy-wide impact of price reform. Similar analysis can be made for assessing the impact of increased charges for wastewater treatment and pollution taxes. Box 9.4 summarizes a simulation study for water charges in Australia.

9.44. The water accounts report emissions of pollution and, if fully monetized, include estimates of the cost of pollution, or the value of maintaining clean water. The economic valuation techniques that would be used for monetization were described in Chapter 8. There are no water accounts that have fully monetized water pollution accounts at this time. In part, the challenge is that most water accounts are compiled at the national level, while water pollution is a localized phenomenon. Based on a cost-benefit analysis rather than water accounts, Box 9.5 provides an example of valuing water quality, and using this approach to assess the costs and benefits of wastewater treatment.

3. Trade and the environment: water use and pollution

9.45. Water use and the emission of pollution is affected by water policies, but is also indirectly affected by policies in other sectors of the economy, which may not anticipate the impact on water resources. For example, agricultural trade policy may have a significant impact on what is produced in a country and indirectly the use of water. This section considers two aspects of trade and the use of water resources: trade in 'virtual water' and the impact of trade barriers on water allocation.

Box 9.5: Benefits of wastewater treatment in Wuxi, China

Zhang (2003) measured the costs and benefits of wastewater treatment in Wuxi, a rapidly industrializing city in China's Yangtze River Delta. Wuxi has over 200 km of waterways and borders a scenic lake that is popular for recreation. The study reported the discharge of 9 different water pollutants from 13 most important industries. The cost of water treatment was measured as the present value (over 20 years) of additional infrastructure and operating costs needed to meet water quality standards. The benefits from treatment were measured as the value of damage prevented. The damage was valued in terms of the reduced capacity of the lake to provide water services: potable drinking water, industry-standard water, water for fish farming, a clean environment for residents on the lake shore and for recreation and tourism.

Costs and benefits from wastewater treatment in Wuxi, China

(millions of US dollars in 1992 prices)

Costs (investment + operating costs)	22.43
Benefits (damages and costs averted)	
Drinking water treatment	2.71
Industrial water treatment	7.28
Drainage costs	1.40
Fish farming productivity	2.86
Health benefits (reduced illness)	2.60
Residents' amenity benefits	3.60
Resident's recreational benefits	1.73
Tourism	3.73
Sub-total, benefits	25.91
Net benefit	3.48

Source: Based on Zhang (2003).

Trade in virtual water

9.46. Global water availability and use are characterized by large regional imbalances, but water itself is not a widely traded commodity. Trade in products allows trade in 'virtual water,' that is, the water used for the production of goods and services. Trade in virtual water allows a country to overcome its water scarcity by importing water-intensive goods; virtual water also provides a measure of a country's impact on global water resources (its 'water footprint') (See Champagain and Hoekstra, 2004). Distorted water pricing, including heavy subsidies to agriculture and omission of charges for ecosystem damage, means that international trade is unlikely to reflect the water 'comparative advantage' of countries. The World Water Council has recently identified virtual water as a critical issue for water management, and has launched a major initiative through its website to better define and measure virtual water (See http://www.worldwatercouncil.org/virtual_water.shtml). This work has also been strongly supported by UNESCO (Champagain and Hoekstra, 2004).

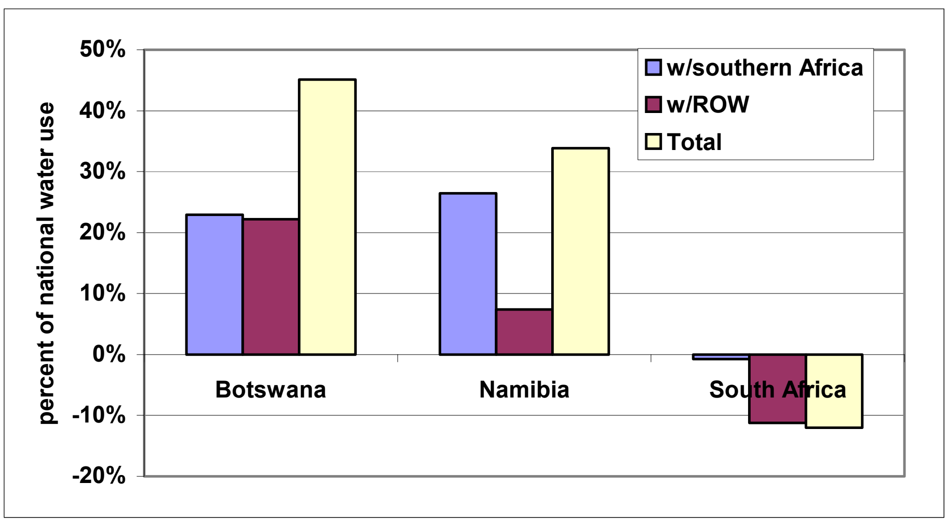
9.47. The measurement of virtual water should include both the direct and indirect water used in production. Direct water is the amount used during the production process; this figure is obtained from the water SUT. Indirect water is the amount used to produce all the non-water inputs to production of a given product. The difference between direct water use and total (direct + indirect) water use can be substantial: for example, very little water may be needed to produce a loaf of bread, but a great deal of water may be embodied in the grain used to make bread. The methodology for measuring total water use based on input-output models extended for direct water inputs (as described in Box 9.1) is well established in the economics literature (Førsund 1985, Miller and Blair 1985, Pearson 1989). Box 9.6 shows an analysis of trade in virtual water among Botswana, Namibia, South Africa, and between these three countries and the rest of the world.

Box 9.6: Trade and the environment: the water content of trade in Southern Africa

Botswana, Namibia and South Africa have designed strategies for economic development based in part on economic growth, diversification, and trade promotion. As in many developing countries, the structure of exports in these countries is heavily weighted toward primary commodities and processing of these commodities, which are often water-intensive. These three countries have identified water as a primary constraint to development and South Africa has already been categorized as a water-stressed country.

An input-output analysis of the total (direct + indirect) water content of trade among the 3 countries and with the rest of the world reveals that Botswana and Namibia are significant net water importers, 45% and 33% of total national water use, respectively. South Africa on the other hand, is a net water exporter, 11% of national water use in 1998.

Net water imports as percent of total national water use for Botswana, Namibia, and South Africa in 1998



Source: Based on Lange and Hassan (2002).

Impact of trade policy on water allocation

9.48. Most of the world's water is used for crop irrigation. Trade protection can result in distorted international patterns of agricultural production. When agriculture depends on irrigation, trade protection can inadvertently divert water to irrigation, increasing pressure on water resources and reducing the water available for other, often higher-value uses. Economic models, either partial or general equilibrium, are used to assess the impact of trade protection on water use and pollution, and the environmental and economic consequences.

9.49. Chapter 8 discussed the impact of trade protection on agriculture and the demand for irrigation water through several examples. The example for Morocco (Bouhia, 2001) used a linear programming model (based on an input-output table with water use accounts) to assess the optimal allocation of water under several alternative scenarios. One of the alternative scenarios included the reduction of trade barriers (import quotas, voluntary export restrictions) on agricultural commodities. In the model, farmers could choose what crops to plant and whether to sell them in domestic or international markets; water was allocated on the basis of profitability of water. The model demonstrated the potential for significant economic gains from reducing trade barriers and allowing a reallocation of water to different crops.

D. Critical issues for water accounts: spatial and temporal characteristics

9.50. Water availability and demand as well as water quality can vary a great deal over time and space. It is difficult to address sustainability on a national level when sustainability of water use is determined on a local or regional basis. Recognizing this, water managers are adopting a regional approach and take into account temporal variations; this principle has been endorsed by IWRM. But this posses a challenge for water accounting because the temporal and spatial dimensions relevant to water often do not match those used for economic data in the national accounts. It is increasingly common for countries to construct water accounts on a regional basis - Australia, the Netherlands, Sweden, Morocco have done so. Seasonal water accounts have not yet been compiled.

1. Accounts at the river basin level or water management area

9.51. Water accounts must be national in coverage and compatible with the national economic accounts for decisions made at the national/macroeconomic level. But hydrological conditions affecting water supply vary considerably across many countries. Factors that drive water use, such as population, economic activity and land use, also vary across a country and may not be distributed where water resources are most abundant.

9.52. One of the important principles for IWRM is to approach water management at the river basin level (or other appropriate water management area). This concept is part of a number of national and regional water policies, such as the EU Water Framework Directive. Although the water accounts are typically constructed at the national level, in principle, the same accounting framework and analysis can be applied for a river basin, an aquifer, or any other region defined by relevant geohydrological characteristics including systems of water infrastructure that may integrate catchment and groundwater resources. In the case of the EU Water Framework Directive, a suitable area is the *River basin district*, that is the upper management unit that can extend over several states.

9.53. In most cases, the catchment area, or river basin, level is the most appropriate geographical level for analysis. In some instances, water management at the catchment level may require international cooperation, for example, a catchment area may cover several countries, or several catchment areas may empty into a regional sea. Both cases require common management of water resources.

9.54. The actual catchment area may differ from the topographic surface watersheds (which are the portions of territory that can be delimited by the lines of crest) because of the existence of underlying groundwater resources. Furthermore, catchment areas generally do not match administrative areas, which constitute the basis for economic data. Because of the need to make hydrological and administrative regions coincide, a compromise is often made and the resulting region called an 'accounting catchment area.' In general, elaborating water accounts at the river basin level necessitates geographically referenced data water flows and discharges of pollutants, i.e. spatial identification of establishments, waste water treatment plants, etc

9.55. All of the indicators and policy analyses discussed earlier in this chapter can be applied at the catchment or regional level as well. The environmental economic profiles can be constructed for each water accounting catchment, as in Table 4.7 in Chapter 4 and Box 9.7 which shows the profiles for two of Sweden's sea basins. The accounts can also be used for modeling at the regional level as well.

Box 9.7: Forecasting water use at the district level in Sweden

Under the EU Water Framework Directive, Sweden prepared forecasts of water use in 2015 at the district level. The estimates were made by using a regional economic model developed by the Swedish Business Development Agency, which allocated 289 municipalities into five water districts. The model is built from relations at municipality level and has five submodels (1) Population, (2) Labour market, (3) Regional economy, (4) Housing market and (5) Supplementary model for municipalities. The regional model first forecast population, employment and economic development until 2015 for each water district and, based on these results, forecast water use based on water use parameters prevailing in the base year, 2000. For the three most water intensive industries—Pulp & paper, Chemicals, Basic metals (NACE 21, 24, 27)—an alternative forecast (scenario 2) was made assuming increased water efficiency (water use/production value), based on the same gains in water efficiency achieved between 1995-2000.

Water use in 2015 by water district, Sweden (thousand m^3)

		Projected water use in 2015	
District/Sea Basin	Water use in 2000	Scenario1	Scenario 2
Bothnian Bay	380,214	477,000	454,400
Bothnian,Sea	786,846	947,300	846,700
North,Baltic,Sea	493,312	590,100	579,000
South,Baltic,Sea	637,382	750,900	713,300
North,Sea	943,550	1,164,500	1,098,500
Total	3,241,304	3,929,800	3,691,900

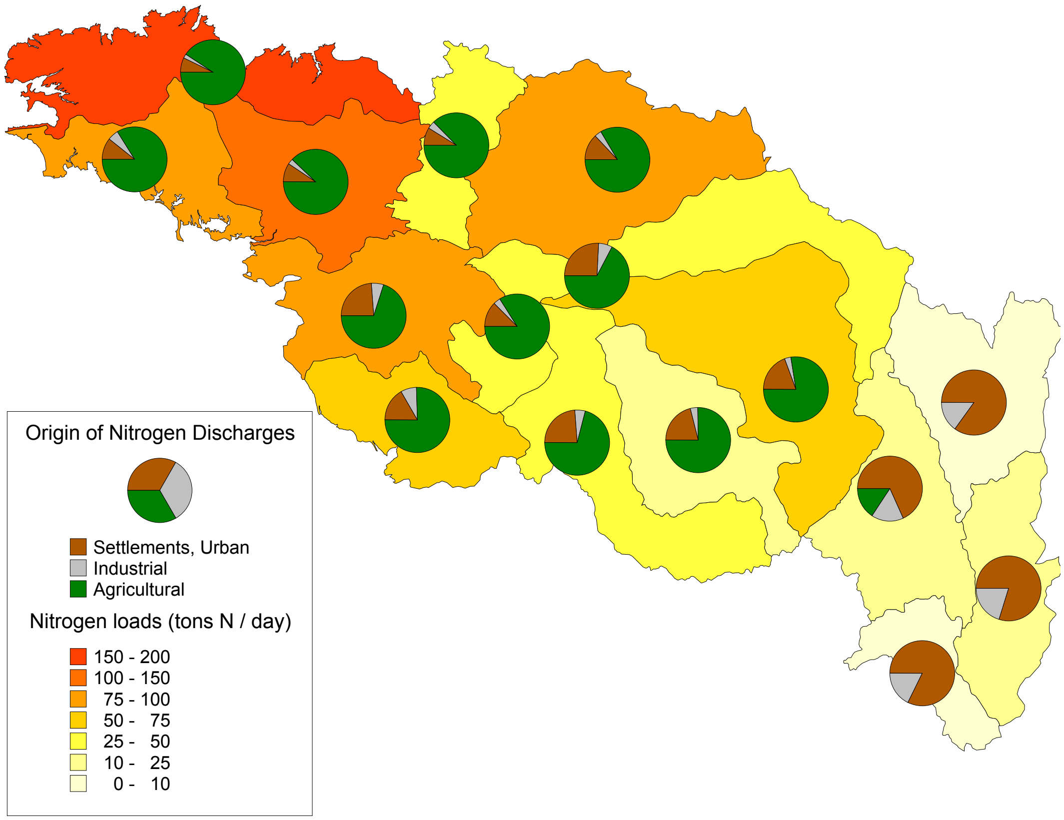
Note: Scenario 2 assumes increased water efficiency in the most water intensive industries.

Source: Statistics Sweden (2004).

9.56. Regional accounts are necessary for management of an individual river basin, but decision-making at the national level also needs an overview that brings together the different regions in a national accounting framework as in Figure 9.6. The overview helps national decision-makers in two ways: (i) it helps them set priorities for actions among different river basins by demonstrating the relative severity if water problems in each basin, and (ii) it provides a tool for national water managers to negotiate with decision-makers in other sectors to coordinate policy.

9.57. Figure 9.6 shows an example for the daily discharge of nitrogen; indicating both the magnitude of nitrogen emissions in each part of the river basin as well as the source of pollution. Agriculture is the major source of pollution in all the heavily polluted parts of the river. Households are the second most important source, and the primary source of nitrogen in areas with little agriculture.

Figure 9.6: Location, level and origin of nitrogen discharges in the French river basin of Loire-Bretagne



Source: Presentation of Ifen results – RBDE meeting, 14 March 2001

2. Temporal dimension

9.58. Water use is often concentrated in certain seasons, notably, the demand for irrigation water in the growing season. Because irrigation requires so much water - up to 80% of total water use in developing countries (MGTFWS, 2003) - it is extremely important to match seasonal supply and demand. Water pollution may also have a different impact on water quality depending on the time of the year. In some periods the quantity of water flowing may be so reduced that dilution of pollutants cannot occur. Abstractions and emissions usually cover an entire year, but this does not provide an accurate picture of the stress on water resources since seasonal variations may be hidden.

9.59. A first possibility is to reduce the duration of the accounting period: in many countries, quarterly national accounts are already built. Quarterly water accounts may be useful in some countries; for example, seasonal water accounts for Spain would reveal higher pressure on water in summer compared to winter. Abstraction of water and emissions are higher in the summer due to tourism, while the volume of available water is smaller. While the quarters of the year used for national accounts may not coincide with seasonal variations in water availability and demand for all countries, quarterly accounts for water would probably be a useful step toward representing seasonal variations.

9.60. Accidents resulting in unusually high discharge of polluting substances at a point in time present another challenge to water accounts. When added to annual discharge, the accidental discharges may not appear serious; averaging annual discharge over annual water resources may indicate an acceptable level of pollutant concentration. However, the temporary concentration from an accident may be high enough to cause serious damage. Even quarterly accounts may not adequately represent the impact of accidental spills. It is not feasible to produce monthly or weekly accounts, so indicators should be designed that would show the degree of damage caused by accidental spills. These indicators should complement the accounts by taking into account factors such as the concentration of a pollutant, the threshold for water abstraction over which aquatic life is impeded and possible synergies between two or several pollutants.

9.61. The construction of these indicators implies a detailed knowledge of the absorption capacities of the different water bodies vis-à-vis the pressures exerted against them. Location and timeliness of the pressure are not independent in their effects since the critical thresholds vary, notably according to the volume and flow of the water body. The severity of the pressure is also related to the present state of the water environment, that is to say, to the pressures accumulated over time. For each place, each period, each type of pressure, thresholds should be estimated. Possible indicators include, for example, the number of days (in the year, in the quarter) in which thresholds have been exceeded. However this type of information cannot presently be handled in the framework of water accounts.

E. Links between water and other resource accounts (fisheries, forestry, land/soil)

9.62. Water is a cross-cutting natural resource because it is used as a commodity in every sector of the economy, it is widely used as a sink for pollution, and it provides ecosystem services to many sectors (Acquay, 2001). The quality and quantity of available water is affected not just by the direct abstraction of water, but by activities in agriculture, forestry, energy, human settlements and other land uses, etc. With regard to IWRM, the SEEA framework has an advantage over other water databases because it is designed for comprehensive representation of all important natural resources, not just water. The SEEA framework integrates water accounts with accounts for land and forests, fisheries, pollution, and any other resources necessary for IWRM, as well as with the economic accounts.

9.63. As treated in this handbook, water accounts are constructed for (i) the direct use of water as an intermediate input to production or as a final consumption good and (ii) the use of waste assimilation services provided by water, represented by the emission of water pollutants from industry, government and households. Many other environmental services provided by water are not addressed here, notably, navigation services, recreational services, and habitat protection. In managing water, it is important to account for these additional services, and for related resources and ecosystems that may affect the quantity or quality of water. The major issues are noted here; future revisions of the handbook for water accounting are likely to address these broader issues.

Dependence of water resources on other resources

9.64. The status of a river may depend greatly on land management and the health of forests and other vegetation in a river basin. Groundwater recharge and quality can be affected by deforestation and land use conversion (affecting rates of infiltration) and runoff of pollutants from agriculture and other economic activities. The water accounts do not usually address some important forms of water quality degradation such as increased turbidity from soil erosion, or increased salinity, although the framework can certainly accommodate this, and the Australian water stock accounts consider salinity.

9.65. Furthermore, in many countries, accounts for the emission of pollutants to water may include only point-source emissions, although non-point source emissions are very important, especially from agriculture. An exception to this is the Netherlands, which has made great progress in monitoring non-point source emissions. Non-point source emissions pose a major challenge to water accounting because the relationship between the use of polluting substances, such as fertilizers, and water quality is not easy to determine. Complex hydro-geological models are required to estimate the amount of fertilizer that leaves the farm field and the route and time it takes to travel from the field to a water body. It is not uncommon for the travel time to exceed one year, the typical accounting period for water accounts.

9.66. Water-based tourism and recreation have become important industries in many countries, both developed and developing. Some forms of water-based recreation may depend mainly on water flow, such as rafting and scenic beauty. But the habitat protection service of water may be extremely important for other forms of tourism that depend on the health of a water ecosystem like fishing or wildlife viewing. This requires accounting for water ecosystems, in addition to the more limited focus of water stock accounts, which emphasize the volume of water and quality classified in terms of suitability for drinking water. Accounts for ecosystems have been identified in the SEEA but are less well defined in practice. Wetland ecosystem stock accounts can be expressed in a combination of area (e.g., hectares) and qualitative classifications such as excellent, good, fair, bad, etc. Ecosystem accounts would monitor the numbers and proportions of key species of flora and fauna that indicate ecosystem integrity.

Dependence of other resources on water ecosystem health

9.67. Many other resources are equally dependent on water resources and their use. Fisheries are particularly sensitive to water quality, water flows, and aquatic ecosystem health, including sea grass beds, mangroves, coral reefs, lagoons, and others ecosystems. Agricultural land has suffered greatly from misuse of water for irrigation, resulting in losses of agricultural productivity due to salination and water logging of soil. Natural vegetation depends on river flow and on the level of groundwater. When groundwater is depleted, vegetation may lose its water source. Wildlife and biodiversity also depend on the health of aquatic ecosystems and an adequate supply of unpolluted water.

Annex I. Set of standard tables for the water accounts

This annex shows the set of standard tables that have been presented in more details throughout the handbook.

Physical supply and use tables (Chapter 3)

Physical use table

Physical units

		Industries (by ISIC categories)							Households	Rest of the world	Total
		1	2-33, 41-43	35	36	37	38,39, 45-99	Total			
From the environment	U1 - Total abstraction (=a.1+a.2= b.1+b.2):										
	a.1- Abstraction for own use										
	a.2- Abstraction for distribution										
	b.1- From water resources:										
	Surface water										
	Groundwater										
	Soil water										
	b.2- From other sources										
	Collection of precipitation										
	Abstraction from the sea										
Within the economy	U2 - Use of water received from other economic units										
U=U1+U2 - **Total use of water**											

Physical supply table

Physical units

		Industries (by ISIC categories)							Households	Rest of the world	Total
		1	2-33, 41-43	35	36	37	38,39, 45-99	Total			
Within the economy	S1 - Supply of water to other economic units										
	of which: Reused water										
	Wastewater to sewerage										
To the environment	S2 - Total returns (= d.1+d.2)										
	d.1- To water resources										
	Surface water										
	Groundwater										
	Soil water										
	d.2- To other sources (e.g. sea water)										
S - **Total supply of water** (= S1+S2)											
Consumption (U - S)											

Note: Grey cells indicate zero entries by definition.

Emission accounts (Chapter 4)

physical units

Pollutant	Industries (by ISIC categories)						Households	Rest of the World	Total
	1	2-33, 41-43	35	36	38,39, 45-99	Total industry			
Gross emissions (= a + b)									
a. Direct emissions to water (=a1 + a2=b1+b2)									
a1. Without treatment									
a2. After on-site treatment									
b1. To water resources									
b2. To the sea									
b. To sewage network (SIC 37)									
d. Reallocation of emission by ISIC 37									
e. Net emissions (= a. + d.)									

Emissions to water by ISIC 37

Pollutant	ISIC 37
c. Emissions to water (= c.1 + c.2)	
c.1. After treatment	
To water resources	
To the sea	
c.2. Without treatment	
To water resources	
To the sea	

Hybrid supply and use tables (Chapter 5)

Hybrid supply table

Physical and monetary units

	Output of industries (by ISIC categories)								Imports	Taxes on products	Subsidies on products	Trade and transport margins	Total supply at purchaser's price
	1	2-33, 41-43	35		36	37	38,39, 45-99	Total output, at basic prices					
			Total	*of which*: Hydro									
Total output and supply (monetary units)													
of which: Natural water (CPC 1800)													
Sewerage services (CPC 941)													
Total supply of water (physical units)													
S1 - Supply of water to other economic units													
S2 - Total returns													
Total (gross) emissions (physical units)													
Pollutants													

Note: Grey cells indicate zero entries by definition.

Hybrid use table

Physical and monetary units

	Intermediate consumption of industries (by ISIC categories)								Actual final consumption				Capital formation	Exports	Total uses at purchaser's price
	1	2-33, 41-43	35		36	37	38,39, 45-99	Total industry	Households			Government			
			Total	*of which*: Hydro					Final consumption expenditures	Social transfers in kind from Government and NPISHs	Total				
Total intermediate consumption and use (monetary units)															
of which: Natural water (CPC 1800)															
Sewerage services (CPC 941)															
Total value added (monetary units)															
Total use of water (physical units)															
U1 - Total Abstraction															
of which: a.1- Abstraction for own use															
U2 - Use of water received from other economic units															

Note: Grey cells indicate zero entries by definition.

Hybrid account for supply and use of water

Physical and monetary units

	Industries (by ISIC categories)								Households	Rest of the world
	1	2-33, 41-43	35		36	37	38,39, 45-99	Total industry		
			Total	*of which*: Hydro						
1. Total output and supply (monetary units)										
of which: Natural water (CPC 1800)										
Sewerage services (CPC 941)										
2. Total intermediate consumption and use (monetary units)										
of which: Natural water (CPC 1800)										
Sewerage services (CPC 941)										
3. Total value added (gross) (= 1-2) (monetary units)										
Gross fixed capital formation for water-related infrastructure (monetary units)										
Total use of water (physical units)										
U1 - Total Abstraction										
of which: a.1- Abstraction for own use										
U2 - Use of water received from other economic units										
Total supply of water (physical units)										
S1 - Supply of water to other economic units										
S2 - Total returns										
Total (gross) emissions (physical units)										
Pollutants										

Note: Grey cells indicate zero entries by definition.

Hybrid account for secondary and ancillary activities of sewerage (ISIC 37)[18]

Physical and monetary units

	Industries (by ISIC categories)					Own produced-consumed households	Total
	1		…	Total industry			
	ISIC 37 as Secondary activity	ISIC 37 as Ancillary activity		ISIC 37 as Secondary activity	ISIC 37 as Ancillary activity		
1. Total output and supply (monetary units)							
of which: Sewerage services (CPC 941)							
2. Total intermediate consumption and use (monetary units)							
of which: Sewerage services (CPC 941)							
3. Total value added (gross) (= 1-2) (monetary units)							
Gross fixed capital formation for water-related infrastructure (monetary units)							
Total use of water (physical units)							
U1 - Total Abstraction							
of which: a.1- Abstraction for own use							
U2 - Use of water received from other economic units							
Total supply of water (physical units)							
S1 - Supply of water to other economic units							
S2 - Total returns							
Total (gross) emissions (physical units)							
Pollutants							

Note: Grey cells indicate zero entries by definition.

[18] These tables are compiled also for activities of Water collection, treatment and supply (ISC 36) and Remediation activities for water (part of ISIC 39).

Economic account for collective consumption of government

monetary units

	Government (ISIC 84) (by COFOG categories)			
	05.2 Wastewater management	05.3 (part) Soil and groundwater protection	05.6 Environmental protection n.e.c.	06.3 Water supply
1. Total output				
2. Intermediate consumption				
3. Value added (gross) (= 1-2)				

National expenditure on sewerage services[19]

monetary units

	USERS/BENEFICIARIES					
	Producers		Final consumers			
	Specialised producers (ISIC 37)	Other producers	Households	Government	Rest of the world	Total
a. Sewerage services (CPC 941**)**						
Final consumption						
Intermediate consumption						
b. Gross Fixed Capital Formation and land						
c. Total domestic uses (=a.+b.)						
d. Financed by the rest of the world						
e. National expenditures (=c.-d.)						

Financing of sewerage services and related products[20]

monetary units

	USERS/BENEFICIARIES					
	Producers		Final Consumers (Actual consumption)			
FINANCING SECTORS:	Specialised producers (ISIC 37)	Other producers	Households	Government	Rest of the world	Total
General government						
NPISHs						
Corporations						
Specialised producers						
Other producers						
Households						
National expenditure						
Rest of the world						
Domestic uses						

[19] These tables are also compiled for activities of Water collection, treatment and supply (ISC 36) and Remediation activities for water (part of ISIC 39).

STANDARD TABLES FOR TAXES,SUBSIDIES TO BE ADDED

Asset accounts (Chapter 6)

Asset accounts

physical units

		EA.131 Surface water				EA.132 Groundwater	EA.133 Soil water	Total
		EA.1311 Reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow, Ice and Glaciers			
Opening Stocks								
Changes due to human activities	Abstraction							
	of which Sustainable use							
	Returns from the economy							
Changes due to natural processes	Precipitation							
	Inflows							
	from upstream territories							
	from other resources in the territory							
	Evaporation/Actual evapotranspiration							
	Outflows							
	to downstream territories							
	to the sea							
	to other resources in the territory							
Other changes in volume								
Closing Stocks								

Annex II. Set of supplementary tables for the water accounts

Supplementary information to the physical supply and use tables (Chapter 3)

Physical use table

physical units

		Industries (by ISIC categories)							Households	Rest of the world	Total
		1	2-33, 41-43	35	36	37	38,39, 45-99	Total			
From the environment	**U1 - Total Abstraction** (=a.1+a.2= b.1+b.2)										
	a.1- Abstraction for own use										
	Hydroelectric power generation										
	Irrigation water										
	Urban runoff										
	Cooling water										
	Mine water										
	Other										
	a.2- Abstraction for distribution										
	b.1- From Water resources:										
	Surface water										
	Groundwater										
	Soil water										
	b.2- From Other sources										
	Collection of precipitation										
	Abstraction from the sea										
Within the economy	**U2 - Use of water received from other economic units**										
U - **Total use of water** (=U1+U2)											

Physical supply table

physical units

		Industries (by ISIC categories)							Households	Rest of the world	Total
		1	2-33, 41-43	35	36	37	38,39, 45-99	Total			
Within the economy	**S1 - Supply of water to other economic units**										
	of which: Reused water										
	Wastewater to Sewerage										
To the environment	**S2 - Total returns** (= d.1+d.2)										
	Hydroelectric power generation										
	Irrigation water										
	Urban runoff										
	Mine water										
	Cooling water										
	Losses in distribution because of leakages										
	Other										
	d.1- To Water resources										
	Surface water										
	Groundwater										
	Soil water										
	d.2- To Other sources (e.g. Sea water)										
S - **Total supply of water** (=S1+S2)											
Consumption (U - S)											
of which: Losses in distribution not because of leakages											

Note: Grey cells indicate zero entries by definition.

Items presented in italics represent supplementary information that is useful for specific analyses and policies.

Matrix of transfers of water within the economy

Supplier ⇩ / User ⇨		Industries (by ISIC categories)							Households	Rest of the world	Total
		1	2-33, 41-43	35	36	37	38,39, 45-99	Total			
Industries (by ISIC categories)	1										
	2-33, 41-43										
	35										
	36										
	37										
	38,39, 45-99										
	Total										
Households											
Rest of the world											
Total											

Supplementary information to the emission accounts (Chapter 4)

Sludge indicators

	ISIC 37
Total sewage sludge produced (vol.)	
Load in total sewage sludge	

Supplementary information to hybrid and economic accounts (Chapter 5)

Economic accounts - supplementary information

	Industry (by ISIC categories)								Households
			35						
	1	2-33, 41-43	total	*of which*: hydro	36	37	38,39, 45-99	Total industry	
Fixed capital of water-related infrastructures									
Closing stocks of fixed assets									
Labour input									
Number of workers									
Total hours worked									

Note: Grey cells indicate zero entries by definition.

Supplementary information to the asset accounts (Chapter 6)

Matrix of flows between water resources

physical units

	EA.131 Surface water				EA.132 Groundwater	EA.133 Soil water	Total (Outflows to other resources in the territory)
	EA.1311 Reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow, Ice and Glaciers			
EA.1311 Reservoirs							
EA.1312 Lakes							
EA.1313 Rivers							
EA.1314 Snow, Ice and Glaciers							
EA.132 Groundwater							
EA.133 Soil water							
Total (Inflows from other resources in the territory)							

Quality accounts (Chapter 7)

Quality accounts

physical units

	Quality classes				
	Quality 1	Quality 2	Quality 3	Quality n	Total
Opening stocks					
Changes in stocks					
Closing stocks					

Supplementary information to the water accounts

Social indicators

Access to water and sanitation
Proportion of population with sustainable access to an improved water source, urban and rural
Proportion of population with access to improved sanitation, urban and rural
Total population

Annex III. Water accounting and water indicators

Water accounting has developed more recently than environmental statistics including water indicators, but water accounting provides a much more powerful tool for improved water management. Many water indicators can be derived from the water accounts and, in contrast to water indicators and statistics, water accounts also provide data in a structured framework linked to economic accounts that can be used much more effectively for quantitative analysis.

The section addresses more thoroughly the link between the water accounts and water indicators. Section 1 draws together the wide range of indicators developed in separate chapters of this handbook to show how, together, they provide a comprehensive set of indicators for water and sanitation policy appropriate for IWRM. Section 2 link indicators proposed in the World Water Development Report (United Nations and World Water Assessment Programme, 2006) to the water accounts.

1. Indicators derived from the water accounts

As a broad concept rather than a technical methodology, IWRM does not adopt a particular set of indicators. However, the indicators measure derived from the water accounts cover many critical aspects of water management under an IWRM approach:

- Water resource availability
- Water use for human activities, pressure on water resources and opportunities to increase water efficiency
- Opportunities to increase effective supply through management of return flows, reuse, and system losses
- Water cost and pricing policy: the user-pays and polluter-pays principles
- Access to and affordability of water and sanitation services
- Beyond the IWRM approach, new indicators are suggested in Chapter 7, dealing with quality issues.
- Overall index of water quality, including the potential for diaggregating between quality and discharge shares
- Pattern and predominance indexes, focusing on the distribution and causes of the observed quality

The major indicators for each of these aspects of water management are discussed below. Although not shown explicitly, it should be understood that most of the indicators can be compiled not only at the national level, but at the regional level, such as for a river basin. The indicators can also be disaggregated by type of resource, for example, surface and groundwater. While a national overview is important, they will be more useful for IWRM if compiled at the level at which IWRM is likely to be implemented, the regional level, for a river basin or other water management area.

Water resource availability

IWRM promotes sustainable, long-term water use that does not compromise the ability of ecosystems to provide water services in the future, including both human water requirements as well as ecological water requirements. Treatment of water availability in the water accounts is addressed in chapters 6 and 7. Box 6.1 in chapter 6 provides a list of indicators for water availability and is presented in Table 1. The first five indicators in this table assess water availability from a simple environmental perspective, the natural volume available. These indicators differentiate between domestic water resources and resources that originate externally because water managers must distinguish water resources that are entirely under national control (internal water resources) from those which must be shared with other countries.

The next indicator, Exploitable water resources, reflects some of the limitations on the naturally available water by taking into account the economic and technological considerations, as well as ecological obligations that constrain the amount of naturally available water resources that can be exploited.

The remaining indicators reflect pressure on water resources from population, total water use, and vulnerability to depletion.

Table 1: Selected indicators of water resource availability and pressure on water derived from the water accounts

Indicator	**Definition and Source** (See chapters 3 & 4 for more detailed explanation)
Internal Renewable Water Resources	"Average annual flow of rivers and recharge of groundwater generated from endogenous precipitation." (FAO/AQUASTAT)
External Renewable Water Resources	"Part of the country's renewable water resources shared with neighbouring countries. Total external resources are the inflow from neighbouring countries (trans-boundary groundwater and surface water inflows), and the part of the shared lakes or border rivers. The assessment considered the natural resources generally; if there are reservations in neighbouring countries, they are called actual resources." (FAO/AQUASTAT)
Total Natural Renewable Water Resources	The sum of internal and external renewable water resources. It corresponds to the maximum theoretical amount of water available for a country on an average year on a long reference period." (FAO/AQUASTAT)
Total Actual Renewable Water Resources	"(Fresh water resources total) The sum of internal and external renewable water resources, taking into consideration the quantity of flow reserved to upstream and downstream countries through formal or informal agreements or treaties and reduction of flow due to upstream withdrawal. cf. external surface water inflow actual or submitted to agreements. It corresponds to the maximum theoretical amount of water actually available for a country at a given moment. The figure may vary with time. Their computation is referring to a given period and not to an inter-annual average. " (FAO/AQUASTAT)
Dependency ratio	"Ratio between the external renewable resources and total natural renewable resources. Indicator expressing the part of the total renewable water resources originating outside the country." (FAO/AQUASTAT, WWDR 2003, Margat 1996)
Exploitable water resources (Manageable resources)	"Part of the water resources which is considered to be available for development under specific technical, economic and environmental conditions." (FAO/AQUASTAT)
Per capita renewable resources	Ratio between Total renewable water resources and population size. (WWDR 2003, Margat 1996)

Density of internal resources	Ratio between the average internal flow and area of the territory (Margat, 1996)
Annual Withdrawals of Ground and Surface Water as a Percent of Total Renewable Water Exploitation index	The total annual volume of ground and surface water abstracted for water uses as a percentage of the total annually renewable volume of freshwater. (UN, 2001)
Consumption Index	Ratio between Water Consumption and Total Renewable Resources. (Margat, 1996)

Water use for human activities

Water availability indicators provide policy-makers with a picture of water availability and stress, but in order to address water problems and prioritize actions, more detailed information is needed about how water is used in an economy and the incentives facing water users, the environmental impacts of water use and pollution, and the social aspects of water use. IWRM calls for treating water as an economic good, which takes into account the value of water in different uses, the costs of water pollution from economic activities, as well as the broader socio-economic benefits generated by use of water by different economic activities. Table 2 presents examples of indicators that can be derived from the supply and use tables in Chapters 3, 4 and 5 are particularly useful for this aspect of IWRM.

Table 2: Selected indicators of water intensity and water productivity

1. Water use and pollution intensity (physical units)		
	m^3 water/unit of physical output	Water use or tons of pollution emitted per unit of output, such as --population, --number of households, or --tons of wheat, steel, etc. produced
	Tons of pollution/unit of physical output	
2. Water and pollution intensity (monetary units)		
	m^3 water/value of output	Water use or tons of pollution emitted per unit of output measured in currency units
	Tons of pollution/value of output	
3. Water productivity ratios		
	GDP/ m^3 water	
	Value-added by sector/m^3 water	
4. Water 'pollutivity' ratios		
	Sector share of pollution/sector share of GDP	

Opportunities to increase effective water supply: return flows, reuse and system losses

Water supply and water productivity are not determined solely by natural conditions. The way that water is managed affects the amount of water that can be utilized by end-users and the productivity of water. Ways in which water availability and productivity can be increased include:

- Increase use of return flows by directing water to storage or other uses and minimizing pollution and salinity of return flows.

- Increase reuse of water
- Reduce system losses from leakages and other causes;

IWRM focuses strongly on these measures to increase effective supply of water. Indicators that could be derived from the water accounts for return flows, reuse, and losses are listed in Table 3.

Table 3: Indicators of opportunities to increase effective water supply

1. Return flows	
Quantity of return flows by source	May distinguish return flows from treated return flows (from municipal and industrial users) from untreated return flows such as agriculture
2. Water reuse	
Reuse water as share of total industry water use	May distinguish reuse of water within a plant from water recycled by municipal water utility
Recycled water as share of total water use by sector	
3. Losses	
Losses in abstraction and treatment as share of total water production	Both the amount and the reason for these losses are usually known by the water utility
Unaccounted for losses as share of total water use	These losses occur for a variety of causes and it is usually not certain how much each cause contributes

Water cost, pricing and incentives for conservation

IWRM notes that the provision of water and sanitation services must be financially sustainable, taking into account the costs of supplying water relative to the revenues generated by water tariffs. Table 4 presents examples of indicators that can be derived from the hybrid accounts in Chapter 5.

Table 4: Indicators for costs and price of water and wastewater treatment services

1. Cost and price of water	
Implicit water price	Volume of water purchased divided by supply cost
Average water price per m^3 by industry	Volume of water purchased divided by actual payments by that industry
Average water supply cost per m^3 by industry	Volume of water purchased divided by cost of supply to that industry
Subsidy per m^3 by industry	Average water price minus average water supply cost
2. Cost and price of wastewater treatment services	
Implicit wastewater treatment price	Volume of water treated divided by supply cost
Average wastewater treatment cost per m3 by industry	Volume of wastewater divided by treatment cost for that industry
Average wastewater treatment price per m3 by industry	Volume of wastewater divided by actual payments for treatment by that industry
Subsidy per m3 by industry	Average wastewater price minus average wastewater supply cost

2. Links between indicators in the WWDR and the SEEAW

Throughout the handbook several indicators that can be derived from the accounts have been presented for illustrative purposes at the end of every chapter. Examples of how countries have disseminated these indicators and used the information derived from the accounts for designing policies are discussed primarily in Chapter 9. This section focuses on the list of indicators proposed in the second World Water Development Report (WWDR)[20] and links those indicators, when possible, to the various modules of the SEEAW.

The focus on the indicator set proposed in the WWDR (2006) is justified by the fact that the 63 indicators suggested have undergone an extensive review and evaluation by UN agencies and academia and NGOs. They result from an analysis of indicator sets proposed by various groups, including the WWDR (2003) and have been recommended by the World Water Assessment Programme (WWAP) of the UN-Water

In the second WWDR, the indicators are grouped by challenge areas. Table 5 only reports indicators of those challenge areas related to the link between the economy and the water resources, namely the following seven challenge areas: global, resources, agriculture, industry, energy, valuing and sharing. Areas such as governance (2 indicators), settlements (3 indicators), ecosystems[21] (5 indicators), health (6 indicators), risk (3 indicators), and knowledge (1 indicator) are not reported in the table as these areas go beyond the scope of water accounts. Although those indicators cannot be directly derived from the water accounts, they can be presented side-by-side with the accounts to allow for integrated analyses.

Table 5 presents a brief description of the indicator and its relevance for water policy is given in the second column of the table, and details on the calculation methods are described in the third column. This information is based on the *Indicator Profile Sheet* of the WWDR (2006) and its CD-Rom. The last column describes the link with the information provided by the water accounts.

As it can be seen from the table, 21 of the 38[22] indicators can be directly derived from the accounts, 5 can be partially derived from the accounts, and 12 can not be derived from the accounts but they can be included as supplementary information. Of these12 indicators, 4 are social indicators (such as urban and rural population), 3 are related to land area and can be derived from land accounts, 3 are related to types of energy and can be derived from energy accounts and the remaining 2 (Trends in ISO 14001 certification and capability of hydropower generation) are not part of the water accounts.

[20] For sake of simplicity, WWDR (2006) refers to the publication UN and the World Water Assessment Programme, 2006, and WWDR (2003) refers to UN and the World Water Assessment Programme, 2003.

[21] Note that two of the five indicators in the challenge area "Ecosystems" can be derived from the quality accounts: concentration of Dissolved Nitrogen and Biological Oxygen Demand.

[22] The indicators in the challenge area 'sharing' and the water pollution index are not included in the analysis as their definition is not provided in the WWDR (2006).

Table 5: Indicators of selected challenge areas from the second WWDR

Challenge Area	Indicator Description based on the Indicator profile sheet of the second WWDR.	Status[1]	Indicator	Link with the water accounts
Global	**Index of non-sustainable water use** This indicator provides a measure of the human water use in excess of natural water supply (local runoff plus river flow). Areas with high water overuse tend to occur in regions that are highly dependent on irrigated agriculture. Urban concentration of water use adds a highly localized dimension to these broader geographic trends. These areas are dependent on infrastructure that transports water over long distances (i.e., pipelines and canals) or on the mining of groundwater reserves, a practice that is not sustainable over the long-term.	K	The indicator is computed as: Q – DIA or Q - A D = domestic water use (km3/yr) I = industrial water use (km3/yr) A = agricultural water use (km3/yr) Q = renewable freshwater resources (km3/yr)	Derived from the water accounts. Water use by sector is derived from the physical supply and use tables (Chapters 3) and renewable water resources from the asset accounts (Chapter 6).
	Urban and rural population This indicator provides a measure total population, urban population and, by difference, rural population. It can be aggregated to basin, national, continental or global scales.	B		Not derivable from the water accounts. This is a social indicator which could be included as supplementary information in the accounts.
	Relative water stress index This indicator provides a measure of the water demand pressures from the domestic, industrial and agricultural sectors relative to the local and upstream water supplies. Areas experiencing water stress and water scarcity can be identified by relative water demand ratios exceeding 0.2 and 0.4, respectively. A threshold of 0.4 (or 40% use relative to supply) signifies severely water stressed conditions. The combination of a water stress threshold and gridded population data allow for identification of water stress "hot spots", areas where large numbers of people may be suffering from the effects of water stress and its consequent impacts.	K	The indicator is computed as: DIA / Q D = domestic water demand (km3/yr) I = industrial water demand (km3/yr) A = agricultural water demand (km3/yr) Q = renewable freshwater resources (km3/yr)	Derived from the water accounts. Water use by sector is derived from the physical supply and use tables (Chapters 3) and renewable water resources from the asset accounts (Chapter 6).
	Domestic and industrial water use This indicator provides a measure of the water demand pressures from the domestic and industrial sectors and can be aggregated to basin, national, continental or global scales. A broad spectrum of water use arises, with high levels associated with dense settlement and level of economic development. Maps of water use can be linked with those depicting water supply to define patterns of water scarcity and stress.	B	The indicator is computed as: (Sectoral per capita water use)(population) where sectoral per capita water use (in m3/yr/person) and population (number of people) are available at national or sub-national scales.	Derived from the water accounts. Water use by sector is derived from the physical supply and use tables (Chapters 3).
	Water pollution index	K	Definition not available	
	Sediment trapping efficiency index The residence time of water in large reservoirs and subsequent sediment trapping efficiencies is calculated as a measure of the impact of these man-made structures on the characteristics of river flow and sediment discharge to the ocean. Estimations of water removed from basins as diversions (i.e., interbasin transfers and consumptive use) also provide information on the impacts of diversions on river flow and sediment transport.	K	The indicator can be computed as: $\tau_R = 0.67 * \text{Max Capacity} / Q$ $TE = 1 - (0.05 * \Delta\tau_{R^{0.5}})$ τ_R = residence time of water in reservoir TE = trapping efficiency of reservoir MaxCapacity = maximum reservoir capacity Q = local mean annual discharge (pre-impoundment).	Partially derived from the water accounts. Only Information on the annual discharge of dams is available in the asset accounts (Chapter 6).

	Climate moisture index (CMI) The CMI ranges from –1 to +1, with wet climates showing positive values and dry climates negative values. As important as the baseline CMI is, its variability over multiple years is also critical in defining reliable water supplies. The indicator is based on the following definition: precipitation and potential evapotranspiration (optimal plant water demand).	K	The indicator is computed as: ratio of plant water demand to precipitation	Partially derived from the water accounts. Precipitation is recorded in the asset accounts (Chapter 6). The asset accounts record actual (and not potential) evapotranspiration.
	Water reuse index (WRI) Consecutive water withdrawals for domestic, industrial and agricultural water use along a river network relative to available water supplies as a measure of upstream competition and potential ecosystem and human health impacts. The water reuse index is a measure of the number of times water is withdrawn consecutively during its passage downstream. Several of the world's river systems bearing large populations, industrial development, and irrigated water use, show water use by society in excess of natural river flow (i.e. >100%). With high values for this Index, we can expect increasing competition for water between users, both nature and society, as well as pollution and potential public health problems. The Water Reuse Index can vary greatly in response to climate variations. The reuse index reflects the aggregate impact of water competition throughout the basin.	K	The indicator is computed as: _ DIA / Q _D = upstream domestic water demand (km3/yr) _I = upstream industrial water demand (km3/yr) _A = upstream agricultural water demand (km3/yr) Q = renewable freshwater resources (km3/yr)	If the underlying data have a spatial reference, the upstream uses can be derived from the physical supply and use tables (Chapter 3). The accounts would also provide information on the upstream water returns to the environment. Renewable water resources can be derived from the asset accounts (Chapters 6) Note that, in the water accounts, the term 'reuse' identifies the water that has been used by an economic unit and is supplied to another for further use.
Resources	**Precipitation annually**	B		This indicator can be derived from the asset accounts (Chapter 6).
	Total actual renewable resources (TARWR) volume The total actual renewable water resource is the theoretical maximum annual volume of water resources available in a country. The maximum theoretical amount of water actually available for the country is calculated from: (a) Sources of water within a country itself; (b) water flowing into a country; (c) water flowing out of a country (treaty commitments). Availability, defined as the surface and ground water resource volume renewed each year in each country, is how much water is theoretically available for use on a sustainable basis. Exploitability is a different matter. While availability undoubtedly exceeds exploitability, there is unlikely adequate data to define the degree of exploitability at this stage. In more specific terms TARWR is: the sum of: • External water resources entering the country • Surface water runoff (SWAR) volumes generated in the country • Ground water recharge (GAR) taking place in the country Less: • Overlap which is the part of the country's water resources that is common to surface waters and to aquifers. Surface water flows can contribute to groundwater as recharge from, for example, river beds or lakes or reservoirs or wetlands. Aquifers can discharge into rivers, lakes and wetlands and can be manifest as base flow, the sole source of river flow during dry periods, or can be recharged by lakes or rivers during wet periods. Therefore, the respective flows of both systems are neither additive nor deductible. • The volume that flows to downstream countries based on formal or informal agreements or treaties.	K	The indicator is computed as: TARWR (in km3/yr) = (External inflows + Surface water runoff + Groundwater Recharge) - (Overlap +Treaty obligations)	Derived from the water accounts. TARWR can be derived from the asset accounts (Chapter 6).

	TARWR per capita	D	The indicator is computed as: TARWR PC = (TARWR / population) 10^9m3/km3	Partially derived from the water accounts. TARWR is derived from the asset accounts (Chapter 6).
	Surface water as a percentage of TARWR This indicator illustrates the degree to which a country is using its surface water resources. It is computed as the quantity of surface water abstracted as a percentage of the surface runoff (SWAR)	D	The indicator is computed as: 100 (Surface water abstraction) / (Surface water runoff)	Derived from the water accounts. This indicator can be derived from the asset account (chapter 6). Sectoral breakdown of water abstraction is available in the physical supply and use tables (Chapter 3)
	Groundwater development (groundwater as a percentage of TARWR) This indicator illustrates to what degree a nation's is exploiting its groundwater water resources. Groundwater abstraction as a percent of the groundwater recharge component of TARWR. The quantity of groundwater resources used by major sectors (municipal, agricultural, industrial) as percentage of the groundwater recharge component (GAR) of TARWR.	K	The indicator is computed as: 100 (groundwater abstraction) / (groundwater recharge)	Derived from the water accounts. This indicator can be derived from the asset account (chapter 6). Sectoral breakdown of water abstraction is available in the physical supply and use tables (Chapter 3)
	Overlap as a percentage of TARWR	D		Derived from the asset account (chapter 6).
	Inflow as a percentage of TARWR	D		Derived from the asset account (chapter 6).
	Outflow as a percentage of TARWR	D		Derived from the asset account (chapter 6).
	Total use as a percentage of TARWR	D		Derived from the asset account (chapter 6).
Agriculture	**Percentage of undernourished people** The proportion of undernourished people provides a measure of the extent of the hunger problem for the region/country and thus may be considered a measure of food insecurity.	K	Percentage of people not having access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life.	Not derivable from the water accounts. This is a social indicator which could be included as supplementary information.
	Percentage of poor people living in rural areas Knowing proportion of poor people living in rural areas, where agriculture and related activities are the primary source of livelihood, provides a measure of the importance of agriculture in the fight against poverty.	K	Percentage of poor people living in rural areas	Not derivable from the water accounts. This is a social indicator which could be included as supplementary information.
	Relative importance of agriculture in the economy The importance of the agricultural sector in the country's economy is an indication of the political muscle that it can bring to bear in the competition for water resources.	K	This indicator is computed as: The share of the country's GDP derived from agriculture	Derived from monetary accounts (Chapter 5).

	Irrigated land as a percentage of cultivated land This indicator provides a measure of the importance of irrigation in agriculture.	K	Area under irrigation as a proportion of total cultivated land.	Not derivable from the water accounts. This indicator can be derived from the land accounts.
	Relative importance of agriculture withdrawals in water balance This indicator measures the importance of agriculture, especially irrigation, in the country's water balance.	K	This indicator is computed as: Water withdrawal for agriculture / Renewable water resources.	Derived from the water accounts. Agricultural water use from physical supply and use tables (Chapter 3); Renewable water form asset accounts (Chapter 6).
	Extent of land salinazed by irrigation Salinization, the process by which water-soluble salts accumulate in the soil, is a concern as excess salts impede crop growth and thus threaten agricultural production. The area salinized by irrigation refers to the total irrigated area affected by salinization. This does not include naturally saline areas.	K	This indicator is computed as: Area of soil salinized by irrigation as a percentage of total irrigated land	Not derivable from the water accounts. This indicator can be derived from the land accounts.
	Importance of groundwater in irrigation The purpose of this indicator is to assess the dependency of a country's irrigated agriculture on groundwater resources.	K	This indicator is computed as: Percentage of land under irrigation relying on groundwater.	Not derivable from the water accounts. This indicator can be derived from the land accounts.
Industry	**Trends in industrial water use** In many developing countries, industrial production and hence the sectoral use of water have grown fast, putting increasing pressure on scarce water resources. The relationship between industrial water withdrawal and industrial growth is not linear, as technological advances lead to water savings as well as water reuse in industry. Hence industrial water withdrawals in many developed countries have flattened off, while industrial water consumption (which is only a fraction of the total water withdrawal) continues to grow.	K	This indicator is computed as: $Wi = Ci + Ei$ where: Wi = the water withdrawal by industry Ci = the water consumption by industry Ei = the industrial effluent discharge	Derived from the physical supply and use tables (Chapter 3).
	Water use by sector Comparing sectoral use patterns is useful for recognizing potential conflicts. This indicator highlights the water demand from industry as compared to other sectoral uses of water.	K	This indicator is computed as: $100 (Wi / Wt)$; $100 (Wa/Wt)$; $100 (Ws/Wt)$; $100(Wd/Wt)$ Where: Wi = water withdrawal by industry; Wa = water withdrawal by agriculture; W s = water withdrawal by services; Wd = water withdrawal domestic sector Wt = total water withdrawal	Derived from the physical supply and use tables (Chapter 3).
	Organic pollution emission by industrial sector Most industrial sectors discharge effluents, containing a load of organic pollutants which can be measured via BOD, thus showing the extent to which the water quality has been compromised. Some sectors pollute more than others. If data were available regarding total annual discharges from industry, as well as the BOD concentrations of these discharges, the values of the indicator could be calculated based upon the actual values. However, as this data is not available for most industries in most countries, it is necessary to calculate the indicator indirectly, based upon an assumed sectoral pollution to labour ratio, as well as the employment data which is currently available for every industrial sector in every country.	K	Proportion of organic water pollution discharged by industrial sector	Derived from emission accounts (Chapter 4).

	Industrial water productivity The productivity of water used in industry, in terms of the economic value added by industrial production based upon the water withdrawn.	K	This indicator is computed as: Pi = Vi / Wi Vi = Total annual value added by industry i (US $/year) Wi = Annual water withdrawal by industry i (m3/year)	Derived from the hybrid accounts (Chapter 5).
	Trends in ISO 14001 certification, 1997-2002 Companies adhering to the ISO 14001 environmental standard conduct water audits and evaluate environmental performance regularly. With this information companies can improve their water use efficiency and water productivity and reduce pollution and thus reduce pressure on the water resources and the environment.	K	This indicator is computed as: 100 (Nc / N) Nc = Number of companies registered per country: N = Total number of companies registered worldwide:	Not derivable from the water accounts. This indicator could be included as supplementary information.
Energy	**Capability of hydropower generation, 2002** In many countries, hydropower is already well developed but still growing, while in others it has the potential to expand greatly. Hydropower generation is measured on a large scale in TWh/year. The gross theoretical capability expresses the total amount of electricity which could potentially be generated, if all available water resources were turned to this use. The technically exploitable capability expresses the hydropower capability which is attractive and readily available with existing technology. The economically exploitable capability is that amount of hydropower generating capacity which could be built, after carrying out a feasibility study on each site at current prices, and producing a positive outcome.	K	Gross theoretical capability of hydropower generation; Technically exploitable capability; and Economically exploitable capability, in TWh/year (tera watthours per year)	Not derivable from the water accounts. This indicator could be included as supplementary information.
	Access to electricity and water for domestic use Comparison of secure access to electricity, versus access to improved water source for domestic use. There are many countries where secure access to electricity still lags far behind access to water.	K	Percentage of population in each country, with secure access to electricity (where secure access to electricity : access to a safe, legal and adequate supply of electricity)	Not derivable from the water accounts. This is a social indicator which could be included as supplementary information.
	Electricity generation by energy source, 1971-2001 This indicator allows to measure the contribution of hydropower to electricity supplies over time as compared to other energy sources.	K	Electricity generation by energy source, worldwide, in time series data Gigawatt-hours (GWh) per year	Not derivable from the water accounts. This indicator can be derived from the energy accounts.
	Total primary energy supply by source, 2001 Primary energy refers to energy sources as found in their natural state. Total global use of the various sources of energy currently deployed, including coal, oil, gas, nuclear, hydropower, geothermal/solar/wind, other combined renewable and waste. This allows computing hydropower as a proportion of total primary energy supply.	K	The percentage share of any given fuel may be calculated as : 100 (Ef / E) Ef = Primary energy supply by fuel, worldwide, in metric tons of oil equivalent (m.t.o.e.) E = Total global primary energy supply	Not derivable from the water accounts. This indicator can be derived from the energy accounts.
	Carbon intensity of electrical production, 2002 This is a measure of the carbon dioxide emissions, associated with climate change, which are produced through electricity generation in various countries. Hydropower is one of the “clean” power options in the sense of not generating greenhouse gases.	K	The indicator is calculated as : Ce = C / Ee Grams of carbon per kilowatt-hour (gC/kWh) where C = Annual carbon emissions from electricity generation are measured in kilograms of carbon released per year (C). Ee = Electricity generation is measured in gigawatt-hours per year	Not derivable from the water accounts. This indicator can be derived from the energy accounts.

	Volume of desalinated water produced Where energy is available, but water supply is constrained, desalination is an increasingly attractive option for providing essential drinking quality water.	K	The indicator is calculated as : Volume of desalinated water produced is measured in millions of cubic metres of drinking quality water produced by these means, per annum	Derived from physical supply and use tables (Chapter 3).
Valuing	**Water sector share in total public spending** Determining what proportion of the public budget is devoted to the water sector would illustrate in concrete terms the investment priority and political commitment assigned by government to meeting the Millennium Development Goals (MDGs) on water. The indicator is based on the following definitions: *National Public Expenditure*: Total public expenditure in all formal and informal economic sectors of the economy. *Water Sector Expenditure:* It covers investments in the water sector infrastructure and its operation and maintenance, including those for capacity building, as well as for implementing policy and institutional reforms. *Sector*: Sectors are segments of the economy, identified in terms of their contributions to the economy and daily quality of life. Water sector generally comprises of: water supply, sewer, sanitation, irrigation and drainage infrastructure, and IWRM.	D	The indicator can be computed as: 100 (PSws/TPSes) where: PSws = Public spending in the water sector TPSes = Total public spending in all economic sectors.	Derived from the monetary accounts (Chapter 5).
	Ratio of actual to desired level of public investment in water supply It would indicate if investments to meet water-related targets are on track. A ratio of less than 1 indicate the magnitude by which actual investment in the water sector will need to be increased, thus allowing the governments to adjust their financial responses to meet the water MDG. The indicator is based on the following definitions: *Actual level of investment*: Actual investment in provision of water supply and services from all sources. *Desired level of investment*: A value that captures cost of providing water to different settlements (urban and rural) for given technological choices and target to be met in terms of providing access to water services.	D	The indicator would be computed as: the ratio of actual level (AL) of investment to the desired level (DL) of investment in providing safe drinking water supply, as warranted under the relevant MDG.	Partially derived from the water accounts. The actual level of investment can be derived from the monetary accounts (Chapter 5). The desired level of investment is exogenous and may be the result of modelling based on the water accounts.
	Rate of cost recovery An assessment of the existing water fees collection system could guide institutional reforms for strengthening financial viability of water utilities, thus improving the water governance. This indicator measures water fees actually collected as percent of the total collectable charges billed by the water utility. The indicator is based on the following definitions. *Water Fees*: Rates/tariffs structure established by the water utility (in the form of per unit of water used or flat rate or block rate etc.) as monetary amount of costs to recover from consumers for purposes of sustaining the supply agency, providing incentives for conservation and assuring supplies for the less well-off. ***Actual water fees collected***: Actual monetary amount collected/received by the water utility from different consumers for providing water supply and services. ***Total water fees to be collected***: This refers to the total amount that should have been collected by the water utility based on the billing to different consumers in accordance with the established water fees structure for different consumer groups.	D	The indicator can be computed as: 100 (AWFC/TWFC) where: AWFC = actual water fees collected TWFC = total water fees to be collected.	Partially derived from the water accounts. Actual water fees collected can be derived from the monetary accounts (Chapter 5). The water accounts provide information on the actual costs of providing water (and wastewater services). Thus the rate of recovery based on the ratio of actual water fees collected and total costs of water supply would measure the part of the total costs of water supply which is recovered through water fees.

	Water charges as percent of households income Water charges are seen as an important economic instrument for improving water use efficiency and securing financial sustainability of water utility. At the same time it is important that water services are made accessible and affordable to all. This indicator shows how much water charges constitute of the household income. The indicator is based on the following definitions. *Expenditure on Water Charges*: Actual monetary amount paid by households to the water utility in return for receiving water supply and services. *Household Income*: In simple terms, it is defined as the total amount of income received by all persons living in the same household. This includes, but is not limited to, wages or salary income; net self-employment income; interest, dividends, or net rental or royalty income or income from estates and trusts etc.	D	The indicator can be computed as: 100 (EW/HI) where: EW = the total amount spent on water supply by the household HI = total household income.	Derived from the monetary accounts (Chapter 5).
Sharing	**Water interdependency indicator**	C	The definitions for these indicators were not available but, in principle, the indicators which are based on physical information on the flows between countries can be derived from the asset accounts (Chapter 6).	
	Cooperation indicator	C		
	Vulnerability indicator	C		
	Fragility indicator	C		
	Development indicator	C		

Notes: 1 Level of development, highest to lowest: B = basic indicator, K= key indicator for which there is an indicator profile sheet and statistical data; D= developing indicators for which there is an indicator profile sheet but not yet statistical presentation; and C= conceptual indicator for which there is a discussion only.

Source: Adapted table from the WWDR (2006)

GLOSSARY

Abstraction: amount of water removed from fresh and non-fresh water resources either permanently or temporarily in a given period of time for consumption and production activities. Water used for hydroelectricity generation is considered as part of water abstraction. Total water abstraction can be broken down according to the type of source (i.e. Freshwater Resources and Non-freshwater Resources) and the type of use. (EDG)

Abstraction for distribution: water abstracted for the purpose of distributing it. (EDG)

Abstraction for own use: water abstracted for own use. However, once water is used, it can be delivered to another user for re-use or for treatment. (EDG)

Actual evapotranspiration: 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. (EDG)

Actual final consumption: "…the value of the consumption of goods acquired by households, whether by purchase (final consumption expenditures) or by transfer from government units or Non-profit Institutions Serving Households (NPISHs), and used by them for the satisfaction of their needs and wants" (para. 9.11, 1993 SNA).

Actual final consumption of general government: is measured by the value of the collective (as opposed to individual) consumption services provided to the community, or large sections of the community, by general government; it is derived from their final consumption expenditure by subtracting the value of social transfers in kind payable. (SNA para. 9.97, and 9.3).

Ancillary activity: an ancillary activity is a supporting activity undertaken within an enterprise in order to create the conditions within which the principal or secondary activities can be carried out; ancillary activities generally produce services that are commonly found as inputs into almost any kind of productive activity and the value of an individual ancillary activity's output is likely to be small compared with the other activities of the enterprise (e.g. cleaning and maintenance of buildings). (SNA Para. 5.9. 5.10 [15.16.])

Aquifer: permeable water-bearing formation capable of yielding exploitable quantities of water. (UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992)

Artificial Reservoirs: man-made reservoirs used for storage, regulation and control of water resources. (Electronic Discussion Group on terms and definitions used in water accounting, 2003) EDG

Brackish Water: water having salinity between that of fresh and marine water. EDG

Catchment syn. river basin: area having a common outlet for its surface run-off. (UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992)

Determinand: parameter, water quality variable or characteristic of water quality.

Direct use benefits: benefits derived from the use of environmental assets as sources of materials, energy or space for input into human activities. (SEEA-2003 7.36)

Emission to water: direct release of a pollutant to air or water as well as the indirect release by transfer to an off-site wastewater treatment plant. From the EPER guidance document (http://www.eper.cec.eu.int/eper/documents/guidance_html/index.htm)

Evapotranspiration: quantity of water transferred from the soil to the atmosphere by evaporation and plant transpiration. (EDG)

Exports: Water that exits the territory of reference through mains or other infrastructures. (EDG)

Final consumption expenditure of households: the expenditure, including imputed expenditure, incurred by resident households on individual consumption goods and services, including those sold at prices that are not economically significant. (SNA para. 9.94).

Fresh water resources: naturally occurring water having a low concentration of salt. EDG

Gross capital formation: the total value of the gross fixed capital formation, changes in inventories and acquisitions less disposals of valuables for a unit or sector. (SNA para. 10.32).

Groundwater: subsurface water occupying the saturated zone. (UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992)

Groundwater recharge: amount of water added from outside to the zone of saturation of an aquifer during a given period of time. Recharge of an aquifer is the sum of natural and artificial recharge (EDG)

Glaciers: bodies of land ice that consist of recrystallized snow accumulated on the surface of the ground" (Langbein W.B. and K. T. Iseri, General Introduction of Hydrologic Definitions", Geological Survey Water-Supply Paper 1541-A, United States Geological Survey.) An accumulation of ice of atmospheric origin generally moving slowly on land over a long period. (UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992)

Hydrological cycle syn. water cycle: succession of stages through which water passes from the atmosphere to the earth and returns to the atmosphere: evaporation from the land or sea or inland water, condensation to form clouds, precipitation, accumulation in the soil or in bodies of water, and re-evaporation. (UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992)

Hydroelectric power water use [water-use category]: water used in generating electricity at plants where the turbine generators are driven by falling water (USGS http://pubs.usgs.gov/chapter11/chapter11M.html)

Imports: Water that enters the territory of reference through mains or other infrastructures. (EDG)

Inflow: water that flows into a stream, lake, reservoir, container, basin, aquifer system, etc. (EDG)

Intermediate consumption: the value of the goods and services consumed as inputs by a process of production, excluding fixed assets whose consumption is recorded as consumption of fixed capital; the goods or services may be either transformed or used up by the production process. (SNA para 6.147).

Irrigation water: Artificial application of water to lands for agricultural purposes. (UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992)

Lake: generally large body of standing water occupying a depression in the earth surface. EDG

Mining water use [water-use category]: water used for the extraction of naturally occurring minerals including coal, ores, petroleum, and natural gas. Includes water associated with quarrying, dewatering, milling, and other on site activities done as part of mining. Excludes water used for processing, such as smelting and refining, or slurry pipeline (industrial water use). (USGS http://pubs.usgs.gov/chapter11/chapter11M.html)

Non-point source of pollution: pollution sources that are diffused and without a single point of origin or not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by storm-water run-off. The commonly used categories for non-point sources are agriculture, forestry, urban areas, mining, construction, dams and channels, land disposal and saltwater intrusion. (On-line glossary of environment statistics, UNSD)

Option benefits: benefits derived from the continued existence of elements of the environment that may one day provide benefits for those currently living. (SEEA-2003 paragraph 7.37)

Outflow: flow of water out of a stream, lake, reservoir, container, basin, aquifer system, etc. (UNESCO/WMO International Dictionary of Hydrology, 2nd edition, 1992. Termdat "Terminology of water Management: Flood Protection". Working copy 2002) EDG

Perennial river: river which flows continuously all through the year. (Based on the Glossary of Hydrology, 2nd edition, 1992 which defined though *perennial stream*).

Point source of pollution: emissions for which the geographical location of the discharge of the wastewater is clearly identified. They include, for example, emissions from wastewater treatment plants, power plants, other industrial establishments.

Population equivalents: one population equivalent (p.e.) means the organic biodegradable load having a five-day biochemical oxygen demand (BOD5) of 60 g of oxygen per day. OECD/Eurostat Joint Questionnaire on Inland Water

Potential evapotranspiration: 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. It thus includes evaporation from the soil and transpiration from the vegetation of a specified region in a given time interval, expressed as depth. (EDG)

Precipitation: total volume of atmospheric wet precipitation (e.g. rain, snow, hail etc.) on a territory in a given period of time. (EDG)

Recycled water: the re-use of water within the same industry or establishment (on site). (EDG)

Reused water: wastewater delivered to a user for further use with or without prior treatment. Recycling within industrial sites is excluded (EDG)

Rivers and streams: body of water flowing continuously or periodically in a channel. (EDG)

River basin: area having a common outlet for its surface run-off. (EDG)

Run-off: the part of precipitation in a given country/territory and period of time, that appears as stream flow. (EDG)

Sewage sludge: the accumulated settled solids separated from various types of water either moist or mixed with a liquid component as a result of natural or artificial processes. (OECD/Eurostat Joint Questionnaire on Inland Water)

Social transfers in kind: individual goods and services provided as transfers in kind to individual households by government units (including social security funds) and NPISHs, whether purchased on the market or produced as non-market output by government units or NPISHs; the items included are: (a) social security benefits, reimbursements, (b) other social security benefits in kind, (c) social assistance benefits in kind, and (d) transfers of individual non-market goods or services. (SNA para 8.99).

Soil water: water suspended in the uppermost belt of soil, or in the zone of aeration near the ground surface, that can be discharged in to the atmosphere by evapotranspiration. (EDG)

Standard river unit (SRU): a river stretch of one kilometre with a water flow of once cubic meter per second. (SEEA 8.128)

Stretch: or reach, is a portion of a stream or river, as from one turn to another, supposedly having constant characteristics. (Philippe Crouzet)

Supply of water to other economic units refers to the amount of water that is supplied by an economic unit to another and is recorded net of losses in distribution (EDG)

Surface water: water which flows over, or is stored on the ground surface. (EDG)

Total water returns: water that is returned into the environment during a given period of time. Total returns can be classified according to the receiving media (i.e. fresh and non-fresh water resources) and to the type of water (e.g. treated water, cooling water, etc.). (EDG)

Total water supply: in water accounts, water supply is water leaving/flowing-out from an economic unit (Industries, Households and rest of the world). Total water supply is the sum of water supply to other economic units and water supply to the environment. (EDG)

Total water use: in water accounts, water use is the water intake of industries and households for production and consumption activities. Total Water Use is the sum of water use within the economy and water use from the environment. (EDG)

Trade margin: difference between the actual or imputed price realized on a good purchased for resale (either wholesale or retail) and the price that would have to be paid by the distributor to replace the good at the time it is sold or otherwise disposed of. (SNA para 6.110)

Transboundary waters: means any surface or ground waters which mark, cross or are located on boundaries between two or more States; wherever transboundary waters flow directly into the sea, these transboundary waters end at a straight line across their respective mouths between points on the low-water line of the banks. (Helsinki Convention 1992)

Transport margin: transport charges paid separately by the purchaser in taking delivery of the goods at the required time and place. (SNA para. 15.40)

Urban run-off: that portion of precipitation *on urban areas* that does not naturally percolate into the ground or evaporate, but flows via overland flow, underflow, or channels or is piped into a defined surface water channel or a constructed infiltration facility (Washington Department of Ecology, 1992). (http://www.epa.gov/owow/nps/MMGI/Chapter4/ch4-8.html) [slightly modified in italic]

Use of water received from other economic units: the amount of water that is delivered to an industry, households and the rest of the world from another economic unit. (EDG)

Water body: mass of water distinct from other masses of water.

Watercourse: natural or man-made channel through or along which water may flow.

Wastewater: water which is of no further immediate value to the purpose for which it was used or in the pursuit of which it was produced because of its quality, quantity or time of occurrence. However, waste water from one user can be a potential supply to a user elsewhere. It includes discharges of cooling water. (EDG)

Water consumption: part of water use which is not distributed to other economic units and does not return to the environment (to water resources, sea and ocean) because during use it has been incorporated into products, consumed by households or livestock. It is calculated as a difference between total use and total supply, thus it may include losses due to evaporation occurring in distribution and apparent losses due to illegal tapping and malfunctioning metering. (EDG)

Water losses in distribution: volume of water lost during transport between a point of abstraction and a point of use, and between points of use and reuse because of leakages, evaporation and illegal tapping. Water lost due to leakage is considered a return flow if it percolates to an aquifer and is available for reuse. Otherwise it is considered as water consumption. (EDG)

Water returns: water that is returned into the environment during a given period of time after use. Returns can be classified according to the receiving media (i.e. water resources and sea water) and to the type of water (e.g. treated water, cooling water, etc.). (EDG)

Water supply to the environment: see Water returns.

Water supply within the economy: Water which is distributed to households and industries (including agriculture) and to the rest of the world (exports). Water supply within the economy is net of losses in distribution. (EDG)

Water use within the economy: water intake for production and consumption activities, which is distributed by industries or households and by the Rest of the World (Imports). (EDG)

Water use from the environment: water abstracted from water resources, seas and oceans, and precipitation collected by industries and households for production and consumption activities, including rainfed agriculture. (EDG)

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