System of Environmental-Economic Accounting for Water

United Nations Statistics Division

NOTE

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The United Nations Statistical Commission adopted Part I of this document as an interim standard, pending the revision of the SEEA 2003. This version was prepared for advanced web dissemination.

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The *System of Environmental and Economic Accounting for Water* (SEEAW) has been prepared by the United Nations Statistics Division (UNSD) in collaboration with the London Group on Environmental Accounting, and in particular with its Sub-group on Water Accounting.

The preparation of the Handbook of National Accounting *Integrated Environmental and Economic Accounting -2003* (commonly referred to as SEEA-2003) provided an opportunity and a challenge to develop methodologies for water accounts. Although country experiences in water accounts at the time the SEEA-2003 was written, was limited, commonalities in the approaches to compile water accounts emerged. The section on water accounts in Chapter 8 of the SEEA-2003 is the first attempt to develop harmonized methodologies for water accounts.

Given the prominence and recognition of water in the national and international development agenda, the increasing demands from countries for harmonization and guidance on water accounting has led UNSD to take on the task of advancing the methodology based on a consensus of best practices. This work builds on the results already achieved during the preparation of the SEEA-2003.

The Eurostat Task Force on Water Accounts has been a major contributor in the development of harmonized concepts, definitions and classifications as well as the set of standard tables. The Sub-group on Water Accounting of the London Group, established at the 8th London Group meeting in Rome (5-7 November 2003), contributed text and country examples, reviewed the various versions of the draft manuscript and assisted in the finalization of the document. The Sub-group comprised approximately 20 experts from countries, academia and international organizations.

Draft chapters were discussed at several meetings including the 8th and 9th London Group meetings in Rome in 2003 and Copenhagen in 2004 respectively. A final draft was discussed and reviewed during a meeting of the Sub-group in New York (11-13 May 2005). During this meeting, the Sub-group agreed to include in the manuscript a set of standard tables for the compilation of water accounts which countries are encouraged to compile. The status of the preparation and the final draft of the SEEAW were presented at the *Preliminary Meeting of the United Nations Committee of Experts on Environmental-Economic Accounting* (UNCEEA) in New York (29 -31 August 2005).

The revised draft was presented at the *User-Producer Conference: Water Accounting for Integrated Water Resource Management* (Voorburg, 22-24 May 2006), organized by UNSD under the auspices of the UNCEEA. The Conference, gathering the major users and producers of water information, endorsed the SEEAW and recognized that it provides the much-needed conceptual framework for organizing hydrological and economic information in support of Integrated Water Resource Management (IWRM). The Conference recommended its adoption as the international standard for water statistics.

In light of the recommendations of the User-Producer Conference, the discussion during the *First UNCEEA Meeting*, New York (22-23 June 2006) and a subsequent e-consultation among the UNCEEA members, the final text of the SEEAW has been revised to conform to the content and style of an international statistical standard and a fictitious dataset has been developed to populate the standard tables.

As a result of the e-consultation among UNCEEA members, the SEEAW has been structured in two parts. The first part includes internationally agreed concepts, definitions, classifications, standard tables and accounts covering the framework, physical and hybrid supply and use tables and asset accounts (Chapters 1 to 6). The second part consists of those accounts that are considered of high policy relevance but still experimental because an international accepted best practice did not emerge.

(Chapters 7 to 9). It covers the quality accounts, the economic valuation of water beyond the 1993 SNA and examples on applications of the SEEAW.

The majority of the UNCEEA members recommended that the SEEAW be submitted for adoption as a statistical standard to the UN Statistical Commission, at its thirty-eighth session, 27 February to 2 March 2007. As a result, the UNCEEA has requested the Statistical Commission in its report to advise on the adoption of Part I of the SEEAW as an international statistical standard, subject to a possible re-evaluation, taking into account the consistency in style and content with the revised SEEA-2003 and the emerging country practices and to encourage the implementation in countries.

The present version of the SEEAW was prepared under the responsibility of the United Nations Statistical Division and, in particular, under the coordination of Ilaria DiMatteo, moderator of the sub-group of the London Group on Water Accounting, under the supervision of Alessandra Alfieri and overall responsibility of Ivo Havinga. Draft chapters were prepared by Alessandra Alfieri, Ilaria DiMatteo, Bram Edens (UNSD), and Glenn-Marie Lange (Columbia University, United States). Philippe Crouzet (European Environment Agency), Anton Steurer (Eurostat), Gerard Gié, Christine Spanneut (consultants to Eurostat) and Jean Michel Chéné (United Nations Division for Sustainable Development, UNDSD) contributed to earlier draft. The development of the framework greatly benefited from discussions with Jean Louis Weber (formerly with French Institute for the Environment and currently with European Environment Agency).

An Electronic Discussion Group (EDG) on Terms and Definitions used in Water Accounting was established and moderated by UNSD in cooperation with the UNDSD. In particular, the contributions of Aslam Chaudhry and Jean Michel Chéné (UNDSD) were invaluable and are greatly acknowledged.

The many contributions, comments and reviews by the members of the Sub-group of the London Group on Water Accounting and by the participants to meeting of the Sub-group in New York (11-13 May 2005) are greatly acknowledged. They include the following experts: Micheal Vardon (formerly with

Australian Bureau of Statistics and currently with UNSD), Martin Lemire and Francois Soulard (Canada), Wang Yixuan (China), Thomas Olsen (Denmark), Philippe Crouzet and Jean Louis Weber (European Environment Agency), Christian Ravets (Eurostat), Jean Margat (France), Christine Flachmann (Germany), Gerard Gie (In-Numeri), Osama Al-Zoubi (Jordan), Marianne Eriksson (Sweden), Riaan Grobler and Aneme Malan (South Africa), Leila Oulkacha (Morocco), Sjoerd Schenau and Martine ten Ham (The Netherlands), Jana Tafi (The Republic of Moldova), Glenn Marie Lange (United States), Jean Michel Chéné (UNDSD) and Saeed Ordoubadi (The World Bank).

The SEEAW also benefited greatly from the comments of the following experts: Roberto Lenton (Global Water Partnership), Nancy Steinbach (Eurostat), Michael Nagy (consultant to UNSD), Ralf Becker and Jeremy Webb (UNSD) and in particular Réné Lalement (France) who substantially reviewed and contributed to the chapter on water quality accounts.

Micheal Vardon (UNSD) and Lisa Lowe (intern to the UNSD) have proofread the manuscript.

Chapter 1 Introduction to the SEEAW

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 results in unprecedented pressures on water resources, with many countries 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 inclusion of two indicators (proportion of population with sustainable access to an improved water source and proportion of population with access to improved sanitation) in a specific target in the Millennium Development Goals (MDGs), namely target 10 - to halve, by 2015, the proportion of people without sustainable access to safe drinking water and 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 (United Nations and the World Water Assessment Programme, 2006).

1.4. The *System of Environmental-Economic Accounting for Water* (SEEAW) provides a conceptual framework for organizing the hydrological and economic information in a coherent and consistent manner. The SEEAW framework is an elaboration of the handbook *Integrated Environmental and Economic Accounting 2003* (United Nations et al. 2003), commonly referred to as SEEA-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-2003 and SEEAW use as basic framework the 1993 System of National Accounts (1993 SNA) (CEC *et. al.*, 1993) which is the standard system for the compilation of economic statistics and derivation of economic indicators, the most notable being gross domestic product (GDP).

1.5. The SEEAW conceptual framework is complemented with a set of standard tables focusing on hydrological and economic information. It also includes a set of supplementary tables covering information on social aspects which permits 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 or not directly linked with the 1993 SNA. The set of tables, standard and supplementary, were designed with the objective of facilitating the compilation of the accounts in countries and to obtain information which is comparable across countries 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 as sinks for the discharge of wastewater, need to be aware of the long-term consequences on water resources and the environment in general.

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 used as an information system to support IWRM.

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

B. Objective and features of the SEEAW

1.10. The SEEAW was developed with the objectives of standardizing concepts and methods in water accounting. It provides a conceptual framework for organizing economic and hydrological information permitting a consistent analysis of the contribution of water to the economy and the impact of the economy on water resources. The SEEAW further elaborates the framework presented in the SEEA-2003 to cover in more detail all aspects related to 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-2003 and the SEEAW from other information systems about the environment. First, the SEEA-2003 and SEEAW directly link environmental data

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 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-2003 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 satellite accounts of the SNA, the SEEA and SEEAW are linked to a 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 further 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 Accounting[1], of elevating the SEEA-2003 to the level of a statistical standard by 2010 (United Nations, 2006c and 2006d).

1.15. The SEEAW includes as part of its standard presentation the following information:

(a) stocks and flows of water resources within the environment;

[1] The United Nations Committee of Experts on Environmental-Economic Accounting (UNCEEA) 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.

(b) 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;

(c) the supply of water and the use of water as input in the production process and by households;

(d) the reuse of water within the economy;

(e) the costs of collection, purification, distribution and treatment of water, as well as the service charges paid by the users;

(f) the financing of these costs, that is, who is paying for the water supply and sanitation services;

(g) the payments of permits for access to abstract water or to use it as sink for discharge of wastewater;

(h) the hydraulic stock in place, as well as investments in hydraulic infrastructure during the accounting period.

1.16. The SEEAW also presents quality accounts, which describe water resources in terms of their quality. These accounts, together with the economic valuation of water resources, are included in the SEEAW for the sake of completeness. However, these modules are still experimental and they are presented in terms of issues in implementation and illustrated by country practices, rather than providing guidelines on the compilation.

1.17. The SEEAW emphasizes the importance of deriving indicators from the accounting system rather than from individual sets of water statistics. The last chapter is dedicated to the uses of water accounting. The SEEAW is an important tool for policy makers as it provides them (a) with indicators and descriptive statistics to monitor the interaction between the environment and the economy, and progress towards 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.

1.18. 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 by Agenda 21 (United Nations, 1992) and that river basin district is the obligatory management unit of the European Water Framework Directive (WFD) (European Parliament and Council, 2000). The water accounting framework can be compiled at any level of spatial disaggregation – a river basin, an administrative region, a city etc. However, since the link between the economic accounts and hydrological information is at the heart of the SEEAW, one should recognize that economic accounts are generally not compiled at the river basin level but at the level of administrative regions.

Note on terminology

1.19. An agreed terminology related to water accounting is used throughout the SEEAW and is presented in the glossary. Water accounting is multidisciplinary and spans many fields such as hydrology, national accounting and environment statistics. Hydrologists, national accountants and environment statisticians need to be able to communicate using a common language. An achievement of the SEEAW is having reached an agreement on a common language and terminology, which is consistent with the specific terminologies of each field.

1.20. An Electronic Discussion Group (EDG)[2] on Terms and Definitions used in Water Accounting was established and moderated by UNSD in cooperation with the United Nations Division for Sustainable Development to reach an agreement on terms and definitions relevant to water accounts.

[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.

The recommendations of the EDG served as an important input in achieving a consensus on terms and definitions and constitute the basis of the SEEAW glossary.

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

1.21. 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, United Nations, 1992).

1.22. IWRM calls for a sustainable management of water resources to ensure that there is enough water for future generations and that water meets high quality standards. 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).

1.23. 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 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).

1.24. The SEEAW is a useful tool in support of IWRM 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, hydroelectric power generation, manufacturing as well as the quantity of wastewater and emissions generated as the result of the 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 derivation of water efficiency and productivity indicators. The SEEAW becomes increasingly important to plan water resources development, allocation and management in the context of multiple uses. It helps water managers to 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 systems as well as the reuse of water. SEEAW provides information on the fees paid for water supply and sewerage services, as well as payments for permits to access water resources, either for abstracting water or for using water resources as a 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 of the introduction of new regulations throughout the economy on water resources.

- *Understanding the impacts of water management on all users.* Policy makers are faced with decisions that have impacts broader than the water sector. It becomes increasingly important to plan water resources development, allocation and management in an integrated manner. SEEAW, because 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 needs 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 industries. Therefore they can be used in economic models to evaluate potential costs and benefits of putting in place new infrastructure.

- *Linking water availability and use.* Improving efficiency in the use of water is particularly important in situations of water stress. For the management of water resources, it is important to link water use with water availability. The SEEAW provides information on the stocks of water resources as well as all changes in stocks due to natural causes (e.g. inflows, outflows, precipitation) and human activities (e.g. abstraction and returns). Further, water abstraction and returns are disaggregated by industry, thus facilitating its management.

- *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 and result in overlaps in data collection. In a similar fashion, data collection may leave out important aspects of water resources, because they are 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 checks 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 collected 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 used by interest groups and communities to argue their position on the basis of sound information.

1.25. 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. To the extent possible, these indicators 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

1.26. The SEEAW is a satellite system of the 1993 SNA and an elaboration of the SEEA framework. It comprises the five categories of accounts described below.

1.27. **Category 1: Physical supply and use tables and emission accounts**. This category of accounts brings together, in a common framework using definitions and classifications of the standard economic accounts of the 1993 SNA, hydrological data on the volume of water used and discharged back to the environment by the economy as well as the amount of pollutants added to water. Bringing the physical information of water in the accounting framework introduces checks and balances in the hydrological data and produces a consistent data system from individual sets of water statistics often collected independently by different line ministries responsible for designing targeted policies.

1.28. Physical supply and use tables (chapter 3) 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 (chapter 4) provide information by economic activity and households on the amount of pollutants which are added to or removed from water (by treatment processes) during use.

1.29. **Category 2: Hybrid and economic accounts**. This category of accounts (chapter 5) aligns physical information recorded in the physical supply and use tables with the monetary supply and use tables of the 1993 SNA. These accounts are referred to as "hybrid" flow accounts to reflect the combination of different types of measurement units in the same accounts. In these accounts, physical quantities can be compared with the matching economic flows (for example, linking volumes of water used with monetary information on the production process, such as value added, and deriving indicators of water efficiency).

1.30. This category of accounts also explicitly identifies those elements of the existing 1993 SNA which are relevant to water. These include, for example, information on the costs associated with water

use and supply such as water abstraction, purification, distribution, and wastewater treatment. They also provide information on financing, that is, the amount users pay for the services of wastewater treatment, for example, and the extent these services are subsidized by the government and other units. These accounts are particularly useful for cost-recovery policies and water-allocation policies and 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.

1.31. **Category 3: Asset accounts**. This category of accounts (chapter 6) comprises of accounts for water resource assets measured mostly in physical terms. Asset accounts measure the 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). These accounts 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.

1.32. **Category 4: Quality accounts**. This 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 yet to be agreement on a standard way of compiling them. Quality accounts describe the stocks of water resources in terms of quality: they show the stocks of certain qualities at the beginning and end of an accounting period. Since it is generally 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.

1.33. **Category 5: Valuation of water resources.** The final category of the SEEAW accounts comprises the valuation of water and water resources (Chapter 8). As for the quality accounts, this

category of accounts is still experimental and there is yet to be agreement on a standard way of compiling them.

1.34. 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 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.

1.35. The valuation of water resources is included in the SEEAW because of its policy relevance. However, since there is yet to be agreement on how to value water (consistent with 1993 SNA valuation concepts), the SEEAW only presents valuation techniques commonly used in economic analyses (which may go beyond the value of the market transactions recorded in the 1993 SNA) and their relationship to the concepts of the 1993 SNA as well as discusses the advantages and disadvantages of different techniques.

E. Structure of the SEEAW

1.36. The SEEAW is structured in two parts. The first part (chapters 2-6) presents those accounts for which there is considerable practical experience and a consensus on best practices has emerged. It presents agreed concepts, definitions and classifications related to water accounts as well as a set of standard tables that countries are encouraged to compile. The second part (chapters 7-9) 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. This second part also provides examples of applications of the water accounts in countries in chapter 9.

1.37. As an aid to understand the relationships among the various accounts, a fictitious but realistic database, SEEAW-land, has been developed. Each chapter presents the tables populated with the information from the database.

1.38. The following gives a brief overview of each chapter of the SEEAW. At the beginning 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.

Part I

Chapter 2: The water accounts framework

1.39. 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.

1.40. Since the SEEAW is rooted in the 1993 SNA, chapter 2 provides an overview of the whole accounting system and describes how the SEEAW expands the 1993 SNA accounting framework. This chapter also describes in great detail the classifications used in the SEEAW which form the backbone of the accounting framework and the interconnections between the different accounts.

1.41. Since water resources present spatial and temporal characteristics, which are usually not addressed in standard accounts, Chapter 2 describes how the SEEAW can be adapted to compile information which is spatially and temporally disaggregated, without disrupting the accounting structure.

1.42. 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 presented in the subsequent chapters.

Chapter 3: Physical water supply and use tables

1.43. 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, using classifications and definitions consistent with the economic accounting structure of the 1993 SNA.

1.44. 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.

1.45. Flows from the environment to the economy consist of water abstraction from the environment for production or consumption purposes. Flows within the economy are the purview of the 1993 SNA. The SNA measures 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.

1.46. Chapter 3 describes the supply and use tables for physical flows of water and provides standard tables as well as more detailed supplementary tables for compilation. The detailed tables are presented as numerical example and they are part of the SEEAW-land data set.

Chapter 4: Emission accounts

1.47. Chapter 4 describes the pressure of the economy on the environment in terms of emission to water. Emission accounts describe the amount of pollutants that is added to wastewater as a result of production and consumption activities and is released to the environment. These accounts also describe the amount of pollutant which is removed as part of treatment by the sewerage industry.

1.48. The chapter presents a set of standard tables to be compiled by countries and the SEEAW-land data set for emission accounts tables.

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

1.49. Chapter 5 describes the economy of water. It describes in monetary terms the use and supply of water-related products, identifies 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. These flows are captured within the 1993 SNA and need to be separately identified.

1.50. 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, generation of wastewater and emission of pollutants to particular industries.

1.51. In addition to the water supply and sewerage industries, other industries and households may abstract water for their own use or distribute it to other users or they may 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 on the full extent of the national expenditure on water.

1.52. Users of water and water-related products do not always bear the entire costs associated with the use: they often benefit from transfers from other economic units (generally the government) which bear part of the costs. Similarly, investments in infrastructures can be partly financed by different units. The financing of water and water-related products is described in this chapter.

1.53. Economic instruments are increasingly being used to manage the use of water resources. They include the imposition of taxes and the issuing of licences and permits to bestow property rights over

water resources to designated users. The recording of these monetary transactions in the accounting framework is also presented in this chapter.

1.54. The chapter provides standard tables for compilation of hybrid accounts for water, financing and taxes, licences and permits. These tables are part of the SEEAW-land data set and are linked with the physical flows presented in the previous chapters.

Chapter 6: The asset accounts

1.55. 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.

1.56. 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. It also presents the compilation of asset accounts for transboundary waters.

Part II

Chapter 7: Quality accounts

1.57. 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. Nevertheless, since quality is an important characteristic of water ecosystems and limits its use, the SEEAW covers the quality accounts.

1.58. Chapter 7 provides basic concepts on the measurement of quality and describes different approaches to defining quality classes and constructing quality accounts.

Chapter 8: Valuation of water resources

1.59. 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 characteristics unique to water. Water is a collective good, heavily regulated and subject to multiple uses. The price charged often does not even reflect its cost of production and property rights are often absent. Economists have developed techniques for estimating the value of water which are non consistent with the 1993 SNA.

1.60. 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 particular policy questions.

Chapter 9: Examples of applications of water accounts

1.61. 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 applications 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-modelling to estimate, for example, the impact of water pricing reforms or projecting future demands.

1.62. Although the applications presented are derived from the techniques and tables presented in the previous chapters, chapter 9 is a stand-alone chapter. It can be read at the outset as it provides an overview of the possible applications 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 also be read at the end as it shows how the information from different accounts is brought together and used for the derivation of indicators and for economic modelling.

1.63. 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.

1.64. 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 a more flexible temporal dimension. It then discusses the links between water accounts and other resource accounts in the SEEA in support of IWRM.

Annexes

1.65. The SEEAW contains three annexes. The first annex includes the standard tables which are presented and discussed in chapters 3 to 6. 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. In particular, the supplementary tables include: a more detailed level of disaggregation of the standard tables; tables on the quality accounts which are still experimental; and tables linking the SEEAW to the social aspects.

1.66. Annex III links the waters accounts to indicators. In particular, Section 1 draws together the wide range of indicators that can be derived from the accounts presented in the SEEAW to show how, together, they provide a comprehensive set of water-related indicators. Section 2 links the indicators proposed in the second World Water Development Report (United Nations and the World Water

Assessment Programme, 2006) to the water accounts. It further describes the indicators that can be derived from the SEEAW and from which module of accounts.

Glossary

1.67. The glossary provides an agreed terminology for water accounting. It combines (a) hydrological terms, which were agreed on by an electronic discussion group; (b) environmental-economic accounting terms, which are drawn from the glossary of the SEEA-2003; and (c) 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 and adapted to the SEEAW needs.

1.68. The glossary standardizes terms and definitions from the hydrological and the economic spheres in an agreed set of definitions. 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

1.69. The modular structure of the water accounts allows for a step-by-step compilation so that countries can start with the compilation of those modules of the accounts which are more relevant to their policy concerns and data availability. For example, countries facing severe water scarcity often start with the compilation of basic information on the hydrological water balance which feeds into the for the asset accounts, and the physical supply and use tables to identify sources of pressure on the environment and possibly design allocation strategies for competing uses of water. In contrast, countries facing problems with water pollution often start with emission accounts, and hybrid 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.

1.70. For analytical purposes, it is important to compile the accounts yearly. 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, can be used to compile the water accounts.

1.71. An analysis of the consistency of the international questionnaires[3] on water resources and the water accounting standard tables was carried out by 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 the SEEAW. The broad consistency of international data collection activities with the SEEAW is an 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

1.72. 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 acquainted with the features of the SEEAW and the advantages of an integrated information system rooted in the 1993 SNA in support of IWRM.

1.73. The SEEAW standardizes concepts and methods in water accounting and related statistics. The following areas, however, need further work and countries' experience: the quality accounts, the valuation of water resources, the expansion of the framework to social aspects and the impacts of natural disasters. Quality accounts have been implemented in relatively few countries and there is not

[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).

enough experience to draw conclusions on best practices. It is expected that more standardized methods for defining quality classes are likely to emerge as a result of the implementation of the mandatory obligations of the Water Framework Directive (WFD)[4] and other initiatives.

1.74. Valuation of water resources is widely applied by resource economists, 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 revision 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 by 2010. Valuation of environmental goods and services remains one of the controversial issues and will in the next years be the subject of further discussion.

1.75. By focusing on the integrations between the economy and the environment, the SEEAW does not fully develop the link with the social aspects related to water. While some social aspects can be included by disaggregating, for example, the household sector on the basis of socio-demographic characteristics (e.g. rural vs. urban, income etc.) and/or presenting information in supplementary tables, further work is needed to expand the accounting framework to include the social aspects of water.

1.76. As more countries compile the SEEAW standard and supplementary tables, the need emerges 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. Those frameworks should be the starting point for the elaboration of the SEEAW data quality framework.

[4] The WFD requires Member States to ensure good ecological status for surface waters, good ecological potential for heavily modified surface water bodies, good chemical status for surface waters and good chemical and quantitative status for groundwaters by 2015, as well as the general principle of non-deterioration of water bodies.

Chapter 2 The SEEAW framework

A. Introduction

2.1. The *System of Environmental and Economic Accounting for Water* (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 2003* (SEEA-2003) framework focusing exclusively on water resources. As the SEEA, the SEEAW expands the 1993 System of National Accounts (1993 SNA) (CEC et al. 1993) by separately identifying information related to water in the 1993 SNA 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 SNA) 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 material inputs and services to the economy, as well as to mankind outside of the economy and to other living beings. Water resources 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. The SEEAW 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 here in terms of the quality of water and its link to the various uses.

2.5. The SEEAW provides 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.). Further methodological research and practical experience is needed to extend the framework to the social dimension.

2.6. The framework of the SEEAW is presented in the simplified diagrammatic form in

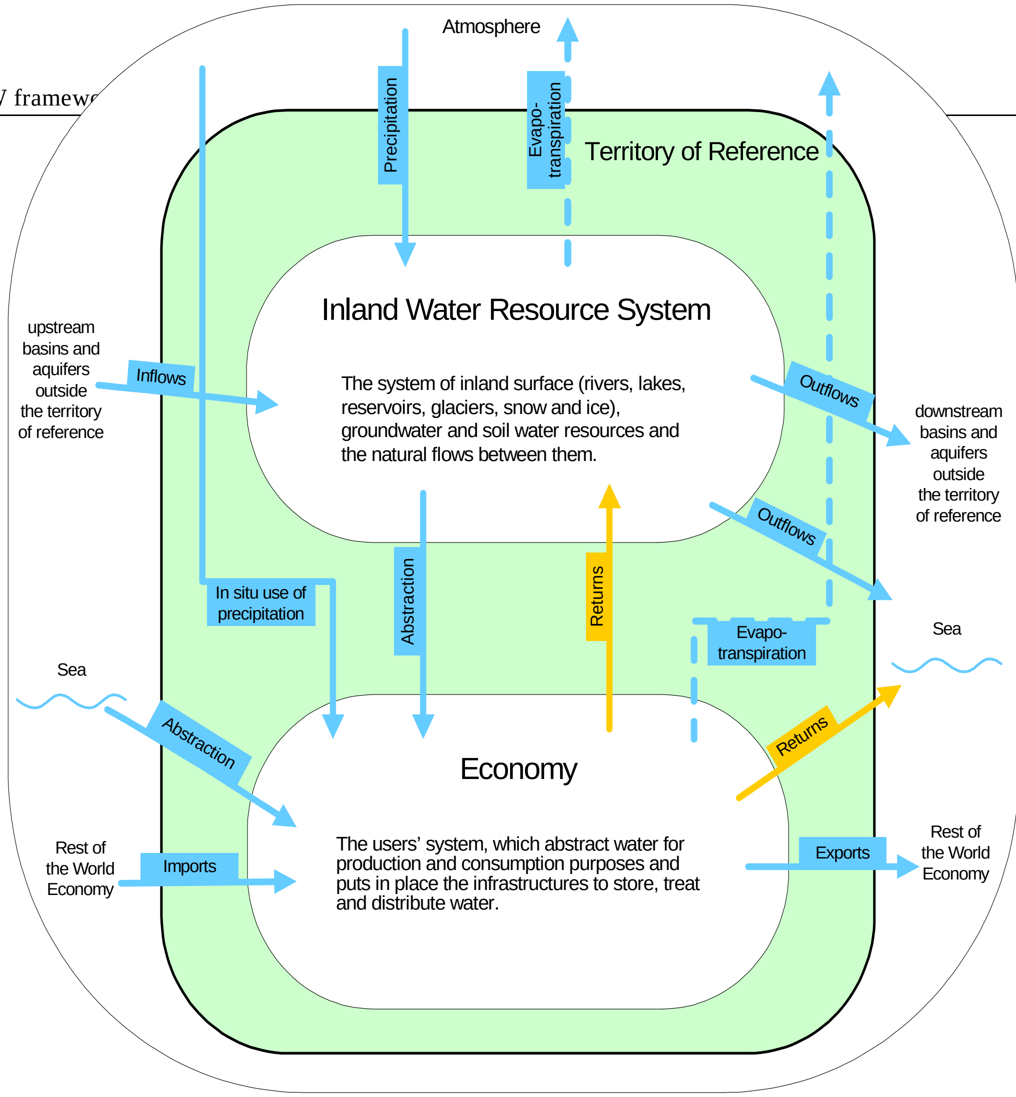
2.7.

2.8. Figure 2.1 which shows 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 as 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[5] water users who abstract

[5] 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" (1993 SNA para 4.15). This concept can be applied also to geographical boundaries other than the national ones.

water for production and consumption purposes and put in place the infrastructure to store, treat, distribute and discharge water. The inland water system and the economy are further elaborated 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



2.9. 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 and outflows to downstream territories (exchanges of water between inland water systems).

2.10.

Figure 2.1 also shows exchanges with the sea and the atmosphere which are considered outside the inland water resource system. These flows are also captured in the SEEAW accounting framework.

2.11. 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

2.12. 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, that 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 the water accounts as they do not involve a displacement of water. It should be mentioned, however, that in the quality accounts their impacts on the quality of water resources could, in principle, be identified.

2.13. In addition to abstracting water, the economy returns water into the environment. As shown in

2.14.

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.

2.15.

2.16. Figure 2.2 shows in more detail the flows of 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 are depicted. For example, direct abstraction of sea water by industries is not explicitly shown even though it is recorded in the accounts.

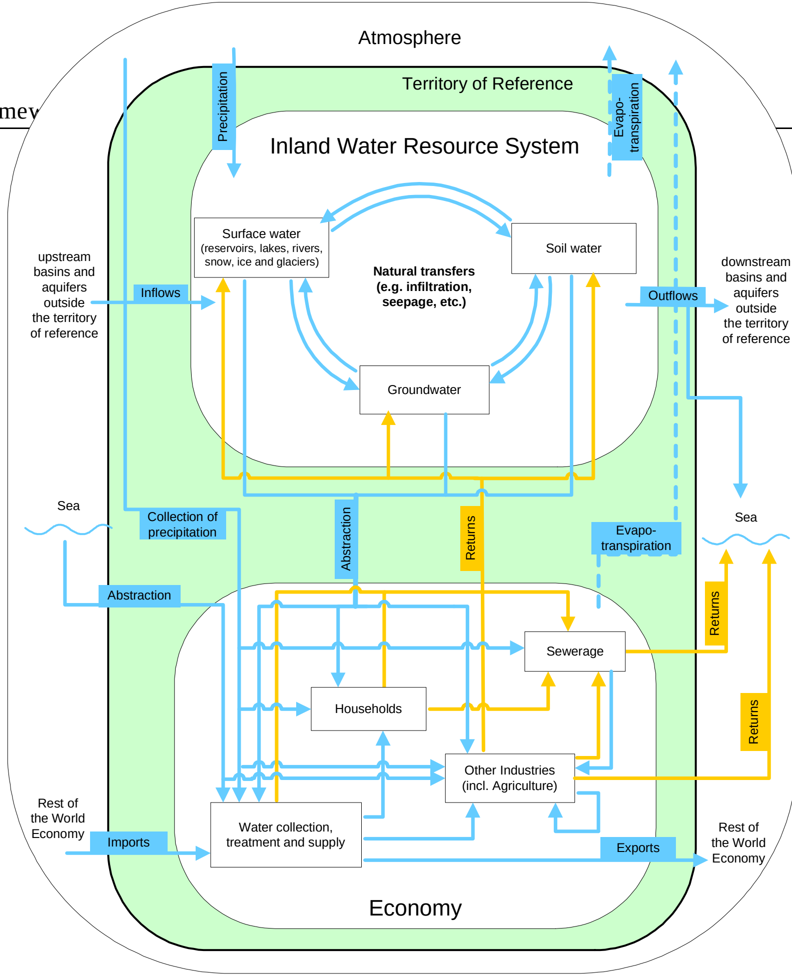


Figure 2.2: Main flows within the inland water resource system and the economy

1. The inland water resource system

2.17. Water is in continuous movement. Solar radiation and gravity keep water moving from land and oceans to the atmosphere in the form of vapour (evapotranspiration) and falling back through precipitation. The inland water resource system is composed of: (a) all inland water resources from which water is, or can be, abstracted; (b) water exchanges between water resources within the territory of reference (e.g. infiltration, runoff, percolation); and (c) water exchanges with water resources of other territories (i.e. inflows, outflows). Exchanges of water between the water resources are also referred to as natural transfers.

2.18. 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.

2.19. 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 economy

2.20. 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. As such, 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.

2.21. In

2.22. 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 (sewerage);
- Other industries which use water as an input in their production processes;
- Households which use water to satisfy their needs or wants.

2.23. 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.

2.24. 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). For the sake of simplicity, not all exchanges within the economy are represented in

2.25. Figure 2.2. Additional information, which is an integral part of the SEEAW, includes:

- 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 (i.e. the sectors bearing the costs of services);
- 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 (current and capital) by industries, households and the government as well as the financing of these expenditure;

- 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.

2.26. 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 which can be either used directly (e.g. for cooling purposes), or after desalinization, 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.

2.27. 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”.

2.28. 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. Here 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* which denotes the water that is received by an industry or households from other industry or directly abstracted. 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.

2.29. Note that

2.30. Figure 2.1 and

2.31. 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

2.32. Figure 2.2 flows of water lost during distribution are not explicitly shown, but they often occur, at times in significant quantities. Although not explicitly shown in the figures, these losses are recorded in the SEEAW.

C. The SEEAW and SNA frameworks

2.33. 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 1993 SNA, the SEEAW has a similar structure to the 1993 SNA as it uses concepts, definitions and classifications consistent with the 1993 SNA 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 explicitly identifying 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" (1993 SNA, Annex of Chapter XIII). The SEEAW expands the

1993 SNA asset boundary by including all water resources, namely 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 1993 SNA, however, they are often not separately identified from 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 an indication of the ability of a country to mobilize water.

- Expanding the 1993 SNA by juxtaposing physical information to the monetary accounts.

In the 1993 SNA the stocks or assets used in the production process and the 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-related 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 abstractions, 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 and management of water resources.

The 1993 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.

2.34. The strengths of using the national accounting framework to describe the interactions between the environment and the economy are manifold. First, the 1993 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 1993 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 facilitates and improves the analysis of the interrelations between the environment and economy.

2.35. Second, the accounting framework contains a series of identities (for example, those 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.

2.36. Third, the accounting structure also 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.

2.37. 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 in isolation but in a comprehensive economic and environmental context.

D. The SEEAW framework

2.38. The SEEAW consists of two parts. The first part describes the accounts for which there has been considerable practical experience in countries and an agreement on how to compile the accounts has been reached. This part presents a set of standard tables which constitutes the minimum data set that countries are encouraged to compile. It also presents supplementary tables which are a further disaggregation of the standard tables and 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. Part I of the SEEAW expands what is presented in the SEEA-2003 by (a) presenting agreed concepts, definitions and classifications related to water, and (b) providing standard compilation tables. Part II describes modules that are more experimental and for which not enough country experience exists and examples of applications of the water accounts. Part II includes: quality accounts, valuation of water and examples of applications of the accounts which are discussed in Chapters 7, 8 and 9 respectively. Chapters 7 and 8 discuss issues in the compilation of those accounts illustrating them by presenting

country experiences and presents supplementary tables for which compilation is still experimental or not directly linked with the 1993 SNA. In Part II, there is no recommendation on how to compile those modules of the accounts. The SEEAW framework consists of the accounts described below.

Flow accounts

2.39. The central framework of the 1993 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 and final uses and exports. The SEEAW 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

2.40. 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).

2.41. 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 industries 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.

Emission accounts

2.42. 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 treatment) or discharged into a sewage network. Emission accounts are presented in Chapter 4.

Hybrid and economic accounts

2.43. 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 part of the hybrid supply and use tables explicitly identifies water-related products and industries. These accounts are a useful tool for obtaining a comprehensive picture of the economics of water and for deriving consistent sets of indicator such as intensity and productivity indicators.

2.44. For analytical purposes, it is useful to identify the government expenditures related to water such as 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* as well as *Sewerage* carried out as principal and secondary activity or for own use provide this kind of information which is useful for compiling resource management and environmental protection expenditure.

2.45. 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 of those which receive transfers from other economic units, government or other countries.

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

Asset accounts

2.47. 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 water resources.

Produced assets

2.48. Produced assets related to water include infrastructure put in place to abstract, distribute, treat and discharge water. They are included in the 1993 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 those produced assets related to water. A large part of these assets are owned either by water companies or water authorities, but can be owned also by other industries or households that collect and treat water or wastewater as a secondary activity or for own use. Changes in the value of these stocks during the accounting period are explained by changes due to transactions in the item in question (acquisitions or disposals of non-financial assets; consumption of fixed capital, etc.), changes in the volume of the asset that are not due to transactions (e.g. discoveries of assets or recognition of their value; the unanticipated destruction or disappearance of assets; changes in classification etc.), and changes in prices (based on para. 13.92, 1993 SNA). Asset accounts for produced assets related to water 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 the SEEAW as these accounts follow the structure of the conventional accounts. Interested readers should refer to chapters X, XII and XIII of the 1993 SNA.

Water resources

2.49. 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, inflows, outflows etc.) and human activities (i.e. abstraction and returns).

2.50. The SEEAW asset boundary of water resources is very broad and includes, 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 when measuring exchanges between water resources (flows within the environment).

2.51. A small part of water resources is already included in the 1993 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. The updating of the 1993 SNA is likely to further expand the asset boundary to include lakes and rivers for which ownership rights are enforced.

2.52. 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 resource rent 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.

Quality accounts

2.53. Asset accounts can also be compiled on the basis of water quality. They describe stocks of water at the beginning and end of an accounting period according to their quality. Since it is generally 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

2.54. This component presents economic valuation techniques of water beyond the market prices and their applicability in answering specific policy questions. 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. As such the SEEAW 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 the SEEAW 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

2.55. 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 (1993 SNA, para. 4.2).

2.56. Institutional units in their capacity as producers 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. Industries are groups of establishments. The production accounts and generation of income accounts are compiled for industries as well as sectors.

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

2.58. 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 (para. 5.41, 1993 SNA).

2.59. 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.

2.60. 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 and secondary activities. The output of principal and secondary activities, respectively 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 the most to the value of the entity, or the activity for which the value added 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.

2.61. In the 1993 SNA, 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. The SEEAW follows the same principle.

2.62. Box 2.1 provides a 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. Even though the simplified standard tables of the SEEAW present only two

of the activities in Box 2.1 (i.e. ISIC 36, *Collection, treatment and supply of water*, and ISIC 37, *Sewerage*), for analytical purposes it is useful to explicitly identify in the accounting tables all the water related activities.

2.63. Note that structural changes were introduced in ISIC Rev.4 since its previous version, ISIC Rev. 3.1 (United Nations, 2004). In particular, for activities related to water, two major changes were 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 under the same section (Section E, ISIC Rev.4) activities of ‘Collection, purification and distribution of water’ and ‘Sewerage’ which were previously classified under 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 (Division 39) to explicitly identify these activities.

2.64. 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 the chapters, reference to a particular class is made according to ISIC Rev. 4. The main activities related to water are described below.

2.65. 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 class 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.

2.66. 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 groundwater 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.

2.67. 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 re-distribute (waste)water to specific users for further use.

2.68. 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’. Since these activities refer to solid waste, they are not discussed further in the SEEAW.

2.69. **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 is 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; and (c) cleaning up of oil spills and other pollutions on land, in surface water, in ocean and seas, including coastal areas.

2.70. 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.

2.71. Activities for the **transport of water** are identified in the ISIC classes 4923 and 4930 depending on whether the transport is by road (e.g. tanker trucks) or via pipeline. These activities are related to the long-distance transport of water as opposed to the distribution of water which is classified under ISIC class 3600.

2.72. 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.

2.73. 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 divisions of ISIC

should be classified in the appropriate division 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.

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 4923 **Freight transport by road** [corresponds to class 6023, ISIC Rev. 3.1]

This class includes:

- all freight transport operations by road (e.g. logging haulage, bulk haulage, including haulage in tanker trucks, etc.)

This class excludes, among other things, distribution of water by trucks, see 3600

ISIC 4930 **Transport via pipeline** [corresponds to class 6023, ISIC Rev. 3.1]

This class includes:

- transport of gases, liquids, water, slurry and other commodities via pipelines
- operation of pump stations

This class excludes: - distribution of natural or manufactured gas, water or steam, see 3520, 3530, 3600; - transport of water, liquids etc. by trucks, see 4923.

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.

Source: UN (2006b).

2.74. 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 national accounts, 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.

2.75. The main products related to water which are identified in the CPC Ver. 2.0 are described in Box 2.2 together with the reference to the ISIC Rev. 4 class in which most of the goods or services in question are generally produced. It should be noted that bottled water is not explicitly included in the list of water-related products as it is treated in the same way as other beverages such as beer, soft drinks and wines. While the SEEAW standard tables do not explicitly record the physical and monetary exchanges of these products within the economy, they can be easily expanded to add this information.

They do, however, record information on the volumes of water used and discharged during the production of these beverages.

2.76. The simplified standard tables explicitly identify only two of the products related to water which constitute the most important water-related products: CPC 18, *Natural water*, and CPC 941, *Sewerage, sewage treatment and septic tank cleaning services*. It is, however, highly recommended to also explicitly include the other water-related products.

2.77. 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 particularly important for water conservation policies which encourage the reuse of water. Examples of relevant categories of water in the physical supply and use tables are presented in Chapter 3.

2.78. 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
Natural water - CPC 18000	ISIC 3600 – Collection, treatment and supply of water
Transport services which includes the following subclasses CPC 65112 *Road transport services of freight by tank trucks or semi-trailers* CPC 65122 *Railway transport services of freight by tanker cars* CPC 65139 *Transport services via pipeline of other goods*	ISIC 4923 - Freight transport by road and ISIC 4630 - Transport via pipeline
Water distribution services which include the following subclasses: CPC 69210 *Water distribution services through mains, except steam and hot water* CPC 69230 *Water distribution services, except through mains* CPC 86330 *Water distribution services through mains (on a fee or contract basis)* CPC 86350 *Water distribution services, except through mains (on a fee or contract basis)*	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)	ISIC 8412 - Regulation of the activities of providing health care, education, cultural services and other social services, excluding social security

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.	
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 Ver. 2.0 are presented together with the reference to the industry, ISIC Rev. 4, in which most of the goods or services in question are generally produced.

Source: UN (2006a).

2. Main identities of the SNA accounting framework

2.79. 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 1993 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 the SEEAW more frequently are described below.

2.80. 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.

2.81. 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.

2.82. 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.

2.83. 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

2.84. 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

2.85. 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, but 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.

2.86. The monetary SUT are shown in Figure 2.3 with unshaded boxes. While the 1993 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.

2.87. 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 separately identify these expenditures. Water protection and management accounts are also presented in chapter 5.

2.88. 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.

2.89. 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. Firstly, these assets represent a minimal part of all water assets; secondly, the valuation of those assets, even though theoretically possible, remains in practice a difficult exercise and it is often embedded in the value of land.

2.90. 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) 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.

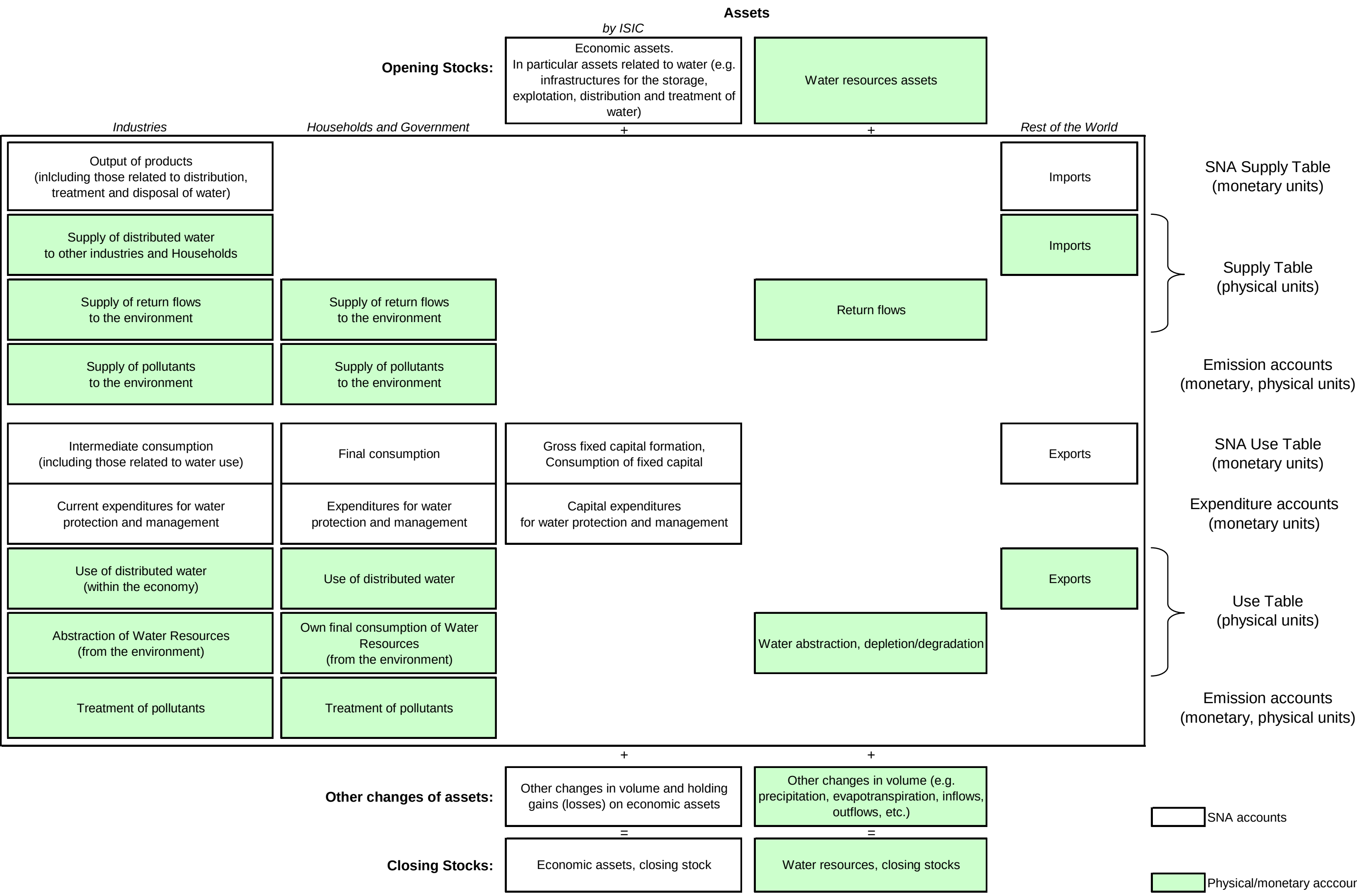


Figure 2.3: SEEAW framework

E. Spatial and temporal issues in water accounting

2.91. 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 smaller spatial scales, there can be 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. 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 and year-to-year variability can be significant.

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

2.93. 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

2.94. 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 decisions on water allocation between different users, it is often more appropriate to use a finer spatial reference.

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

2.96. 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.

2.97. 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 (see, for example, Agenda 21 (United Nations, 1992) and the EU Water Framework Directive (WFD)). In particular, the WFD requires Member States to formulate a river basin management plan for each river basin district[6] within their territory, and, in the case of an international river basin district, Member States shall ensure coordination with other Member States or third countries with the aim of producing a single international river basin plan. Water management can in fact be more effectively pursued at the river basin level since all water resources within a river basin are inextricably linked to each others both in terms of quantity and quality. In this way, managers are

[6] In the WFD, "River basin district" means the area of land and sea, made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters, which is identified under Article 3(1) as the main unit for management of river basins. It may include several river basins and their sub-basins.

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.

2.98. 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.

2.99. River basin agencies have been increasingly established in countries. They are usually government bodies endowed with their 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. The WFD, for instance, requires the establishment of competent authorities in the river basin districts to be responsible for the implementation of the Directive.

2.100. While the compilation of physical water accounts at river basin can be easily undertaken (as river basin agencies generally collect physical data at river basin level), the compilation of monetary water accounts at the river basin level requires extra work to reconcile the spatial reference of economic information (such as output, value added etc.) which is only available at administrative region. Often techniques to allocate economic data to river basin involve the allocation of economic accounts at the administrative region level to the river basin on the basis of other socio-economic data.

2.101. 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 would be 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

2.102. 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[7]); 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 that the reference period for the compilation of the accounts is the 12-month accounting period of the national accounts.

2.103. 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 and thus are often not considered a feasible option.

2.104. 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

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

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).

2.105. To reflect the long-term 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 physical water 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 the pressure on water. In combination with monetary information on value added, indicators of water use intensity and productivity can be calculated.

3.3. The objective of this chapter is to provide a comprehensive overview of physical supply and use tables. 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.

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 the interactions between the environment and the economy. It describes: (a) flows from the environment to the economy; (b) flows within the economy; and (c) flows from the economy to the environment as described in Figure 3.1. Note that 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. The 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.

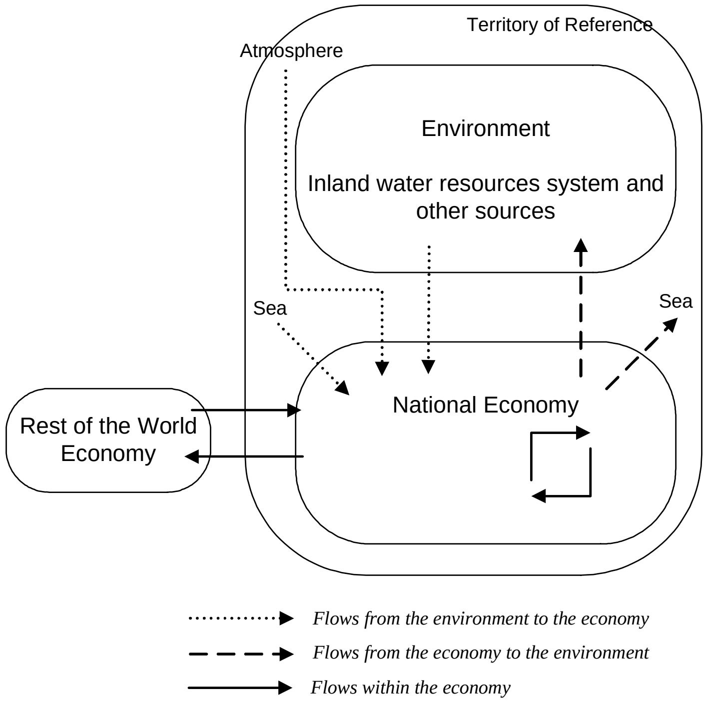


Figure 3.1: Flows in the physical supply and use tables

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. Abstraction from other resources includes abstraction from the sea (for example, for direct use for cooling, 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, could be included as supplementary items in the accounts, in particular in the quality 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 of in-situ uses of water resources is generally made.

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 Rev. 4, *Water collection, treatment and supply*. There may be, however, other industries which abstract and supply water as a secondary activity.

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 (pipes), but other means of transporting water are not excluded. The origin and destination of these flows 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 involves 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.

3.10. Figure 3.2 presents a more detailed description of water exchanges. 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. The dotted line arrows represent flows from the environment to the economy and the dashed line arrows represent flows from the economy to the environment.

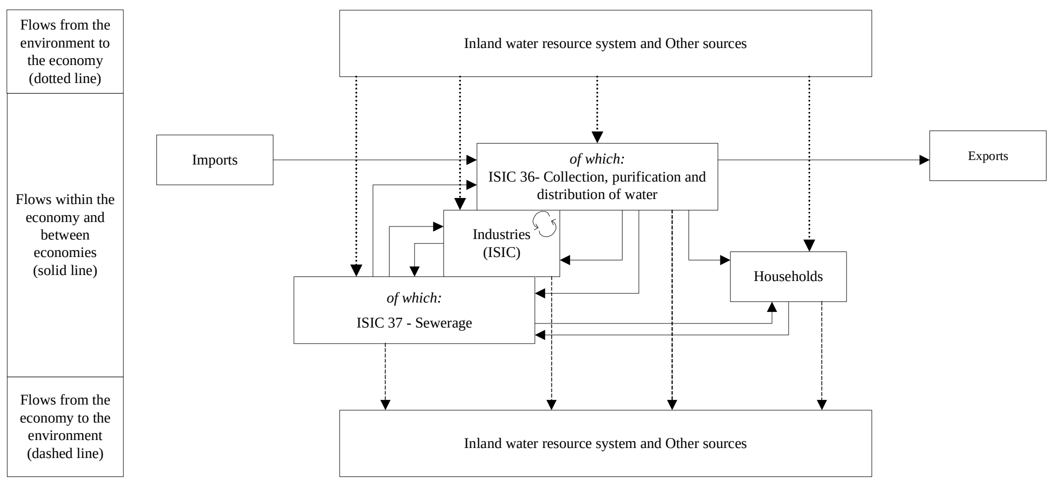


Figure 3.2: Detailed description of physical water flows within the economy

3.11. Most of the water is generally supplied by the industry ISIC 36, *Water collection, treatment and suppl*y; 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 generally represents a flow of wastewater to ISIC 37, *Sewerage*.

3.12. The collection of wastewater by ISIC 37, *Sewerage*, 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[8] 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; and 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, theft, 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.

[8] Note that the term "water loss" may have a different meaning in a different context. Here the term refers to a loss of water from 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 returning to water resources, becomes available for use again.

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 (residual flows). 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, for these flows, use equals supply.

3.17. Flows from the economy to the environment are described in accounting terms in the supply table as a supply of an economic unit to the environment. Each entry represents the amount of water generated by an economic unit and discharged into the environment (in the SEEAW discharges of water back to the environment are also referred to as *returns* or *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 (as specified in the asset classification in chapter 6) and 'other sources' such as seas or oceans.

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 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 an overview of water flows. In addition, all the information contained in the table is balanced: i.e. 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 the standard physical supply and use tables for water. The breakdown of the economic activities, classified according to ISIC Rev.4, distinguishes the following groups:

- ISIC 1-3 which includes *Agriculture*, *Forestry* and *Fishing*;
- ISIC 5-33, 41-43 which includes: *Mining and quarrying*, *Manufacturing* and *Construction*;
- ISIC 35 - *Electricity, gas, steam and air conditioning supply*;
- ISIC 36 - *Water collection, treatment and supply*;
- ISIC 37 - *Sewerage*;
- ISIC 38, 39, 45-99, which corresponds to the *Service industries*.

3.23. ISIC 35, 36 and 37 have been separately identified because of their importance in the use and supply of water and water-related services. In particular, ISIC 36 and 37 are separately identified as they are key industries for the distribution of water and wastewater. Cost-recovery policies and policies

aiming at improving the access to safe drinking water and sanitation are examples of policies involving almost exclusively these two economic activities.

3.24. ISIC 35 is a major user of water for hydroelectric power generation and cooling purposes: it abstracts and returns into the environment enormous quantities of water. Aggregating information on water use and supply by ISIC 35 with that of other industries would provide misleading information as the water use (and returns) of ISIC 35 alone may outweigh any other industry's water use (and returns).

3.25. A detailed description of each flow of water in the simplified standard physical supply and use table, Table 3.1, is presented below.

3.26. **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 inland water resources – surface water, groundwater and soil water as in the asset classification - and from other sources which include sea water and precipitation).

3.27. 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**. As mentioned earlier, most of the water is abstracted for distribution by ISIC 36, *Water collection, treatment and supply*; however, there may be other industries which abstract and supply water as a secondary activity.

3.28. **Abstraction from water sources** includes the abstraction from the inland water resources as well as 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.

Table 3.1: Standard physical supply and use tables for water

Physical use table

Physical units

<table>
<tr><td colspan="2" rowspan="2"></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>1-3</td><td>5-33, 41-43</td><td>35</td><td>36</td><td>37</td><td>38,39, 45-99</td><td>Total</td></tr>
<tr><td>From the environment</td><td>1. Total abstraction (=1.a+1.b=1.i+1.ii)
1.a. Abstraction for own use
1.b. Abstraction for distribution
1.i. From inland water resources:
1.i.1 Surface water
1.i.2 Groundwater
1.i.3 Soil water
1.ii. Collection of precipitation
1.iii. Abstraction from the sea</td><td colspan="7"></td><td></td><td></td><td></td></tr>
<tr><td rowspan="2">Within the economy</td><td>2. Use of water received from other economic units</td><td colspan="7"></td><td></td><td></td><td></td></tr>
<tr><td>Of which:
2.a. Reused water
2.b. Wastewater to sewerage</td><td colspan="7"></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">3. Total use of water (=1 + 2)</td><td colspan="7"></td><td></td><td></td><td></td></tr>
</table>

Physical supply table

Physical units

<table>
<tr><td colspan="2" rowspan="2"></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>1-3</td><td>5-33, 41-43</td><td>35</td><td>36</td><td>37</td><td>38,39, 45-99</td><td>Total</td></tr>
<tr><td>Within the economy</td><td>4. Supply of water to other economic units
of which:
4.a. Reused water
4.b. Wastewater to sewerage</td><td colspan="7"></td><td></td><td></td><td></td></tr>
<tr><td>To the environment</td><td>5. Total returns (=5.a+5.b)
5.a. To inland water resources
5.a.1. Surface water
5.a.2. Groundwater
5.a.3. Soil water
5.b. To other sources (e.g. sea water)</td><td colspan="7"></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">6. Total supply of water (=4+5)</td><td colspan="7"></td><td></td><td></td><td></td></tr>
<tr><td colspan="2">7. Consumption (=3-6)</td><td colspan="7"></td><td></td><td></td><td></td></tr>
</table>

Note: Grey cells indicate zero entries by definition.

3.29. **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.

3.30. 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 (pipes), but other means of transportation are not excluded (such as artificial open channels, etc.). It also includes wastewater to sewerage, which is separately identified along with reuse water. The **use of water received from other economic units** by the rest of the world corresponds to the **exports** of water. It is generally the industry, ISIC 36, which exports water.

3.31. The **total water use** (row 3 in Table 3.1) of an industry is computed as the sum of the amount of water directly abstracted (row 1 in Table 3.1) and the amount of water received from other economic units (row 2 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.

3.32. The **supply of water to other economic units** refers to the amount of water that is supplied by an economic unit to another. It includes the supply by one establishment to another. The supply of water 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 **import** of water.

3.33. The supply and use of water to other economic units can be disaggregated in several categories. However, in the standard tables only **reused water** and **wastewater to Sewerage** are explicitly identified given their importance in water conservation policies.

3.34. 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) (recorded as wastewater to Sewerage) or 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.

3.35. **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 does not use higher-quality water that may be best used somewhere else).

3.36. 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.

3.37. 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.

3.38. Within the economy, water can be exchanged between water producers and distributors (i.e. ISIC 36) 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, and thus they are not recorded in the physical supply and use tables.

3.39. **Total returns** include water that is returned to the environment. Total returns can be classified according to the receiving media (i.e. inland 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.

3.40. The **total water supply** (row 6 in Table 3.1) is computed as the sum of the amount of water supplied to other economic units (row 4 in Table 3.1) and the amount of water returned to the environment (row 5 in Table 3.1).

3.41. **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 supply and use tables.

3.42. Table 3.1 can be 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.

3.43. 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 the column containing 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 flows of water within the economy

Physical units

User ⇨		Industries (by ISIC categories)							Households	Rest of the world	[illegible] economic units (Row 4 of Table 3.1)
Supplier ⇩		1-3	5-33, 41-43	35	36	37	38,39, 45-99	Total			
Industries (by ISIC categories)	1-3										
	5-33, 41-43										
	35										
	36										
	37										
	38,39, 45-99										
	Total										
Households											
Rest of the world											
Use of water received from other											

2. *Water consumption*

3.44. 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 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 3 in Table 3.1) and the water supply (row 6 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 the SEEAW 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.

3.45. 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.

3.46. 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.

3.47. 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 use of water by industry *i* – Total supply of water by industry *i*

3.48. 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 resource 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).

3.49. 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 was abstracted from fresh water sources and is discharged into non-fresh water sources[9].

3.50. Since water consumption is calculated as a difference, it may include flows that are very different in nature (for example, the part of the losses in distribution which do not return to the water

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

resources). For analytical purposes it is useful to distinguish water consumption that results from evaporation and transpiration or enters into products (result of the production process) from water consumption as a result of illegal tapping and malfunctioning meters.

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

3.51. 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 the breakdowns of water flows (in italic) which are useful for analytical purposes, together with a numerical example.

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

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

3.53. 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.

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

3.55. **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 damaging to the environment.

3.56. **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.

3.57. It is important to record the collection and discharge of urban runoff for the following reasons: (a) 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; (b) for consistency with the monetary tables, as the value of corresponding services (collection of urban run-offs) is recorded in the economic table; and (c) 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.

3.58. 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.

3.59. **Cooling water** is defined as water which is used to absorb and remove heat. Cooling water has the potential of not only inducing thermal pollution but also emitting pollutants that are collected in the water during use (when, for example, water is also used for rinsing in the manufacturing of basic metals).

3.60. Note that in Table 3.3 abstraction for own use by ISIC 36, *Water collection, treatment and supply*, 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 428.7 millions cubic metres of water of which 23.0 are for own use and the rest for distribution.

3.61. Returns to the environment (row 5 of Table 3.3) 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
- Cooling water
- Losses in distribution because of leakages

3.62. 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 37 combines urban runoff with other wastewater discharges, estimates are necessary. In Table 3.3, 100 millions cubic metres of urban runoff are collected by the sewerage system and 99.7 per cent of it is discharged into the environment.

Table 3.3: Detailed physical water supply and use tables

Physical use table

Millions cubic metres

		Industries (by ISIC categories)							Households	Rest of the world	Total
		1-3	5-33, 41-43	35	36	37	38,39, 45-99	Total			
From the environment	**1. Total abstraction** (=1.a+1.b=1.i+1.ii)	**108.4**	**114.5**	**404.2**	**428.7**	**100.1**	**2.3**	**1158.2**	**10.8**		**1169.0**
	1.a. Abstraction for own use	108.4	114.6	404.2	23.0	100.1	2.3	**752.6**	10.8		763.4
	Hydroelectric power generation			*300.0*				***300.0***			***300.0***
	Irrigation water	*108.4*						***108.4***			***108.4***
	Mine water							***0.0***			***0.0***
	Urban runoff					*100.0*		***100.0***			***100.0***
	Cooling water			*100.0*							
	Other		*114.6*	*4.2*	*23.0*	*0.1*	*2.3*	***144.2***	*10.8*		***155.0***
	1.b. Abstraction for distribution				*405.7*			**405.7**			**405.7**
	1.i. From inland water resources:	108.4	114.5	304.2	427.6	0.1	2.3	**957.1**	9.8		**966.9**
	1.i.1 Surface water	55.3	79.7	301.0	4.5	0.1	0.0	**440.6**	0.0		**440.6**
	1.i.2 Groundwater	3.1	34.8	3.2	423.1	0.0	2.3	**466.5**	9.8		**476.3**
	1.i.3 Soil water	50.0						**50.0**			**50.0**
	1.ii. Collection of precipitation					100.0	0.0	**100.0**	1.0		**101.0**
	1.iii. Abstraction from the sea			100.0	1.1			**101.1**			**101.1**
Within the economy	**2. Use of water received from other economic units**	**50.7**	**85.7**	**3.9**	**0.0**	**427.1**	**51.1**	618.5	**239.5**		**858.0**
	of which:										
	2.a. *Reused water*	*12.0*	*40.7*					***52.7***			***52.7***
	2.b. Wastewater to sewerage										
	2.c. *Desalinated water*										
3. Total use of water (=1 + 2)		**159.1**	**200.2**	**408.1**	**428.7**	**527.2**	**53.4**	**1776.7**	**250.3**		**2027.0**

Physical supply table

Millions cubic metres

		Industries (by ISIC categories)							Households	Rest of the world	Total
		1-3	5-33, 41-43	35	36	37	38,39, 45-99	Total			
Within the economy	**4. Supply of water to other economic units**	**17.9**	**127.6**	**5.6**	**379.6**	42.7	**49.1**	**622.5**	**235.5**		**858.0**
	of which:										
	4.a. Reused water	-	10.0	-	-	42.7		**52.7**			**52.7**
	4.b. Wastewater to sewerage	17.9	117.6	5.6	1.4		49.1	**191.6**	235.5		**427.1**
	4.c. *Desalinated water*				1.0			**1.0**			**1.0**
To the environment	**5. Total returns** (=5.a+5.b)	**65.0**	**29.4**	**400.0**	**47.3**	**483.8**	**0.7**	**1026.2**	**4.8**		**1031.0**
	Hydroelectric power generation			*300.0*				***300.0***			***300.0***
	Irrigation water	*65.0*						***65.0***			***65.0***
	Mine water							***0.0***			***0.0***
	Urban runoff					*99.7*		***99.7***			***99.7***
	Cooling water			*100.0*							
	Losses in distribution because of leakages				*24.5*			***24.5***			***24.5***
	Treated wastewater		*10.0*			*384.1*	*0.5*	***394.6***	*1.5*		***396.1***
	Other		*19.4*	*0.0*	*22.9*		*0.2*	***42.5***	*3.3*		***45.8***

5.a. To inland water resources(=5.a.1+5.a.2+5.a.3)	65.0	23.5	300.0	47.3	227.5	0.7	**664.0**	4.6		**668.6**
5.a.1. Surface water			300.0		52.5	0.2	**352.7**	0.5		**353.2**
5.a.2. Groundwater	65.0	23.5		47.3	175.0	0.5	**311.3**	4.1		**315.4**
5.a.3. Soil water							**0.0**			**0.0**
5.b. To other sources (e.g. sea water)		5.9	100.0		256.3		**362.2**	0.2		**362.4**
6. Total supply of water (=4+5)	**82.9**	**157.0**	**405.6**	**426.9**	**526.5**	**49.8**	**1648.7**	**240.3**		**1889.0**
7. Consumption (=3-6)	**76.2**	**43.2**	**2.5**	**1.8**	**0.7**	**3.6**	**128.0**	**10.0**		**138.0**
of which:										
7.a. Losses in distribution not because of leakages				0.5			**0.5**			**0.5**

Note: Grey cells indicate zero entries by definition. Blank cells indicate cells which are non-zero, but small in the numerical example.

Source: SEEAW-land.

3.63. In Table 3.3, 404.2 millions cubic metres of water are abstracted from the environment by the industry *Electricity, gas, steam and air conditioning supply*, ISIC 35, of which 300 millions cubic metres are used for hydroelectric power generation and 100 millions cubic metres for cooling purposes.

3.64. Losses in distribution, which are discussed in detail in the next section, are allocated to the water supplier. In the numerical example of Table 3.3, the losses in distribution because of leakages occur in the water supply of ISIC 36, *Water collection, treatment and supply*. The remaining part of the losses in distribution (which in the table corresponds to 0.5 million cubic metres, row 7.a of Table 3.3) includes both losses because of evaporation and apparent losses (illegal use and malfunctioning metering).

3.65. In addition to the breakdowns shown in Table 3.1, for countries which rely on water desalination as a source of water, it may be useful to explicitly identify the supply of *desalinated water* (row 4.c of Table 3.3). It is generally ISIC 36 which desalinises water and supplies it within the economy. Other industries may also desalinate sea water, but it is often for their own use.

3.66. Table 3.4 shows the matrix of flows associated with Table 3.3. This numerical example shows the origin and destination of the water flows within the economy. In particular, it can be seen that ISIC 37, *Sewerage*, supplies reclaimed wastewater to ISIC 5-33,41-43, *Mining and quarrying, Manufacturing and Construction*, (40.7 millions cubic metres) and to ISIC 1-3, *Agriculture, forestry*

and fishing (2 millions cubic metres). In addition, *Agriculture, forestry and fishing* also receive reused water from *Mining and quarrying, Manufacturing and Construction* (10 millions cubic metres).

Table 3.4: Matrix of water flows within the economy

Millions m³

User ⇨ / Supplier ⇩		Industries (by ISIC categories) 1-3	5-33, 41-43	35	36	37	38,39, 45-99	Total	Households	Rest of the world	other economic units (Row 4 of Table 3.3)
(by ISIC categories)	1-3					17.9		17.9			17.9
	5-33, 41-43	10				117.6		127.6			127.6
	35					5.6		5.6			5.6
	36	38.7	45	3.9		1.4	51.1	140.1	239.5		379.6
	37	2.0	40.7			0.0		42.7			42.7
	38,39, 45-99					49.1		49.1			49.1
	Total	50.7	85.7	3.9	0.0	191.6	51.1	383.0	239.5		622.5
Households							235.5		235.5		
Rest of the world											
Use of water received from other		**50.7**	**50.7**	**85.7**	**3.9**	**0.0**	**427.1**	**51.1**	**618.5**	**239.5**	**858.0**

Note: SEEAW-land.

4. Losses in distribution

3.67. Within the economy, water supply is recorded net of losses in distribution. Losses in distribution are recorded in the tables as follows:

- The net supply plus the losses are shown in the amount abstracted from the environment by the suppliers of water (typically ISIC 36)
- The losses are allocated to the supplier of water but are not explicitly shown in Table 3.1, although they are shown in the more detailed Table 3.3
- Losses due to leakages are recorded in the return flows 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 of the supplier of water

3.68. A supplementary table can be constructed to explicitly show the losses in distribution. Table 3.5 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 3.5: Supplementary table of losses in distribution

Millions cubic metres

	Industries (by ISIC categories)							Households	Rest of the world	Total
	1-3	5-33, 41-43	35	36	37	38,39, 45-99	Total			
1. (Net) Supply of water to other economic units	17.9	127.6	5.6	379.6	42.7	49.1	622.5	235.5		**858.0**
2. Losses in distribution (=2.a+2.b)	0	0	0	25.0	0	0	25.0	0		**25.0**
2.a Leakages	0	0	0	24.5	0	0	24.5	0		**24.5**
2.b Other (e.g. evaporation, apparent losses)	0	0	0	0.5	0	0	0.5	0		**0.5**
3. Gross supply within the economy (=1.+2.)	**17.9**	**127.6**	**5.6**	**404.6**	**42.7**	**49.1**	**647.5**	**235.5**		**883.0**

Source: SEEAW-land.

3.69. 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.

3.70. 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 may be required to determine the extent of this phenomenon.

3.71. 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 would be very useful for policy purposes as it provides a more accurate indication of the actual water use by industries and households. When linked to the monetary accounts, the information could be used for pricing policies.

3.72. Consistent with the 1993 SNA, where illegal tapping is not considered as a transaction (use) in the supply and use tables, the SEEAW does not explicitly record it in the standard tables.

Chapter 4 Water 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. 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. Similarly, other substances, such as nitrogen and phosphorus, can lead to eutrophication, or organic substances can have negative effects on the oxygen balance thus affecting the ecological status of the receiving water body.

4.2. Emission accounts describe the flows of pollutants added to wastewater as a result of production and consumption, and flowing into water resources either directly 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. water resources and sea). Emission accounts are a useful tool for designing economic instruments, including new regulations to reduce emissions into water. When analysed in conjunction with the technology in place to reduce emissions and treat wastewater, they can be used in impact studies of new technologies.

4.3. Section B presents some basic concepts used in the compilation of emission accounts and defines the scope and coverage of the emission accounts. Section C describes in detail the standard tables for the compilation of the emission accounts.

B. Coverage of emission accounts and basic concepts

4.4. Emissions to water refer to the direct release of pollutants to water as well as the indirect release by transfer to an off-site wastewater treatment plant (European Commission, 2000). In the SEEAW, emission accounts focus only on the release of pollutants into water resources through the (direct and indirect through a wastewater treatment plant) discharge of wastewater into water resources. The direct discharge to water resources of heavy metals and hazardous waste not through wastewater is not covered in the water emission accounts but in the waste accounts as it involves the discharge of solid waste[10].

4.5. Emission accounts record the amount of 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 from agriculture. 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

4.6. Sources of pollution are classified as 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

[10] In the European context, emissions to air, land and water are covered, for example, in the Directive 96/61/EC concerning integrated pollution prevention and control (the IPPC Directive) and in the European Pollutant Release and Transfer (E-PRTR) Regulation (REGULATION (EC) No 166/2006).

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 runoff 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 and urban areas.

4.7. 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.

4.8. 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. Returns of irrigation water and rainfed agriculture are 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.

4.9. 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 landfill sites 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 after having absorbed pollutants present in the air infiltrate natural land.

Include:	Exclude:
Point sources:	Point sources:
Pollutants added to wastewater	Discharges of heavy metal and hazardous wastes not contained 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 and rainfed agriculture	All non-point sources except for urban runoff, irrigation water and rain-fed agriculture (*included in the quality accounts)*

Box 4.1: Scope of emission accounts

Water pollutants

4.10. 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, inter alia, an indicative list of pollutants (which is reported in Table 4.1) as well a list of priority substances. The list of priority substances which has been established in 2001 by the Decision No 2455/2001/EC of the European Parliament and of the Council contains 33 substances or groups of substances which have been shown to be of major concern for European Waters.

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

4.11. 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 follows. The economic units identified in the figure are: households, agriculture, other industries and the rest of the world. The wastewater and associated pollutants are either discharged directly into the environment with or without self-treatment, or supplied to a wastewater treatment plant.

4.12. 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. In practice, however, an economic activity may discharge part of its wastewater directly into water resources (thus releasing the pollutants directly), and supply the rest to a wastewater treatment plant which, after treatment, discharges the ‘treated’ wastewater into the environment. Since 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.

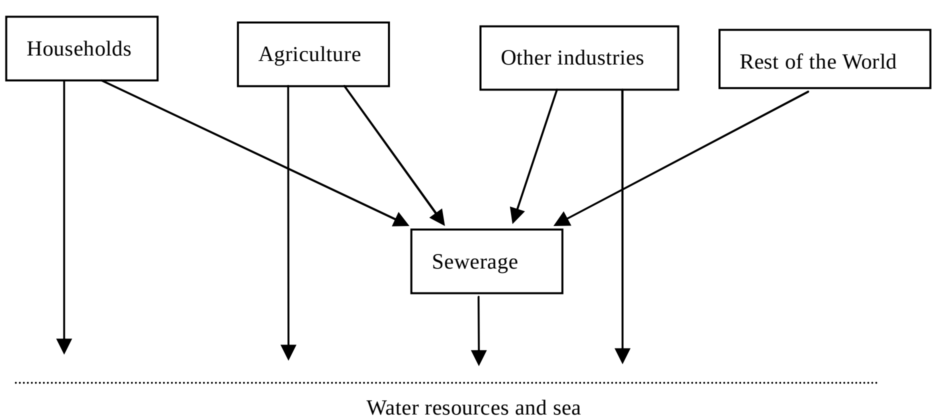


Figure 4.1: Wastewater and associated pollutant pathway

Source: Based on Preux and Fribourg-Blanc (2005).

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

4.14. 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.

4.15. 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. For example, the pollutant content of rivers crossing country borders and/or flowing to the open sea. These are covered in the quality accounts in chapter 7.

C. Emission accounts

4.16. 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.

4.17. Pollution is generally measured in terms of quantity of a measured parameter (see for example, the list of pollutants in Section B) 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. For example, population equivalent[11] made of five-day biochemical oxygen demand (BOD5), Nitrogen (N), Phosphorus (P), Suspended solids (SS).

4.18. Information on emissions to water is organized in the accounts according to Table 4.2. In order to avoid the double counting of the emissions by ISIC 37, *Sewerage*, emission accounts comprise of two tables. The first table, table A, starts with a description of gross emissions by industries. In this table, only the pollutant content of the urban runoff collected and discharged by ISIC 37, *Sewerage*, is recorded under the column of ISIC 37 as ISIC 37 is the economic activity responsible for its collection and discharge.

4.19. The second table of the emission accounts, table B, records the emissions to water by ISIC 37. It allows for the reallocation of emissions of ISIC 37 to the industries generating them in the first place thus allowing for the calculation of net emissions. Table A 'gross and net emissions' in Table 4.2 reports the following items:

- The total amount of a pollutant generated by an economic unit (gross emission) measured at the point of discharge (row 1 of Table 4.2). This information is disaggregated in the following categories:

[11] One population equivalent (p.e.) means the organic biodegradable load having a BOD5 of 60 g of oxygen per day.

- The amount of pollutant that is released directly into water (that is, it is contained in the direct discharge of wastewater into the environment) (row 1.a of Table 4.2);
- The amount of pollutant that is released into the sewer system (row 1.b of Table 4.2). Note that the pollutant content of the urban runoff collected by ISIC 37 is recorded in this row.

• The indirect emissions to the environment of each industry through ISIC 37 (row 2 of Table 4.2). These emissions can be calculated once the emissions to water by ISIC 37 are identified in table B;

• The net emission by industry (row 3 in Table 4.2) is obtained by the sum of direct and indirect emission.

4.20. The direct emissions to water are further disaggregated according to whether wastewater has undergone on-site treatment (row 1.a.1 and 1.a.2 of Table 4.2)[12] and/or according to the receiving media (row 1.a.i and 1.a.ii of Table 4.2) – water resources and the sea. Additional information can be presented in supplementary tables to further disaggregate emissions according to the type of receiving media, e.g. surface water and groundwater.

4.21. Table B 'emission by ISIC 37' in Table 4.2 presents detailed information on the emissions to water by ISIC 37, *Sewerage*, 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 ISIC 37, *Sewerage*, (row 4 of Table 4.2), which is disaggregated to:

[12] 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.

- The amount of pollutant that is released directly into water after having undergone treatment (row 4.a of Table 4.2).

- The amount of pollutant that is released directly into water without treatment (row 4.b of Table 4.2). For example, in discharges of raw sewage through a sewage collecting system.

Table 4.2: Emission accounts

Table A. Gross and net emissions

tonnes

Pollutant COD	Industries (by ISIC categories)							Households	Rest of the world	Total
	1-3	5-33, 41-43	35	36	37	38,39, 45-99	Total			
1. Gross emissions (=1.a+1.b)	**3150.2**	**5047.4**	**7405.1**	**1851.0**	**498.5***	**1973.8**	**19925.9**	**11663.6**		**31589.5**
1.a. Direct emissions to water (=1.a.1+1.a.2=1.a.i+1.a.ii)	2470.0	390.1	7313.2	1797.8	0.0	27.7	11998.7	2712.7		14711.5
1.a.1 Without treatment	*2470.0*	*257.4*	*7313.2*	*1797.8*		*7.9*	*11846.2*	*1865.0*		*13711.3*
1.a.2 After on-site treatment		*132.7*	*0.0*	*0.0*		*19.8*	*152.5*	*847.7*		*1000.2*
1.a.i To inland water resources	*2470.0*	311.8	*5484.9*	*1797.8*		*27.7*	*10092.2*	*2599.7*		*12691.9*
1.a.ii To the sea	*0.0*	78.3	*1828.3*	*0.0*		*0.0*	*1906.6*	*113.0*		*2019.6*
1.b. To Sewerage (ISIC 37)	680.2	4657.3	92.0	53.2	498.5	1946.0	7927.2	8950.9		16878.0
2. Reallocation of emission by ISIC 37	213.6	1403.3	66.8	16.7	498.5	585.9	2784.7	2810.1		5594.8
3. Net emissions (=1.a+2)	2683.6	1793.3	7380.0	1814.5	498.5	613.6	14783.5	5522.8		20306.3

Note: * this corresponds to the pollutant content of the urban runoff collected by Sewerage. In this numerical example, urban runoff is collected and discharged without treatment, thus gross and net emissions coincide for ISIC 37.

Table B. Emissions by ISIC 37

tonnes

Pollutant COD	ISIC 37
4. Emissions to water (=4.a+4.b)	**5,594.8**
4.a After treatment	5,096.3
To water resources	*2396.4*
To the sea	*2,699.9*
4.b Without treatment	498.5
To water resources	*234.4*
To the sea	*264.1*

Source: SEEAW-land.

4.22. Emissions by ISIC 37 are disaggregated according to receiving media. Additional information can be presented in supplementary tables to further disaggregate emissions by ISIC 37 according to the type of receiving media, i.e. surface water and groundwater.

4.23. In order to calculate net emission by industry, the emissions to water by ISIC 37 (row 4 of Table 4.2) have to be reallocated to the industry responsible for the discharge in the first place. Row 2 of Table 4.2 explicitly shows the reallocation of emissions from ISIC 37 to the various industries. In this example, the emission by ISIC 37 has been reallocated to the industries applying a global abatement rate of 67[13] per cent to the pollutant release of each industry to the sewage network (row1.b of Table 4.2). Note that in this numerical example, it is assumed that urban runoff is discharged without treatment (see also Table 3.3 of chapter 3), hence for ISIC 37 the figures in row 2 and row 4.b are the same. Net emissions (row 3 of Table 4.2) are calculated by adding the direct emission by industry (row 1.a of Table 4.2) and the reallocation of emission by ISIC 37 (row 2 of Table 4.2).

4.24. 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).

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

4.26. In some countries there is legislation regulating the generation and disposal of sewage sludge which requires 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

[13] The global abatement rate is obtained in this example by dividing the pollutants removed by ISIC 37 (row 1.b - row 4.) by the pollutant received by ISIC 37 (row 1.b). This corresponds to (16878.0-5594.8)/ 16878.0 = 0.67

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.

4.27. During wastewater treatment, sewage sludge is generated as accumulated solids and is 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.

4.28. The indicator on the number of people with access to improved sanitation, target 10 of the Millennium Development Goals, is an 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. Improved sanitation technologies consist of connection to a public sewer, connection to a septic system, pour-flush latrine, ventilated improved pit latrine. Not improved sanitation technologies 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

4.29. The collection and discharge of urban runoff is recorded both in terms of volume (in the physical supply and use table) and in terms of pollutant load (in the emission accounts). This is because it is highly polluted and there is an increasing awareness in the potential danger of discharging it into

the environment without treatment. Urban runoff usually contains a great deal of litter and organic and bacterial wastes as well as 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).

4.30. Even though the pollution content of urban run-offs is the result of a ‘diffuse’ pollution and often it can be also the result of natural origins (For example, leaves in the gutters that create an organic pollution), its emissions to water are allocated to ISIC 37, *Sewerage*, since this is the economic unit responsible for its collection and discharge.

4.31. Note that when urban runoff is collected in the same sewer system that collects domestic and commercial wastewater (sanitary sewers), it may be difficult to measure the amount of pollutant, which pertains specifically to urban runoff.

“Water collection, treatment and supply” ISIC 36

4.32. 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*, does 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).

4.33. 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).

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

A. Introduction

5.1. The formulation and evaluation of 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, are at the heart of water management. 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 and to identify: (a) the costs associated with the production of these products, (b) the income generated by their production, (c) the investment in water-related infrastructure and the costs to maintain them, (d) the fees paid by the users for water-related services as well as the subsidies received. The economic instruments to manage water, namely taxes on the use of the resource and permits to access it, are also discussed in this chapter.

5.2. The starting point to study the economy of water is to present the conventional national accounts together with the physical information on water abstraction, namely the use and supply within the economy, and discharges of wastewater and pollutants into the environment. These accounts are referred to as “hybrid accounts”, where the name “hybrid” refers to the combination of different types of units of measurement in the same accounts. The presentation of physical and monetary information in the same accounts allows for the derivation of consistent indicators for evaluating the impact on water resources of changes in the economy, e.g. changes in the economic structure, changes in interest rates, etc. Using the hybrid accounts in economic models permits the analysis of possible trade-offs

between alternative water policies and economic strategies. The structure of the hybrid accounts is presented in section B.

5.3. Economic accounts expand the hybrid accounts (a) for water-related activities carried out for own use (that is when industries, as well as households, abstract water for their own use, or treat the wastewater they generate) and (b) for expenditure of the government for water-related services (for example, the formulation and administration of government policy, the setting and enforcing of public standards, etc.). Even though the value of these activities is likely to be small compared with the other activities, the full extent of national expenditures on water can be understood only when all these expenditures are accounted for. Economic accounts for water-related activities carried out for own use and for government expenditure for water-related services are discussed in section C.

5.4. Even though they are not explicitly discussed in the SEEAW, complete stock accounts (in physical and monetary units) for water-related infrastructures can be compiled by disaggregating the relevant information from the standard 1993 SNA accounts for produced assets. The standard tables only provide information on the stocks of water-related infrastructure, such as pumps and dams, as an example of the form of such accounts. Stock accounts for water-related infrastructure, which are already part of the 1993 SNA, often require additional data sources and data collection activities 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, depreciation, etc.). Stock accounts for water-related infrastructure can assist in formulating and evaluating policies that aim to improve access to water and sanitations, which are highly dependent on investments in infrastructure or on infrastructures which are already in place.

5.5. Section D discusses how other monetary flows related to water, such as taxes and subsidies are recorded in the accounts.

5.6. Section E presents national expenditure and financing accounts for water-related activities classified by purpose. The national expenditure accounts give an indication of the expenditure by resident units on specific activities related to water, such as wastewater and water management. The financing accounts are particularly important as users of water and water-related products do not always pay for 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 are also often partly financed by units other than the one that benefits from its use. The analysis of the financing of the use of water and water-related products, as well as investments in water-related infrastructures, 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 example, for assessing the implementation of the polluter/user-pay principle as the accounts for financing show the portion of the total cost paid by the polluter/user.

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, classifications and concepts. Physical information is juxtaposed to the monetary supply and use tables. This includes: (a) water abstraction, use and supply within the economy, and returns into the environment; and (b) emissions of pollutants. At finer levels of disaggregation, the hybrid accounts provide the scientific community with access to a structured database for monitoring the overall hydrological-economic performance of national economies. In this way, hybrid accounts build a bridge between (aggregate) policy assessment and (underlying) policy research (para. 4.6, SEEA-2003).

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 and input

output tables, we refer to Chapter 4 of the SEEA-2003 (UN et al., 2003) and Chapter XV of the 1993 SNA (Cec et al., 1993). Here we focus on the supply and use table presentation of the hybrid accounts.

5.9. The starting point for hybrid SUT is the 1993 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 Products Classification (CPC) Ver. 2.0 (UN, 2006a). The industries are classified, by column, according to International Standard Industrial Classification of all Economic Activities Revision 4, ISIC Rev. 4 (UN, 2006b).

5.10. The simplified standard hybrid SUT explicitly identify the following two water-related products in the monetary part of the tables:

- *Natural water* - CPC 1800, which is primarily associated with the output of ISIC 36, *Water collection, treatment and supply*. In the monetary supply and use tables, natural water corresponds to the exchanges of water between economic units (mainly between ISIC 36 and the other economic units such as other 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 including 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 ISIC 37, *Sewerage*.

5.11. Depending on data availability, other products related to water could also be explicitly identified in the tables. These include: *Operation of irrigation systems for agricultural purposes,* which is part of CPC 86110 and is primarily (and uniquely) associated with the output of ISIC 0161, *Support activities for crop production*; *Water-related administrative services,* which are part of CPC 91123 and primarily associated with the output of ISIC 8412; and *Site remediation and clean-up services* for

surface and ground water (CPC 94412 and part of CPC 94413) primarily associated with the output of ISIC 3900.

5.12. Economic activities, classified according to ISIC Rev.4, are identified by column in the supply and use tables. The level of disaggregation of industries depends on the country's situation and data availability. The simplified standard tables identify a limited number of groups of industries for ease of compilation. These include the following groups:

- ISIC 1-3 - *Agriculture, forestry and fishing*;
- ISIC 5-33, 41-43 - *Mining and quarrying, Manufacturing and Construction*;
- ISIC 35 - *Electricity, gas, steam and air conditioning supply* in particular, *Hydroelectric power generation, transmission and distribution* (part of ISIC 3510);
- ISIC 36 - *Water collection, treatment and supply*;
- ISIC 37 - *Sewerage*;
- ISIC 38,39, 45-99 – the so-called S*ervice industries*.

5.13. As mentioned in para 5.11, it is highly recommended for analytical purposes when compiling water accounts to further disaggregate the activities related to water other than ISIC 36 and 37, namely *Operation of agricultural equipment* (part of ISIC 0161), *Remediation activities and other waste management services related to water* (part of ISIC 3900), and *Administration of water-related programmes* (part of ISIC 8412).

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. This makes 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 each of these activities. Additional information and estimation may be needed to separate these

activities. As recommended by the 1993 SNA, in the case where water and wastewater are produced in an integrated production process, one may use the cost structure of a firm which is treating wastewater only to estimate the portion of the cost for treating wastewater.

1. Hybrid supply table

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

- *Monetary supply table.* It describes in monetary units the origin of products. This information is organized according to the 1993 SNA supply table where products are shown in rows and the producers are presented in columns.
- *Physical supply table of water*. It contains information on the volumes of water supplied to other economic units (which corresponds to row 4 of Table 3.3) and discharged (returns) into the environment (which corresponds to row 5 of Table 3.3). This information corresponds to the physical supply table described in chapter 3.
- *Total emission of pollutants in physical units*. It shows gross emissions by industry for the sake of simplicity (which corresponds to row 1 of Table 4.2). Information on net emissions could also be shown in the same table. This information corresponds to the emission accounts described in chapter 4.

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

- Output at basic prices by industries classified according ISIC Rev. 4;
- Imports;
- Other items to derive the total supply at purchasers' prices, namely (a) taxes and subsidies on products; and (b) 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 (para. 15.40, 1993 SNA). In the case of water, transport margins are

generally not separately invoiced and trade margins are often insignificant. For these reasons, Table 5.1 reports a zero value for trade and transport margins.

5.17. The bulk of the supply of *Natural water* (CPC 1800) and *Sewerage services* (CPC 941) appears in the columns corresponding to ISIC 36 and ISIC 37 as they group together establishments whose principal activities are the distribution of water and wastewater services respectively. Since an establishment may engage in other activities, the SNA makes a distinction between *principal* and *secondary activity*. 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 - the output of the principal activity must consist of goods or services that are capable of being delivered to other units even though they may be used for own consumption or own capital formation (para. 5.7, 1993 SNA). The *secondary activity* is an activity carried out within a single producer unit in addition to the principal activity and whose output, like that of the principal activity, must be suitable for delivery outside the producer unit (para. 5.8, 1993 SNA).

5.18. In the numerical example in Table 5.1, an industry (or group of industries) in ISIC 5-33, 41-43 supplies water as a secondary activity (for a total of 40 millions currency units). In addition, ISIC 37 supplies water as a secondary activity. This corresponds to reused water from ISIC 37 for further use in other industries.

Table 5.1: Hybrid supply table

Billions currency units, Millions cubic metres

	Output of industries (by ISIC categories)											
			35									
	1-3	5-33, 41-43	Total	*of which:* Hydro	36	37	38,39, 45-99	Total output, at basic prices	Imports	Taxes less Subsidies on products	Trade and transport margins	Total supply at purchaser's price
1. Total output and supply (Billions currency units)	137.6	749.0	22.1	3.3	1.7	9.0	367.0	1286.4	363.0	70.0	0.0	1719.4
of which:												
1.a Natural water (CPC 1800)	0.0	0.040	0.0	0.0	1.7	0.2	0.0	1.9	0.0	-0.1	0.0	1.8
1.b Sewerage services (CPC 941)	0.0	0.0	0.0	0.0	0.0	8.8	0	8.8	0.0		0	8.8

2. Total supply of water (Millions cubic metres)	82.9	157.0	405.6	300.0	426.9	526.5	49.8	1648.7	0.0			1648.7
2.a Supply of water to other economic units	17.9	127.6	5.6	0.0	379.6	42.7	49.1	622.5	0.0			622.5
of which: 2.a.1- Wastewater to Sewerage	17.9	117.6	5.6	0.0	1.4	0.0	49.1	191.6	0.0			191.6
2.b Total returns	65.0	29.4	400.0	300.0	47.3	483.8	0.7	1026.2				1026.2
3. Total (gross) emissions of COD (Thousand of tonnes)	3150.2	5047.4	7405.1	0.0	1851.0	498.5	1973.8	19925.9				19925.9

Note: Grey cells indicate zero entries by definition.

Source: SEEAW-land.

2. Hybrid use table

5.19. Table 5.2 shows the format of the standard hybrid use table. The table consists of two parts:

- *Monetary use table*. It provides information on the destination (use) in monetary units of products and, in particular, water-related products. The use table shows products by rows and industries by columns as the conventional 1993 SNA use table.

- *Physical use table*. It contains information on the volumes of water abstracted from the environment (row 1 of Table 3.3) and received from other economic units (row 2 of Table 3.3). This information corresponds to the physical use table described in chapter 3.

5.20. The uses of products in Table 5.2 are described by column in terms of: intermediate consumption, final consumption, exports and gross capital formation. Each of these uses are described next.

5.21. **Intermediate consumption** 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.

5.22. In the SEEAW, **final consumption** is measured in Table 5.2 in terms of actual final consumption rather than in terms of expenditures which is the common practice in the 1993 SNA. This is done to monitor the link between physical quantities of water and the monetary values of goods and services delivered to the households: often water-related services are not purchased directly by households, but are provided to them by government and non-profit institutions serving households

(NPISHs) free or almost free of charge. Actual final consumption measures the value of the goods or services delivered to households, regardless of whether they are paid by households themselves or by government units and NPISHs through social transfers in kind. Box 5.1 shows how to compute actual final consumption from final consumption expenditures.

5.23. Actual final consumption comprises of the following two categories:

- **Actual final consumption of households** 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).

5.24. Collective consumption expenditures of the government include the value of those 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 (para. 9.91, 1993 SNA). 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. Box 5.2 presents the conditions of the 1993 SNA that distinguish between individual and collective goods and services.

Total final consumption in the economy may be viewed from two angles. It may be defined from the expenditure side as the total value of all expenditures on individual and collective consumption goods and services incurred by resident households, resident NPISHs and general government units. Or, it may be defined in terms of actual final consumption as the value of all the individual goods and services acquired by resident households plus the value of the collective services provided by general government to the community or large sections of the community. Below the relevant paragraphs of the 1993 SNA describing the concepts of final consumption expenditure and actual final consumption are presented.

Final consumption expenditure includes (para 9.94, 1993 SNA):

(a) Household final consumption expenditure: This consists of 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;

(b) Final consumption expenditure of NPISHs: This consists of the expenditure, including imputed expenditure, incurred by resident NPISHs on individual consumption goods and services;

(c) Government final consumption expenditure: This consists of expenditure, including imputed expenditure, incurred by general government on both individual consumption goods and services and collective consumption services. This expenditure may be divided into:

(i) Government expenditure on individual consumption goods and services;

(ii) Government expenditure on collective consumption services.

Actual final consumption includes (para 9.96, 1993 SNA):

(1) Actual final consumption of households. This is measured by the value of all the individual consumption goods and services acquired by resident households. There are three sets of goods and services entering into household actual final consumption:

- Those acquired through expenditure by households themselves (which corresponds to (a) Household final consumption expenditure);
- Those acquired as social transfers in kind from NPISHs; (which corresponds to (b) Final consumption expenditure of NPISHs)
- Those acquired as social transfers in kind from general government (which corresponds to (c_i) Government expenditure on individual consumption goods and services).

(2) Actual final consumption of general government. This is measured by the value of the collective consumption services provided to the community, or large sections of the community, by general government (which corresponds to (c_{ii}) Government expenditure on collective consumption services).

The table below shows how to obtain information on actual final consumption from the 1993 SNA use table. Total final consumption may be presented by reorganizing the columns as follows. The table on the left shows the 1993 SNA presentation of the use table. (table 15.1 of the 1993 SNA) using the expenditure side. The table on the right shows the SEEAW presentation of the use table using the acquisition side.

Total final consumption recorded in the 1993 SNA use table

<table>
<tr><td rowspan="3"></td><td colspan="5">Final consumption expenditure</td></tr>
<tr><td rowspan="2">Households (a)</td><td rowspan="2">NPSHIs individual (b)</td><td colspan="2">Government (c)= (c_i)+(c_{ii})</td><td rowspan="2">Total = (a)+(b)+ (c)</td></tr>
<tr><td>Collective (c_i)</td><td>Individual (c_{ii})</td></tr>
<tr><td>Total use of products</td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

⇒

Total final consumption recorded in the SEEAW use table

<table>
<tr><td colspan="4">Actual Consumption</td></tr>
<tr><td colspan="2">Households</td><td rowspan="2">Government (c_i)</td><td rowspan="2">Total = (a)+(b)+ (c_i)+(c_{ii})</td></tr>
<tr><td>Final consumption expenditures (a)</td><td>Social transfers in kind from Government and NPISHs (b)+(c_{ii})</td></tr>
<tr><td></td><td></td><td></td><td></td></tr>
</table>

Box 5.1: From final consumption expenditure to actual final consumption

The consumption expenditures incurred by government units and NPISHs have to be divided into those incurred for the benefit of individual households and those incurred for the benefit of the community as a whole, or large sections of the community.

Individual goods and services are essentially "private", as distinct from "public" goods. They have the following characteristics:

(a) It must be possible to observe and record the acquisition of the good or service by an individual household or member thereof and also the time at which it took place;

(b) The household must have agreed to the provision of the good or service and take whatever action is necessary to make it possible - for example, by attending a school or clinic;

(c) The good or service must be such that its acquisition by one household or person, or possibly by a small, restricted group of persons, precludes its acquisition by other households or persons.

Most goods can be privately owned and are individual in the sense used here. On the other hand, certain kinds of services can be provided collectively to the community as a whole. The characteristics of these collective services may be summarized as follows:

(a) Collective services can be delivered simultaneously to every member of the community or of particular sections of the community, such as those in a particular region of a locality;

(b) The use of such services is usually passive and does not require the explicit agreement or active participation of all the individuals concerned;

(c) The provision of a collective service to one individual does not reduce the amount available to others in the same community or section of the community. There is no rivalry in acquisition.

The collective services provided by government consist mostly of the provision of security and defence, the maintenance of law and order, legislation and regulation, the maintenance of public health, the protection of the environment, research and development, etc. All members of the community can benefit from such services. As the individual usage of collective services cannot be recorded, individuals cannot be charged according to their usage or the benefits they derive. There is market failure and collective services that must be financed out of taxation or other government revenues.

The services provided by NPISHs are often confined to the members of the associations that control them, although they may also provide individual goods or services to third parties. Many NPISHs are only concerned with protecting the interests or welfare of their members or providing recreational, sporting or cultural facilities which households or persons cannot otherwise easily obtain for themselves acting individually. Although NPISHs may provide services to their members in groups, the services are essentially individual rather than collective. In general, persons other than their members are excluded and derive no benefit from the services provided. Therefore, as already noted, all the services provided by NPISHs are by convention treated as individual.

Box 5.2: Individual and collective goods and services of government and NPISHs

Source: paras. 9.80-9.85, 1993 SNA. (CEC et al, 1993).

5.25. **Gross capital formation** (GCF) is the total value of gross fixed capital formation, changes in inventories and acquisitions less disposals of valuables. It is included in Table 5.13 at the aggregated level for consistency of presentation with the 1993 SNA tables to show the basic identity that supply equals use. In Table 5.13, GCF of Natural water is zero as it represents the use of this product for

capital formation. Only in the case in which water is stored over two accounting periods could the value of GCF for natural water be non-zero. GCF for sewerage services is not applicable.

5.26. **Exports** consist of sales of products from residents to non-resident units. In the numerical example in Table 5.2, there are no exports of water and wastewater services.

Table 5.2: Hybrid use table

Billions currency units, Millions cubic metres

	Intermediate consumption of industries (by ISIC categories)								Actual final consumption					Capital formation	Exports	Total uses at purchaser's price
			35						Households							
	1-3	5-33, 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	Government	Total			
1. Total intermediate consumption and use (Billions	72.9	419.4	9.9	1.1	1.1	1.7	157.8	664.0	321.4	131.4	452.8	53.6	506.4	146.0	403.0	1719.4
of which:																
1.a Natural water (CPC 1800)	0.2	0.3	0.02	0.0	0.0		0.2	0.8	0.6	0.4	1.0	-	1.0	0.0	0.0	1.8
1.b Sewerage services (CPC 941)	0.4	2.4	0.1	0.0	0.03		1.0	3.9	2.4	2.4	4.9	-	4.9		0.0	8.8
3. Total use of water (Millions cubic metres)	159.1	200.2	408.1	300.0	428.7	527.2	53.4	1776.7			250.3		250.3		0.0	2027.0
3.a (U1) Total Abstraction	108.4	114.5	404.2	300.0	428.7	100.1	2.3	1158.2			10.8		10.8			1169.0
of which: 3.a.1- Abstraction for own use	108.4	114.6	404.2	300.0	23.0	100.1	2.3	752.6			10.8		10.8			763.4
3.b - Use of water received from other economic units	50.7	85.7	3.9	-	0.0	427.1	51.1	618.5			239.5		239.5		0.0	858.0

Note: Grey cells indicate zero entries by definition.

Source: SEEAW-land.

3. Hybrid account for supply and use of water

5.27. Table 5.1 and Table 5.2 can be presented together to form the hybrid account for supply and use of water as presented in Table 5.3. Table 5.3 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. It forms the basis for the calculation of a consistent set of hydrological-economic indicators.

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

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

5.30. Table 5.3 also presents information on gross fixed capital formation for water-related infrastructure by industry, which represents investments in fixed capital related to water (infrastructure). It also shows the closing stocks of fixed assets for water supply and sanitation. The stocks of fixed assets represent the total value of infrastructure in place, disaggregated according to whether they relate to water supply or wastewater services.

Table 5.3: Hybrid account for supply and use of water

Billions currency units, Millions cubic metres

	Industries (by ISIC categories)								Rest of the world	Taxes less subsidies on products, trade and transport margins	Actual final consumption		Capital Formation	Total
			35											
	1-3	5-33, 41-43	Total	*of which:* Hydro	36	37	38,39, 45-99	Total industry			Households	Government		
1. Total output and supply (Billions currency units)	137.6	749.0	22.1	3.3	1.7	9.0	367.0	1286.4	363.0	70.0				1719.4
of which:														
1.a. Natural water (CPC 1800)	0.0	0.04	0.0	0.0	1.7	0.2	0.0	1.9	0.0	-0.1				1.8
1.b. Sewerage services (CPC 941)	0.0	0.0	0.0	0.0	0.0	8.8	0.0	8.8	0.0	0.0				8.8
2. Total intermediate consumption and use (Billions currency units)	72.9	419.4	9.9	1.1	1.1	1.7	157.8	664.0	403.0		452.8	53.57	146.0	1719.4
of which:														
2.a. Natural water (CPC 1800)	0.2	0.3	0.0	0.0	0.0	0.0	0.2	0.8	0.0		1.0	-		1.8
2.b. Sewerage services (CPC 941)	0.4	2.4	0.1	0.0	0.0	0.0	1.0	3.9	0.0		4.9	-		8.8

3. Total value added (gross) (= 1-2) (Billions currency units)	64.7	329.5	12.2	1.8	0.6	7.3	209.2	622.4	0.0				622.4
4. Gross fixed capital formation (Billions currency units)	6.6	65.7	13.1		11.8	10.5	23.7	131.4					131.4
of which:													
4.a. For water supply		0.311			11.8	1.3		13.4					13.4
4.b. For water sanitation		0.2				9.2	0.01	9.4					9.4
5. Closing Stocks of fixed assets for water supply (Billions currency		5.2			197.1	22.2		224.4					224.4
6. Closing Stocks of fixed assets for sanitation (Billions currency		2.4				115.7	0.1	118.2					118.2
7. Total use of water (Millions cubic metres)	159.1	200.2	408.1	300.0	428.7	527.2	53.4	1776.7	0.0		250.3		2027.0
7.a. Total Abstraction	108.4	114.5	404.2	300.0	428.7	100.1	2.3	1158.2			10.8		1169.0
*of which:*7. a.1- Abstraction for own use	108.4	114.6	404.2	300.0	23.0	100.1	2.3	752.6			10.8		763.4
7.b. Use of water received from other economic units	50.7	85.7	3.9	-	0.0	427.1	51.1	618.5	0.0		239.5		858.0
8. Total supply of water (Millions cubic metres)	82.9	157.0	405.6	300.0	426.9	526.5	49.8	1648.7	0.0		240.3		1889.0
8.a. Supply of water to other economic units	17.9	127.6	5.6	0.0	379.6	42.7	49.1	622.5	0.0		235.5		858.0
of which: 8.a.1- Wastewater to Sewerage	17.9	117.6	5.6	0.0	1.4	0.0	49.1	191.6	0.0		235.5		427.1
8.b. Total returns	65.0	29.4	400.0	300.0	47.3	483.8	0.7	1026.2			4.8		1031.0
9. Total (gross) emissions of COD (Thousand of tonnes)	3150.2	5047.4	7405.1		1851.0	498.5	1973.8	19925.9			11663.6		31589.5

Note: Grey cells indicate zero entries by definition.

Source: SEEAW-land.

5.31. To enhance their analytical capacity, the accounts can be augmented with supplementary information on specific aspects related to water. This includes labour input in the supply of water and sanitation services and information on social aspects that are important for water management. Indicators on access to water and sanitation, which are the indicators in Target 10 of the Millennium Development Goals, are notable examples of social indicators that could be linked to the SEEAW accounting tables. Information on labour input may be important for analysing 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 aiming at improving access to water and sanitation.

C. Further disaggregation of hybrid accounts

5.32. In order to provide a complete picture of the economy of water, the hybrid accounts presented in Table 5.3 should be complemented with the accounts for water-related activities carried out for own use and for expenditures of the government on collective consumption services related to water.

5.33. Water-related activities carried out for own use are not explicitly identified in the national accounts. Their costs are incorporated into those of the principal activity of the establishment. In the SEEAW, these costs are explicitly identified to obtain a more complete picture of the total water-related expenditures by the economy and to assess how much each economic activity spends for the direct provision of water and wastewater services.

5.34. Accounts for the expenditure of the government on collective consumption services related to water are a further disaggregation of the information in Table 5.2 (and Table 5.3). Consumption expenditure of the government (intermediate consumption, compensation of employees and consumption of fixed capital) are separately identified by purpose, that is, in the case of the SEEAW, according to whether they are related to collective services related to water. These accounts are useful for the compilation of environmental protection expenditure and resource management accounts, as well as for the compilation of the financing table.

1. Hybrid accounts for activities carried out for own use

5.35. The accounts presented in this section explicitly identify the intermediate costs and output of water-related activities when they are carried out for own use by households and industries. To assess the contribution of water-related activities to the economy, the costs of these activities need to be separately identified.

5.36. Hybrid accounts for own use are compiled for the following activities:

- *Water collection, treatment and supply* (ISIC 36),
- *Sewerage* (ISIC 37)

Remediation activities related to water (part of ISIC 39) could also be carried out for own use. They, however, are not included in the simplified standard tables because they are usually small.

5.37. Economic units may carry out abstraction or wastewater treatment for own use. This includes, for example, farmers who abstract water directly from the environment for irrigation purposes, electric power plants or other industrial establishments that directly abstract water for their own use (e.g. for cooling purposes). By the same token, 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.

5.38. In the 1993 SNA, goods and services produced for own use should be valued at the basic prices at which they could be sold if offered for sale in the market (para. 6.84, 1993 SNA). However, since for water-related activities reliable market prices do not generally exist, in the SEEAW the value of the output of these activities is deemed, by convention, equal to the sum of the costs of production: that is, as the sum of intermediate consumption, compensation of employees, consumption of fixed capital and other taxes (less subsidies) on production.

5.39. Table 5.4 presents the hybrid account for activities of W*ater abstraction* and *Sewerage* carried out for own use. In the SEEAW, these activities are recorded under the ISIC class of the principal activity. For example, if a manufacturing industry (ISIC 17) treats wastewater on-site before discharging it to the environment, the activity of treating water is recorded under ISIC 17. This presentation is consistent with the way information is organized in physical terms (as presented in chapters 3 and 4) where wastewater discharged to the environment (with or without treatment) by an industry is recorded under the ISIC class of the industry discharging water. The costs of water abstraction are therefore directly linked for each industry to the volumes of water abstracted, and the costs of treating wastewater with the volume of wastewater discharged after on-site treatment.

5.40. For other purposes it may be relevant to re-organize and allocate activities for own use to the relevant ISIC (e.g. ISIC 36 or ISIC 37). The separate identification of water-related activities for own use, as done in the SEEAW, easily allows for this re-organization if so desired.

5.41. Note that Table 5.4 also includes 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 5.4: Hybrid account for water supply and sewerage for own use

Millions of currency units, Millions cubic metres

		Industries (by ISIC categories)								Households	Total industry
				35							
		1-3	5-33, 41-43	Total	*of which*: Hydro	36	37	38,39, 45-99	Total		
Water supply for own use	**1. Costs of production** (=1.a+1.b) (Millions of currency units)	336.0	355.3	1,253.0	930.0	71.3	310.3	7.1	2,333.1	33.5	2,366.5
	1. a. Total intermediate consumption	162.6	171.9	606.3	450.0	34.5	150.2	3.5	1,128.9	16.2	1,145.1
	1.b. Total value added (gross)	173.4	183.4	646.7	480.0	36.8	160.2	3.7	1,204.2	17.3	1,221.4
	1.b.1 Compensation of employees	104.1	73.3	258.7	192.0	14.7	64.1	1.5	516.4	0.0	516.4
	1.b.2 Other taxes less subsidies on production	-1.7	-1.8	-6.5	-4.8	0.4	1.6	0.0	-8.0	0.5	-7.5
	1.b.3 Consumption of fixed capital	71.1	111.8	394.5	292.8	21.7	94.5	2.2	695.8	16.8	712.6
	2. Gross fixed capital formation (Millions of currency units)	672.1	781.6	1,503.6	1,116.0			2.9	2,960.1	70.3	3,030.4
	3. Stocks of fixed assets (Billions of currency units)	11.2	13.1	25.1	18.6			0.0	49.4	1.2	50.6
	4. Abstraction for own use (Millions of m³) (from Table 3.3)	108.4	114.6	404.2	300.0	23.0	100.1	2.3	752.6	10.8	763.4
Sewerage for own use	**1. Costs of production** (=1.a+1.b) (Millions of currency units)		121.0					6.1	127.1	18.2	145.2
	1.a. Total intermediate consumption (Millions of currency units)		30.0					1.5	31.5	4.5	36.0
	1.b. Total value added (gross)		91.0					4.6	95.6	13.7	109.2
	1.b.1 Compensation of employees		27.3					1.4	28.7	4.1	32.8
	1.b.2 Other taxes less subsidies on production		-0.9					0.0	-1.0	-0.1	-1.1
	1.b.3 Consumption of fixed capital		64.6					3.2	67.8	9.7	77.5
	2. Gross fixed capital formation (Millions of currency units)		266.2					2.4	268.6	38.1	306.7
	3. Stocks of fixed assets (Millions of currency units)		3354.1					30.5	3384.6	480.2	3864.9
	4. Return of treated water (Millions of m³) (from Table 3.3)		10.0					0.5	10.5	1.5	12.0

Source: SEEAW-land.

5.42. The information required for Table 5.4 is not likely to be readily available in many countries. Specific surveys need to be put in place in order to estimate the costs associated with the activities of water collection, treatment and supply and wastewater treatment when they are carried out for own use.

Information on the physical quantities of water abstracted and average costs could be used to populate the table as a first step in the compilation of the table.

2. Government accounts on water-related collective consumption services

5.43. For analytical purposes and, in particular for compiling the table of financing, it is useful to develop economic accounts for government expenditures on water-related services. These are classified according to the Classification of the Functions of Government (COFOG) (UN, 2000b). COFOG is a classification of expenditures by the government according to purpose: it classifies transactions such as outlays on final consumption expenditure, intermediate consumption, gross capital formation and capital and current transfers by general government according to the function that the transaction serves.

5.44. The following functions classified in 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 wastewater 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, covers 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.

5.45. Note that the above COFOG categories refer to collective services of the government. The classes COFOG 05.2 and 06.3 should not be confused with activities of *Sewerage* and *Water collection, treatment and supply*, classified in ISIC 37 and 36 respectively, which are considered as individual services in the SEEAW. Expenditures incurred by governments at a national level in connection with individual services such as water supply and sanitation are to be treated as collective when they are concerned with the formulation and administration of government policy, the setting and enforcement

of public standards, the regulation, licensing or supervision of producers, etc. as in the case of education and health. (Based on para. 9.86, 1993 SNA).

5.46. In the cases in which the activities of water supply and sewerage are carried out by the government and are classified under ISIC 84, *Public administration and defence*, the activities related to the production of individual goods and services carried out by the government (such as water supply and wastewater services) should be separately identified, to the extent possible, from the activities related to the production of the collective services (such as the management and administration of water-related programmes, the setting and enforcement of public standards, etc. see also Box 5.1) and classified under the relevant ISIC category.

5.47. Table 5.5 presents economic accounts for government expenditures on water-related collective consumption services. The collective consumption services are assumed to be produced and used by the government. The value of these activities is equal to the costs of their production, namely the sum of intermediate consumption, compensation of employees, consumption of fixed capital and other taxes less subsidies on production. These accounts could 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: Government accounts for water-related collective consumption services

Millions of currency units

	Government (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. Costs of production (=1.a+1.b)	3.79	0.56	1.55	0.22
1. a. Total intermediate consumption	2.82	0.42	0.86	0.04
1.b. Total value added (gross)	0.97	0.14	0.69	0.17
1.b.1 Compensation of employees	0.42	0.13	0.69	0.11
1.b.2 Consumption of fixed capital	0.55	0.00	0.01	0.07

Source: SEEAW-land.

D. Taxes, fees and water rights

[The issue of treatment of permits and license in the update of the 1993 SNA is currently under discussion. This section will be updated as soon as agreement is reached]

5.48. This section deals with specific government instruments used to regulate the use of environmental services and how they are recorded in the SNA. Economic instruments used by government include decisions and actions that affect the behaviour of consumers and producers by causing a distortion in the prices to be paid for environmental services. One way that governments control the use of water and water resources is through taxes/subsidies. The other is through the issuing of licences – for a fee or for free – which entitle the owner to some sort of exclusive use of an environmental asset or part of it (for example, through water rights).

1. Taxes, subsidies and rent

5.49. As mentioned in the previous sections, the uses are valued at purchaser's price. Therefore, they include taxes paid by the final consumer (taxes on products) as well as by the producer (other taxes on production). They also include subsidies to water related activities and products which lower the price paid by users or/and the production costs for the producers. Due to their importance as water policy instruments, a more in-depth examination of how taxes, subsidies and rent on water are treated in the 1993 SNA context is useful.

5.50. It must first be clarified that sometimes taxes and fees are used as a payment of a service (e.g. water delivery or collection of wastewater). In many countries, notably where water use is not metered, water services are recovered through local 'taxes' paid to the municipality, the county etc. In the accounts, these taxes are to be considered as payments in counterpart to a service, equivalent to a price (see para. 8.54(c), 1993 SNA) although they may not cover the total cost of the service. These taxes are therefore recorded in the use table as a purchase of water related products.

5.51. The following entries, as described in the 1993 SNA, are relevant for water:

- *Other taxes on production* (D29) include all taxes except taxes on products that enterprises incur as a result of engaging in production. Such taxes do not include any taxes on the profits or other income received by the enterprise and are payable irrespective of the profitability of the production. They may be payable on the land, fixed assets or labour employed in the production process or on certain activities or transactions. (para. 7.70, 1993 SNA). They explicitly include taxes on pollution defined as: "Taxes levied on the emission or discharge into the environment of noxious gases, liquids or other harmful substances; they do not include payments made for the collection and disposal of waste or noxious substances by public authorities" (para. 7.70, 1993 SNA).

- *Other current taxes* (D59), in the secondary distribution of income accounts, which include payment by households to obtain certain licences.

- *Rent* is a property income receivable by the owner of a tangible non-produced asset in return for putting the tangible non-produced asset at the disposal of another institutional unit. In other words, rent is the property income received from certain leases on land, sub-soil assets and other naturally occurring assets (para. 5.91, IMF 2001).

5.52. One of the regulatory functions of government is to forbid the ownership or use of certain goods or the pursuit of certain activities unless specific permission is granted by issuing a license or other certificate for which a fee is demanded. If the issue of such licenses involves little or no work on the part of the government, the licenses being granted automatically on payment of the amount due, it is likely that the licenses are simply a device to raise taxes (and thus are recorded as other taxes on production) even though they provide a certificate or authorization in return.

5.53. Thus payments to government on access (including abstraction and exploitation) of water resources, granted with little or no work on the part of the government, are recorded as other taxes on

production (1993 SNA, D29) when paid by enterprises and other current taxes (1993 SNA, D59) when paid by households (para. 5.38, IMF 2001) when the resource is owned by the government. However, when government uses the issue of license to exercise a regulatory function (for example, by carrying out some sort of control that it would otherwise not be obliged to) the sale of licenses should be recorded as a sale of services (based on para. 5.54 IMF 2001). Payment on access to water resources owned by the government units are recorded as rent (para. 5.94, IMF 2001).

5.54. Subsidies can be thought of as negative taxes on production and their impact on the operating surplus is in the opposite direction to that of taxes on production. They are current unrequited payments that government units, including non-resident government units, make to enterprises on the basis of the levels of their production activities or the quantities or values of the goods or services which they produce, sell or import (para. 7.71, 1993 SNA). Subsidies are receivable by resident producers or importers and are not payable to final consumers.

5.55. Current transfers that governments make directly to households as consumers are treated as social benefits. Subsidies do not include grants that government may make to enterprises in order to finance their capital formation, or compensate them for damage to their capital assets, such grants being treated as capital transfers (para. 7.72, 1993 SNA).

2. Water rights

5.56. Water rights represent another economic instrument that government may use to regulate water use and give incentives to use water efficiently. Governments manage water resources by issuing rights (e.g. licenses, allocations, entitlements) to control water use and allocate water among different uses. Water rights vary enormously, within and between countries, in their duration, security, flexibility, divisibility and transferability.

5.57. The 1993 SNA introduced a new category of assets called non-financial intangible non-produced assets among which is an item called leases and other transferable contracts. The characteristic of intangible non-produced assets is that they entitle their owners to engage in specific activities or to produce certain specific goods and services and to exclude other institutional units from doing so except with the permission of the owner. The leases themselves are not produced but are legal constructs designed to permit or inhibit certain actions. They may control, for example, who may extract a natural resource and under what conditions (para. 6.39-6.40, SEEA-2003). It is important to note the distinction between the right to control use of an asset and the asset itself: only the right of usage is designated an intangible non-produced asset.

5.58. In light of this new category of assets, water rights constitutes an intangible non-produced asset only if the right to use the asset is (or was) conveyed for a period exceeding a year. Sometimes the right of use will be indefinite. Almost certainly, some legal documentation will exist to evidence control over the property right. If the agreement is for a year only, even if it is renewable, then this agreement is commonly called a licence and the payment due under it is treated as rent (see previous section). It should be noted, though, that it is the period of the agreement which determines whether the payment constitutes rent or acquisition of an intangible asset and not the use of the word "licence" alone.

5.59. When water rights are acquired by purchase, the total cost will be negotiated at the outset. This cost is seldom subject to adjustment or renegotiation during the period of its validity. The transactions for the sale and acquisition of water rights are recorded as capital transactions and do not affect the saving of either the asset owner or user. If the cost is not met in full at the time the water right passes from the (original) owner to the new owner/user, the difference will be recorded in terms of financial assets and liabilities between the two parties. If a tax on the right to use the asset is levied, it is likely that the user will be responsible for paying this.

5.60. When water rights are tradable, the unit issuing the rights (almost always government) creates the asset and records this creation in its other changes in assets account. If the water right is sold, the sale and purchase are recorded in the capital accounts of the two units involved. If it is issued free, but has a positive value, determined e.g. on markets or through net present value calculations, it is still recorded in the same way as sale and purchase in the capital account, but in addition a capital transfer of the same size is made from the issuer to the new owner of the permit. This transfer exactly cancels the acquisition of the water right so the lending or borrowing position of each of the two units is unaffected.

E. National expenditure and financing accounts

5.61. This section presents national expenditure and financing accounts for water-related activities classified by purpose. These activities are described in more detail below.

5.62. The accounts presented in this section are based on environmental protection expenditure accounts (EPEA) (SEEA-2003, Eurostat 1994, 2002a and 2002b). Information from the hybrid and economic accounts presented in the previous sections provide inputs to the tables on national expenditure and financing presented in this section.

1. Environmental protection and resource management related to water

Environmental protection

5.63. This section describes environmental protection (EP) activities but also products, actual outlays (expenditure) and other transactions related to water. They are classified according to the Classification of Environmental Protection Activities and Expenditure (CEPA 2000) which is a generic, multi-purpose, functional classification for environmental protection. CEPA can be used to classify **environmental protection activities**, **environmental protection products** and **expenditure for environmental protection**.

5.64. *Environmental protection activities* are those where the primary purpose is the protection of the environment; that is the prevention, reduction and elimination of pollution as well as any other degradation of the environment caused by economic activities. 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.

5.65. Environmental protection activities are production activities in the sense of national accounts (see, for example, 1993 SNA paragraph 6.15), that is, they combine resources such as equipment, labour, manufacturing techniques, information networks or products to create an output of goods or services. An activity may be principal, secondary or for own use.

5.66. ***Environmental protection products*** are:

- Environmental protection services produced by environmental protection activities; and
- Adapted (cleaner) 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 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 (Eurostat, 2002a).

The expenditures recorded are the purchasers' prices of environmental protection services and connected products and the extra costs over and above a viable but less-clean alternative for cleaner products.

5.67. ***Expenditure for environmental protection*** includes outlays and other transactions related to:

- inputs for environmental protection activities (energy, raw materials and other intermediate inputs, wages and salaries, taxes linked to production, consumption of fixed capital);
- capital formation and the purchase of land (investment) for environmental protection activities;
- outlays of users for the purchase of environmental protection products;
- transfers for environmental protection (subsidies, investment grants, international aid, donations, taxes earmarked for environmental protection, etc.).

5.68. In the case of water, *Wastewater management* and *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-2000).

5.69. *Wastewater management* (CEPA 2) comprises activities and measures aimed at the prevention of pollution of surface water through the reduction of the release of wastewater into inland surface water and seawater. It includes the collection and treatment of wastewater including monitoring and regulation activities. Septic tanks are also included. (Explanatory notes of CEPA-2000, SEEA-2003). In particular, *Wastewater management* includes: (a) activities for the collection, treatment and disposal of wastewater, activities aimed at controlling the quality of surface and marine water, administration activities in the wastewater domain (these activities corresponds to Sewerage, ISIC 37 and part of the public administration activities ISIC 84); (b) the use of specific products relevant for wastewater management such as septic tanks; and (c) specific transfers.

5.70. *Protection and remediation of soil, groundwater and surface water* (CEPA 4) refers to measures and activities aimed at the prevention of pollutant infiltration, cleaning up of soils and water bodies and

the protection of soil from erosion and other physical degradation as well as from salinisation. Monitoring, control of soil and groundwater pollution is included. (Explanatory notes of CEPA-2000, SEEA-2003). *Protection and remediation of soils, groundwater and surface water* mainly include (a) activities for the protection of soil and groundwater (which correspond to part of ISIC 39 - Remediation activities and other waste management services - and part of the public administration activities ISIC 84) and (b) specific transfers.

Management and exploitation

5.71. *Natural resources management* includes activities and measures for 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. *Natural resource exploitation* includes 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 paras. 5.39-5.41, SEEA-2003).

5.72. The management of natural resources (for example, water supply) are not included in CEPA. Even though there is no agreed classification for natural resources management and exploitation, the framework of environmental protection expenditure accounts (EPEA) can be extended to cover natural resources management and exploitation.

5.73. *Water management and exploitation* include (a) activities for the collection, storage, treatment and supply of water (ISIC 36), the administration of water ways and water bodies, supervision, research, elaboration of plans and legislation and water policy (part of ISIC 84) and (b) specific transfers.

2. National expenditure accounts

5.74. National expenditure accounts aim at recording the expenditure of resident units and financed by resident units in order to get a total that corresponds to the effort a nation is making out of its own resources. They are compiled for environmental protection related to water, namely *Wastewater management* and *Protection and remediation of soil, groundwater and surface water* as well as for *Water management and exploitation*. The standard tables for the national expenditure and financing accounts are compiled only for *Wastewater management* and *Water management and exploitation*. The compilation of the tables on *Protection and remediation of soil, groundwater and surface water* require additional data disaggregation of what is included in the standard tables and are thus included as part of the supplementary tables.

5.75. This sub-section describes the component of the national expenditure for EP and illustrates the national expenditure accounts for *Wastewater management* in Table 5.6. These accounts can also be compiled for *Water management end exploitation* and *Protection and remediation of soil, groundwater and surface water*.

5.76. The main components of the national expenditure for environmental protection, described by row in the accounts presented in Table 5.6, consist of the following:

- *Use of environmental protection* (EP) *services* by resident units (except *Specialised producers* to avoid double counting – see para. 5.70 for a detailed explanation). This is the sum of intermediate and final consumption and capital formation. Intermediate consumption includes the use of EP services for own use and EP services purchased by *Other producers*. Only in the case of soil remediation can the use of EP services for capital formation (row 1.c of Table 5.6) be non-zero for *Other producers*. This entry consists of improvement of land resulting from decontamination of soil. It is not included in row 2 of Table 5.6 as it is a use of

the output of ISIC 39 by other producers and not an investment for production of EP services or land acquisition, which are recorded in row 2 of Table 5.6.

In the case of *Wastewater management*, the use of EP services corresponds to the use of *Wastewater services* (CPC 941 and CPC 91123) for intermediate and final consumption by resident units (except by *Specialised producers* – in this case ISIC 37). Capital formation is not relevant for water and wastewater services thus it is not recorded under this category.

- Use of *Adapted* and *Connected products* for intermediate and final consumption.

In the case of *Wastewater management*, *adapted products* include, for example, phosphate free washes and highly biodegradable products. *Connected products* include, for example, septic tanks, biological activators of septic tanks and services for collecting septic tanks sludge.

- *Gross capital formation* for producing EP services. This item corresponds to the investments made by EP producers for producing EP services. It includes gross fixed capital formation and net acquisition of land.

In the case of *Wastewater management*, it corresponds to the gross capital formation related to wastewater management activities: e.g. the installation of sewage networks, treatment plants, etc. This corresponds to the investments made by the producers of wastewater services for collecting, treating and discharging wastewater.

- *Specific transfers* received for EP. Specific transfers are unrequited payments received by residents or non-resident units which contribute to the financing of characteristics activities and uses of specific products or constitute a compensation for income or losses related with environmental protection (SERIEE[14] § 2039, Eurostat, 1994). This item includes current and

[14] SERIEE stands for European System for the Collection of Economic Information on the Environment (Eurostat, 1994).

capital transfers for EP. They are not the counterpart of the previous items in the table in order to avoid the double counting.

In the case of *Wastewater management*, specific transfers consist, for example, of subsidies to specialised producers of sewerage and treatment services and also of transfers to the rest of the world in order to finance programs of collective sewerage and treatment in other countries (international public or private aid for development) (SERIEE § 4071).

5.77. The sum of the categories above corresponds to the *total domestic use* of EP services. Since the national expenditure aims at recording the expenditure of resident units and financed by resident units in order to get a total that corresponds to the effort a nation is making out of its own resources, the financing of the *Rest of the world* (row 6 of Table 5.6) for EP has to be subtracted from the total domestic use. In the case of *Wastewater management*, this financing consists of international aid for *Wastewater management*.

5.78. National expenditure for EP is allocated by column to the following categories of beneficiaries: *Producers, Final consumers* and the *Rest of the world*. Producers are further disaggregated into *Specialised producers* and *Other producers*. *Specialised producers* which are defined as those producers which carry out an EP activity as their principal activity. In the case of wastewater management, they correspond mainly to producers classified in ISIC 37. *Other producers* as those producers that use EP services (including the use of EP services for own use) and connected and adapted products for their intermediate consumption, invest for their production of EP services for own use and receive specific transfers for EP.

5.79. Final consumers identified in national expenditure accounts include *Households* as actual consumers of EP services and connected and adapted products or as beneficiaries of specific transfers and *Government* in its capacity as consumer of collective services.

5.80. The *Rest of the world* is included by column as part of the users/beneficiaries as it may receive specific transfers for EP. In the case of *Wastewater management*, transfers to the *Rest of the world* include transfers "to finance programs of collective sewerage and treatment in other countries" (SERIEE § 4071).

5.81. Expenditure by *specialised producers* (ISIC 37) consists of gross capital formation for the production of *Wastewater services* (capital formation, row 2 of Table 5.6) and specific transfers (row 4 of Table 5.6). The entries in the other cells of the column of *Specialised producers* should not be recorded in order to avoid double counting between the output (and subsequent uses). The use of *Wastewater services* and *Connected and adapted products* for intermediate consumption by *Specialised producers* is part of the output of the *Specialised producers* and recorded as intermediate consumption of *Other producers* and final consumption of *Households* and *Government*. It is thus already included in the total national expenditure. The use of EP services for capital formation (row 1.c of Table 5.6) should also not be recorded for specialised producers as it represents the use of capital goods for the production of EP services and thus included in the gross capital formation in row 2.

5.82. Expenditure of *Other producers* includes: the use of *Wastewater services* as intermediate consumption (including also services produced for own use) (row 1.b); investments for the production of wastewater services as secondary activity or for own use (row 2); the use of *Connected and Adapted products* (row 3); and specific transfers (row 4).

5.83. Information in the row 1 and 2 of Table 5.6 is derived from the hybrid account for supply and use of water in Table 5.3, hybrid account for water related activities for own use in Table 5.4 and government accounts on water related collective services in Table 5.5. For example, the use of *Wastewater services* by *Other producers* is the sum of the use of *Sewerage services* from Table 5.3 (3.95 billions currency units in row 2.b of Table 5.3) and the value of the output of *Sewerage service* for own use from Table 5.4 (0.14 billions of currency unit in row 1 of Table 5.4).

Table 5.6: National expenditure accounts for wastewater management

Billion currency units

	USERS/BENEFICIARIES					
	Producers		Final consumers			
	Specialised producers (ISIC 37)	Other producers	Households	Government	Rest of the world	Total
1. Use of Wastewater services (CPC 941 and CPC 91123)		4.09	4.85	3.79		12.74
1.a Final consumption			4.85	3.79		8.64
1.b Intermediate consumption		4.09				4.09
1.c Capital formation	nr	Na				Na
2. Gross Capital Formation	9.18	0.51				9.69
3. Use of connected and adapted products						
4. Specific transfers		0.001	0.000			0.001
5. Total domestic uses (=1.+2.+3.+4.)	9.18	4.60	4.85	3.79	0.00	22.43
6. Financed by the rest of the world	1.00					1.00
7. National expenditures (=5.-6.)	8.18	4.60	4.85	3.79	0.00	21.43

Note: Grey cells indicate non relevant or zero entries by definition, nr not recorded to avoid double counting; Na not applicable in the case of wastewater management.

5.84. The use of *Wastewater services* by Households corresponds to their actual final consumption: 4.9 billion currency units are derived from row 2.b of Table 5.3. The use of *Wastewater services* by the government is derived from the government accounts on water-related collective services. It corresponds to row 1 of Table 5.5 (3.79 Millions of currency units).

5.85. Additional information to that in the tables in sections B and C is required to compile the national expenditure accounts, namely information on the use of *connected and adapted products*, *Specific transfers* and *financing from the Rest of the world*.

3. Financing accounts

5.86. 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 receive 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 expenditure or from specific taxes. This

section describes the financing of national expenditure 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 the amount being financed.

5.87. Table 5.7 presents the financing accounts for *Wastewater management* to show how the national expenditure for *Wastewater management* is financed. The columns of Table 5.7 show the same categories of users/beneficiaries identified in Table 5.6. The rows of Table 5.7 show the different financing units (that is, 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.

5.88. The expenditures recorded in the column of *Specialised producers* correspond to their gross capital formation (and net acquisition of land). The table entries describe how capital formation is financed: partly by the specialised producers themselves (row 3.a); and partly by the government through investment grants (row 1). If the investment grants, however, are funded from earmarked taxes, it is assumed that those who pay the taxes (in general households and other producers) are the financing units (row 4 and 3.b respectively).

5.89. The national expenditure recorded in the column of *Other producers* corresponds to the sum of the intermediate consumption of *Wastewater services* (including those produced for own use), the capital formation (investment in infrastructure and net acquisition of land) for secondary and own-use activities for wastewater services and specific transfers they may receive. The various column entries describe how this expenditure is financed. Other producers may finance their intermediate consumption and capital formation themselves (row 3.b) or may receive subsidies from specialised producers (row 3.a) or the government (row 1) through specific transfers and investment grants. If these subsidies and

investment grants are funded through revenues from earmarked taxes, it is assumed that the unit that pays the taxes is the financing unit.

5.90. National expenditure of *Households* corresponds to their actual final consumption of *Wastewater services*, *Connected and adapted products* and any transfers they receive. Entries in the column describe how this expenditure is financed. Households may finance part of their final consumption themselves (row 4), however, they may receive: (a) social transfers in kind from the Government and NPISH (rows 1 and 2) and (b) subsidies that lower the price of environmental protection services or products, in which case it is assumed that the government is the financing unit. 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.

5.91. The expenditure of the *Government* as a collective consumer corresponds to its expenditure on collective consumption services. In general, this expenditure is financed by the government from the general budget (row 1). 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.

5.92. The expenditure recorded in the column of the *Rest of the world* corresponds to the transfers paid for international co-operation for environmental protection. These transfers can be financed either by the government or by households, through NPISHs.

Table 5.7: Financing accounts for wastewater management

Millions currency units

FINANCING SECTORS:	USERS/BENEFICIARIES			
	Producers	Final Consumers	Rest of	Total

	Specialised producers (ISIC 37)	Other producers	Households	Government	the world	
1. General government	1.64	0.001	2.43	3.79		7.86
2. NPISHs						
3. Corporations	6.55	4.40				10.55
3.a Specialised producers	6.55					6.55
3.b Other producers	0.00	4.40				4.25
4. Households		0.20	2.43			2.63
5. National expenditure	8.18	4.60	4.85	3.79	0.00	21.43
6. Rest of the world	1.00					1.00
7. Domestic uses	9.18	4.60	4.85	3.79	0.00	22.43

Note: Grey cells indicate non relevant or zero entries by definition

Source: SEEAW-land.

Chapter 6 Water 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. This allows for an assessment of how current levels of abstraction and discharges affect the stocks of 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). Unlike other natural resources, such as forest or mineral deposits which are subject to slow natural changes, water is in continuous movement through the 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, for example, to answer the question on how to meet the water demand in dry seasons.

6.3. Section C describes how the 1993 SNA asset boundary has been expanded. It presents the SEEAW asset classification and describes the SEEAW standard tables for asset accounts. In the case where 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 can 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 D describes how to include information on transboundary waters in the asset accounts.

6.4. 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 with in this chapter: as yet there are no standard techniques to assess the economic value of water; market prices do not fully reflect the value of the resource itself; and the resource rent is often negative. A discussion on various methods of valuing water is presented in chapter 8.

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 to explain spatial and temporal differences in water distribution. Figure 6.1 shows the various stages of 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 groundwater, 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.

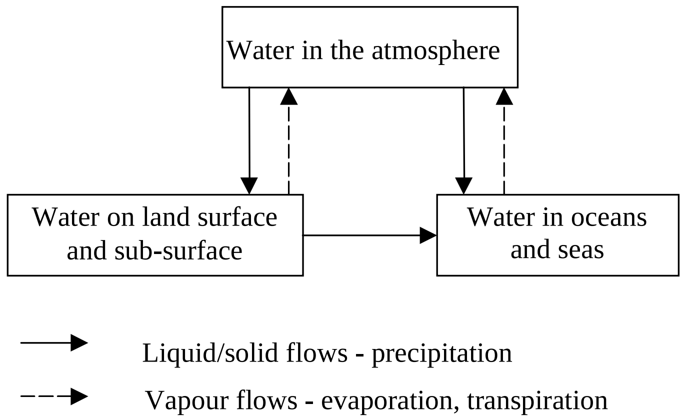


Figure 6.1: Natural water cycle

Source: UNESCO (1989).

6.6. The natural water balance describes 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), or flows within rivers or streams (runoff), or is stored in natural or man-made water bodies (changes in storage).

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 1993 SNA and its expansion in the SEEA-2003.

1. Extension of the 1993 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 (para 10.2, 1993 SNA).

6.10. In particular, in the case of water, the 1993 SNA defines water resources within its asset boundary 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-2003 extends the 1993 SNA boundary to include all water resources that provide direct use and non-use benefits. This implies that the SEEA-2003 asset category “water resources” (classified in the category EA.13) includes all the water resources from which water can be extracted in the current period as well as other resources which may be extracted in the future. This amounts to include all water resources in the national territory.

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 consists of 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 SEEAW asset classification expands the SEEA-2003 classification by including the categories EA.1314 Glaciers, snow and ice and EA.133 Soil water. While the SEEA-2003

acknowledges the importance of these resources in terms of flows, it does not include them in the asset classification because they represent only a temporary storage of water. The explicit inclusion of glaciers, snow, ice and soil water in the SEEAW asset classification reflects the increasing importance of these resources in terms of stocks (in particular soil water) and also 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. Water management tends to focus water in rivers, lakes etc. and neglects 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.

6.14. 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 dry months and contribute to water peaks. Moreover, monitoring glacier stocks is also important for monitoring climate change.

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 defined as an accumulation of ice of atmospheric origin, generally moving slowly on land over a long period. Snow, ice and glaciers are measured in water equivalent.

6.16. *Groundwater* comprises of water which collects in porous layers of underground formations known as aquifers. An aquifer is a geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and

springs. It may be unconfined, that is have a water table and an unsaturated zone, or may be confined when it is between two layers of impervious or almost impervious formations. Depending on the recharge rate of the aquifer, groundwater can be fossil (or non-renewable) in the sense that water is not replenished by nature in human life spans. 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.

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 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, hydroelectric power generation and mixed use. Rivers could be further classified on the basis of the regularity of the runoff as perennial rivers, where water flows continuously throughout the year, or ephemeral rivers, when water flows only as a result of precipitation or to the flow of an intermittent spring.

6.19. 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 those cases in which the separation between two categories is not possible, a category combining the two categories could be introduced for ease of compilation in the table.

Fresh and non-fresh water resources

6.20. Water resources include all inland water bodies regardless of their salinity level: they include fresh and brackish inland water. Freshwater 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 freshwater is not clear cut: the salinity levels used in the definition vary between

countries. Brackish water is included in the asset boundary on the ground that this water can be (and often is) used, with or without treatment, for some industrial purposes, for example, cooling water or even for irrigation of some 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 the salinity level. Chapter 7 presents quality accounts for water which can be based on 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 the abstraction. These assets, in general, do not incur depletion. Water in oceans, seas and atmosphere is recorded in the accounts only in terms of abstracted water. In particular:

- the physical supply and use tables (see chapter 3) record: (a) water abstracted from and returned into the sea (in the case, for example, of abstraction of sea water for cooling purposes or for desalination); (b) the precipitation directly used by the economy (in the case, for example, of water harvest); and (c) evaporation and evapotranspiration which occur within the economic sphere (part of water consumption);
- the asset accounts record: (a) water flowing into oceans and sea (outflows from rivers); (b) water vaporised and evapotranspired from water resources; and (c) 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 the SEEAW as non-produced assets, that is, they are "non-financial assets that come into existence other than through

processes of production" (para. 10.6, 1993 SNA). It could be argued, however, that water contained in artificial reservoirs comes into existence through a production process: a dam has to be built, and, once the dam is in place, activities of operation and management of the dam that regulate the stock level of the water have to be exercised on a continuous and regular basis. The discussion on whether to consider water in a reservoir as a produced asset has not yet concluded. For this reason, the SEEAW has retained the classification of the SEEA-2003.

3. Asset accounts

6.24. The water asset accounts describe the stocks of water resources and their changes during a period of time. Figure 6.2 presents a schematic form of an asset account. In particular, it presents

- Opening and closing stocks which are the stocks level at the beginning and end of the period of time;
- Increases in stocks which include those due to human activities (i.e. returns) and natural causes (e.g. inflows, precipitation); and
- Decreases in stocks which include those due to human activities (i.e. abstraction) and natural causes (e.g. evaporation/evapotranspiration, outflows etc.).

These accounts are particularly relevant because they link water use by the economy (represented by abstraction and returns) and natural flows of water to the stocks of water in a country.

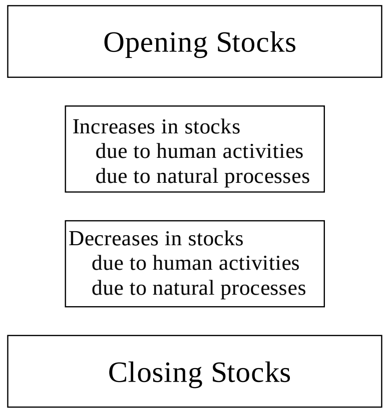


Figure 6.2: Schematic representation of an asset account

6.25. The standard table for asset accounts for water resources is presented in Table 6.1. The columns refer to the water resources as specified in the asset classification, and the rows describe in detail the level of the stocks and the changes therein due to economic activities and natural processes. The items presented in the table are discussed in detailed below.

Table 6.1: Asset accounts

Millions cubic metres

	EA.131 Surface water						
	EA.1311 Artificial Reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow, Ice and Glaciers	EA.132 Groundwater	EA.133 Soil water	Total
1. Opening Stocks	1,500	2,700	5,000	0	100,000	500	109,700
Increases in stocks							
2. Returns	300	0	53		315	0	669
3. Precipitation	124	246	50			23,015	23,435
4. Inflows	1,054	339	20,137		437	0	21,967
4.a. From upstream territories			17,650				17,650
4.b. From other resources in the territory	1,054	339	2,487	0	437	0	4,317
Decreases in stocks							
5. Abstraction	280	20	141		476	50	967
6. Evaporation/Actual evapotranspiration	80	215	54			21,125	21,474
7. Outflows	1,000	100	20,773	0	87	1,787	23,747
7.a To downstream territories			9,430				9,430
7.b To the sea			10,000				10,000
7.c To other resources in the territory	1,000	100	1,343	0	87	1,787	4,317

8. Other changes in volume							0
9. Closing Stocks	1,618	2,950	4,272		100,189	553	109,583

Note: Grey cells indicate zero entries by definition.

Source: SEEAW-land.

6.26. *Returns* represent the total volume of water that is returned from the economy 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. In this case, the breakdown should mirror that used to disaggregate the returns in the physical supply and use tables in chapter 3.

6.27. *Precipitation* consists of the volume of atmospheric wet precipitation (e.g. rain, snow, hail etc.) on the territory of reference during the accounting period before evapotranspiration takes place. The majority of precipitation 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.

6.28. *Inflows* represent the amount of water that flows into water resources during the accounting period. The inflows are disaggregated according to their origin: (a) inflows from other territories/countries; and (b) from other water resources within the territory. Inflows from other territories occur with shared water resources. For example, in the case of a river that enters the territory of reference, the inflow is the total volume of water that flows into the territory at its entry point during the accounting period. If a river borders two countries without eventually entering either of them, each country could claim a percentage of the flow to be attributed to their territory. If no formal convention exists, a practical solution is to attribute 50 per cent of the flow to each country. Inflows from other resources include transfers, both natural and man-made, between the resources within the territory.

They include, for example, flows of infiltration and seepage as well as channels built for water diversion.

6.29. A*bstraction* represents the amount of water removed from any resource, either permanently or temporarily, during the accounting period for final consumption and production activities. Water used for hydroelectric power generation is considered part of water abstraction. Given the large volumes of water abstracted for hydroelectric power generation, it is advisable to separately identify the abstraction and returns from hydroelectric power generation. Abstraction also includes the use of precipitation for rain-fed agriculture as this is considered a removal of water from the soil as a result of human activity (e.g. agriculture). Water used in rain-fed agriculture is thus recorded as an abstraction from soil water.

6.30. *Evaporation/Actual evapotranspiration* is the amount of evaporation and actual 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.

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

other water resources within the territory represent water exchanges between water resources within the territory. In particular, they include the flows of water going out of a water body and reaching other water resources within the territory. Outflows to other territories represent the total volume of water that flows out of the territory of reference during the accounting period. Shared rivers are a typical example of water flowing from one upstream country to a downstream country. Outflows to the sea/oceans represent the volume of water that flows into the sea/oceans.

6.32. *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.

6.33. Exchanges of water between water resources are also described in more detail in a separate table, Table 6.2. This table, which expands the information in rows 4.b and 7.c of Table 6.1, 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. This table is also useful for the calculation of internal renewable water resources and for reducing the risk of double counting when assessing separately this indicator for surface and groundwater due to the water exchanges between these resources (FAO/AQUASTAT, 2001). Table 6.2 assists in identifying the contribution of groundwater to the surface flow as well as the recharge of aquifers by surface runoff.

Table 6.2: Matrix of flows between water resources

Millions cubic metres

	EA.131 Surface water						
	EA.1311 Artificial Reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow, Ice and Glaciers	EA.132 Groundwater	EA.133 Soil water	Outflows to other resources in the territory
EA.1311 Artificial Reservoirs			1,000				1,000
EA.1312 Lakes			100				100

EA.1313 Rivers	1,000	293			50		1,343
EA.1314 Snow, Ice and Glaciers							0
EA.132 Groundwater			87				87
EA.133 Soil water	54	46	1,300		387		1,787
Inflows from other resources in the territory	1,054	339	2,487	0	437	0	4,317

Source: SEEAW-land.

6.34. In Table 6.1 sustainable water abstraction which, broadly speaking, is the level of abstraction which meets the needs of the present without compromising the ability of future generations to meet their own needs, can be specified for each water resource. 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.

4. Definition of stocks for rivers

6.35. 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 groundwater 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).

6.36. 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. 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, computing the stock of rivers is not realistic and can be omitted from the accounts.

Link with Supply and Use tables

6.37. 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 intersection 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, row 1.i of Table 3.1 or Table 3.3. Similarly, the returns that appear in Table 6.1 correspond to the Total Returns to Water Resources in the physical supply table, row 5.a of Table 3.1 or Table 3.3.

6.38. 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 the destination of water discharges by the economy. It allows for the evaluation of the pressure exerted by the economy on the environment in terms of abstraction and returns.

D. Accounting for transboundary water resources

6.39. When the accounts are compiled for water resources that are shared by several countries, the part of the shared resources which belongs to each riparian country as well as the origin and destination of specific flows can be explicitly identified. 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) as well as the European Water Framework Directive cover issues related both to the quality and quantity of transboundary waters. Physical water asset accounts can provide information on inflows coming from and outflows going to neighbouring countries.

6.40. Table 6.3 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 of origin (in the case of inflows) and destination (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 alongside 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.

6.41. If the territory of reference of the accounts is a river basin which extends beyond the boundary of a country, the opening and closing stocks of water resources could be disaggregated according to the country the water resources belong to. Similarly, information on abstraction and returns could be disaggregated according to the country responsible for those flows. Table 6.4 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 where there are more riparian countries sharing waters.

Table 6.3: Asset account at national level

Cubic metres

	Water Resources (classified according to the asset classification)	*Legal quotas established by treaties*
1. Opening Stocks		
Increases in stocks		
2. Returns [(a)]		
3. Precipitation		NA
4. Inflows		
4.a from upstream territories[(a):]		
4.a.1 Country 1[(a):]		
…		
4.b from other Water Resources in the territory		NA
Decreases in stocks		
5. Abstraction [(a)]		
6. Evaporation/Actual evapotranspiration		NA
7. Outflows		
7.a to other Water Resources in the territory		NA

7.b to the sea		NA
7.c to downstream territories [(a)]:		
7.c.1 Country 2[(a)]:		
…		
Other changes in volume		NA
Closing Stocks		

Note: (a) Each of these flows may be subject to quotas established in treaties and agreements between riparian countries; NA not applicable.

6.42. The opening and closing stocks of the water resources in the basin are disaggregated by 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 share of the asset. However, there may be cases that a country abstracts more than their share of the stock that is assigned by a treaty. In this case, there is a transfer of water from one country to the other.

6.43. 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 6.3. However, for sake of simplicity of presentation, this information is not included in Table 6.4.

Table 6.4: Asset accounts for a river basin shared by two countries

	Water Resources (classified according to the asset classification)		Total
	Country 1	Country 2	
1. Opening Stocks			
Increases in stocks			
2. Returns[(a)]:			
2.a by Country 1[(a):]			
2.b by Country 2[(a):]			
3. Precipitation			
4. Inflows from other resources[(a)]:			
4.a Country 1[(a):]			
4.b Country 2[(a):]			
Decreases in stocks			
5. Abstraction[(a)]:			
5.a by Country 1[(a):]			
5.b by Country 2[(a):]			
6. Evaporation/Actual evapotranspiration			
7. Outflows to other resources in the country[(a)]:			
7.a Country 1[(a):]			
7.b Country 2[(a):]			
8. Outflows to the sea			
9. Other Volume changes			
10. Closing Stocks			

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.

Part II

Chapter 7 Water quality accounts

A. Introduction

7.1. Water quality determines the uses that can be made of it. Pollution creates health hazards, detrimentally affects biodiversity, raises 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. The importance of monitoring and accounting for water quality is internationally recognized (see, for example, World Meteorological Organization, 1992, and Agenda 21 (United Nations, 1992)). International targets have been established with regards to the quality of water. This is the case for example of the European Water Framework Directive (WFD) of the European Parliament and of the Council, which requires EU countries to establish water policies to ensure that all water meets "good status" by 2015 (see Box 7.1).

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

7.4. Quality accounts do not have a direct link to the economic accounts, in the sense that changes in quality cannot be attributed to economic quantities using linear relationships, as in the case of the water asset accounts presented in Chapter 6. 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 the quality of the stocks of water resources. 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 two main issues with its implementation: the definition and measurement of water quality classes. Water quality is generally defined for a specific concern and there is little standardisation of concepts and definitions or aggregation methods. Aggregation can be (i) over different pollutants to reach one index, which measures the combined impact of pollutants on water resources, (ii) over time to address seasonal variations; (iii) 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. Section B describes basic concepts of water quality assessment, including the difficulty of defining quality in the presence of multiple uses. Section C discusses the structure of quality accounts. Section D focuses on two issues: the choice of determinands and the assessment. Two indices that are used when aggregating over space are presented in section E. Section F describes the exercise currently under way in the European Environment Agency to construct quality accounts for rivers.

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. “Water bodies” are the units that will be used for reporting and assessing compliance with the Directive’s environmental objectives. For each surface water category, water bodies are differentiated according to their “type” (depending on the ecoregion, geology, size, altitude, etc.). The main purpose of this typology is to enable type specific “reference conditions” to be defined, which are the key of the quality assessment process.
- It sets a deadline of 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 physico-chemical characteristics. Member States will report the ecological status 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 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.

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

Source: European Parliament and Council, 2000.

B. Basic concepts of water quality assessment

7.8. Natural waters exhibit a wide variety of chemical (e.g. nitrate, dissolved oxygen, etc.), physical (e.g. temperature, conductivity, etc.), hydro-morphological (water flow, river continuity, substrate, etc.) and biological (e.g. bacteria, flora, fish, etc.) characteristics that result from natural processes and anthropogenic activities. Water quality is described by all these characteristics.

7.9. Quality applies to water bodies, waterbeds which contain or transport this water, and to the riparian zone. The quality of water running through a river could be very good, whereas the riverbed could be severely polluted with heavy metals that have sunk into its sediment. In this chapter we restrict ourselves to the quality of water bodies.

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

Table 7.1: Indicators and their determinands included in SEQ-eau

Indicators	**Determinands***
Organic and oxidizable matter	Dissolved O_2, $\%O_2$, COD, BOD_5, DOC, 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 on 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

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

Source : Oudin, 2001.

7.11. For policy purposes (such as setting objectives and checking compliance), it is necessary to define the quality of water either by specifying series of normative values for its determinands, which represent the requirements for certain uses (Train, 1979) or allowable deviations from reference conditions, in the case, for example, of the Water Framework Directive. For reasons of practicality, ease of reporting as well as the inherent uncertainty, water quality is eventually reported in the form of discrete classes. The description of quality accounts in the SEEA 2003 supposes that quality classes have been defined (see section C).

7.12. The quality of a water body may be approached in terms of its uses/functions. There is no standard classification of water uses/functions. However, the uses/functions most commonly used are: drinking water, leisure, irrigation, and industry. France distinguishes aquatic life, drinking water, leisure, irrigation, livestock and aquaculture (Oudin and Maupas, 1999). Australia and New Zealand 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) (ANZECC/ARMCANZ, 2000). The Millennium Ecosystem Assessment investigates functions as services supplied by the aquatic ecosystems: flood mitigation, groundwater recharge, food provision, pollution control, etc. (Millennium Ecosystem Assessment, 2005).

7.13. Gascó et. al. (2005) assess water quality in terms of hydrological power defined based on topographic position (which gives indications of potential for hydroelectric power generation) and osmotic power due to salt concentration (which limits water availability for animal and plant nutrition).

7.14. Countries assign water uses/functions to water bodies in different ways. One approach used in France has been to use the same water uses/function for all water bodies of a certain type (rivers, lakes, or groundwater) independent of the actual uses/functions of the specific water bodies.

7.15. Since 1999, France has used the System for the Evaluation of the Quality of Water (SEQ-eau) (Oudin, 2001) as an assessment framework. It is based on the concept of suitability for a use or function, with a specific instance for every category of water (rivers, lakes, groundwater, etc.). For rivers, SEQ-eau considers five uses (drinking water, leisure, irrigation, livestock watering and aquaculture) and one function (aquatic life), together called "uses". The evaluation system is based on 15 suitability indicators (see Table 7.1), each expressing a possible alteration of suitability. For each use, a subset of these indicators is selected: for example, for the use 'irrigation' only four indicators are selected (salinity, micro-organisms, micro-pollutants and pesticides), but for drinking water 13 out of 15 are selected. Each indicator has a set of determinands, which is a group of parameters having similar impacts, from a list of 135 monitored parameters, as specified in Table 7.1. For example, the "Nitrogen (except nitrates)" indicator is computed from NH4+, NKj, NO2- concentration values. A class is assigned to each determinand of an indicator using threshold values which are indicator specific and use specific. A final suitability class for a each use can then be defined by taking the worst score obtained for any relevant indicator, and for each indicator, the worst score obtained for any determinand; when multiple samples are used during the monitoring period, the "90^{th} percentile" rule is applied.

7.16. In the French approach, it is possible to derive a global quality index and a global quality class of a water body. This is not done by taking the worst of the worst score obtained for the different uses,

but by defining "quality" threshold values for each indicator determinand and selecting the "suitability" threshold values associated to the most restrictive use (considering only aquatic life, drinking water and leisure). For instance, the high quality threshold for nitrate is defined as 2 mg/l, the lower value of 2 mg/l (for aquatic life) and 50 mg/l (for drinking water). The global quality index is the worst score obtained for any indicator.

7.17. Other countries, such as the United States of America and Australia, define water uses/functions specific to the actual uses/ function of the water body. For each water body a specific use or uses are identified and the quality criteria are set accordingly. Standards are water body-specific. In the case of multiple uses, water quality could be defined in terms of its most sensitive or stringent use. This is, for example, the case in 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).

7.18. The quality assessment for ecological status used in the European Water Framework Directive (WFD) (see Box 7.1) is not based on a specific classification for different uses, but evaluates quality as the deviation from reference conditions observed for each "type" of water body. The WFD classifies surface water bodies into five ecological status classes: high, good, moderate, poor and bad. This classification results from the observation of quality elements: biological, physico-chemical (as illustrated in Table 7.2) , and hydro-morphological quality elements.

7.19. The observation of a quality element reoiesn on the monitoring of its determinands. For example, three determinands are considered for the "oxygenation" quality element: COD, BOD and dissolved oxygen. Each determinand is valued using a "ratio" between 0 and 1, with values close to 1 representing reference conditions for the water body's type. The [0, 1] interval is divided into five subintervals, for each of the status classes. The boundaries between moderate and good status and between good and high status are made comparable across countries through an inter-calibration

exercise. In order to determine the quality class for a quality element, the values of a group of determinands may be combined (by taking an average, median etc.) when they show a sensitivity to the same range of pressures, otherwise, the worst class is assigned to the quality element. At the end, the worst class of all relevant quality elements determines the status class of the water body.

Table 7.2: Physico-chemical quality elements used for the ecological status classification of rivers in the WFD

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-	Concentrations remain within the	Concentrations not in excess of the	Conditions consistent with the

synthetic pollutants	range normally associated with undisturbed conditions.	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.	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).

C. The structure of the accounts

7.20. The general structure of the quality accounts is the same as that of the water asset accounts in Chapter 6. The only difference is the addition of the quality dimension, which describes the volume of water. Table 7.3 shows the general structure for quality accounts as presented in the SEEA 2003. This table shows the opening and closing stocks together with the changes in stocks that occur during the accounting period for each quality class.

Table 7.3: Quality accounts

physical units

	Quality classes				
	Quality 1	Quality 2	…	Quality n	Total
Opening stocks					
Changes in stocks					
Closing stocks					

Source: SEEA-2003.

7.21. Each column 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.

7.22. Since water quality is not only affected by activities in the last accounting period, but also by activities in previous (at times several) accounting periods, multi years average figures could be used for the opening and closing stock.

7.23. Table 7.3 can be compiled also for costal waters given the direct pressure of the economy through discharges of wastewater into the sea, their socio-economic importance and their links with the quality of inland water resources (affected directly by land-based pollutions).

7.24. Each entry in Table 7.3 represents the amount of water of a certain quality measured in volumes. However, for rivers this is not a convenient unit due to the flowing nature of the water. A specific unit of account has been introduced for river quality the "standardized river-kilometre" (Heldal and Østdahl, 1984) later changed into *standard river unit* (SRU). To complete the spatial aggregation at the level of a river basin, rivers are divided into a number of stretches of homogeneous quality (for instance, between consecutive monitoring sites) and water flow. The value, in SRU, of a stretch of river of length L and of flow q is the product L x q. Quality accounts for rivers can be compiled by assessing the quality class for each stretch, computing the SRU value for each stretch, and summing the corresponding SRU per quality class to populate the quality accounts in Table 7.3. The different quality classes can be aggregated without double counting (para. 8.128, SEEA-2003).

7.25. The total quantity of SRU should appear in the "total" column of Table 7.3 (even though it cannot be related to the "total" column in the asset accounts for rivers, which is expressed in volume, not in SRU). This quantity strongly depends on the minimum size of rivers to be considered in a river

basin. Because of a lack of adequate data, the marginal contribution of the smallest rivers is generally unknown.

7.26. In the case of France, the river system is comprised of about 10.8 million SRU for its approximately 85,000 km of main courses and is disaggregated into 55 catchments. Estimates from the Institut Français de l'environnement (1999) suggest that considering all rivers mapped at the 1:50,000 scale would increase by 2,5 the total SRU mapped at the 1:1,400,000 scale. Therefore, it was concluded that the total quantity of SRU should not aim at covering the entire river system, but only the part of it which is actually monitored and subject to a quality assessment. The ratio between the quantity of SRU for monitored rivers and (an estimate of) the quantity of SRU for the entire system gives an estimate of the monitoring coverage of the river system.

7.27. Table 7.4 shows the quality accounts for rivers as compiled in France for the years 1992 and 1994. Five quality classes are used, 1A (best), 1B, 2, 3 and NC (not classified, worst). 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 SRU in good quality classes (1A and 1B) 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 1992 and 1994. This is because of difficulties in comparing certain groups of watercourses in some watershed basins between the two years. The 'organic matter indicator' considers the following parameters: dissolved oxygen, BOD5 (biochemical oxygen demand at 5 days), COD (chemical oxygen demand) and ammonium (NH_4^+). It also looks at eutrophication and nitrates.

Source: Institut Français de l'Environnement, 1999.

7.28. In the case of groundwater quality, since flow is very low, quality accounts can directly be constructed in volumetric units (e.g. cubic metres). Table 7.5 provides an example of quality accounts for groundwater in Australia, using salinity levels for defining quality classes: "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).

7.29. 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 volume of brackish water also increased between the two years.

Table 7.5: 1985 and 1998 accounts of the groundwater quality

in Victorian provinces, Australia

Gigalitres

	Fresh	**Marginal**	**Brackish**	**Saline**	**Total**
1985	477.5	339.2	123.3	32.3	972.3
1998 (incomplete)	(39.1)	(566.6)	(141.1)	(NA)	(746.8)

Note: The 1998 assessments are based on Permissible Annual Volume (PAV) which is equivalent to sustainable yield. NA not applicable.

Source: Australian Bureau of Statistics, 2000.

7.30. Quality accounting is useful for following the evolution of the water quality and provides an indication of the efficiency of the measures taken 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, as 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 changes in water quality. This is illustrated in the conceptual scheme below: water quality at time t_1 is the result of an unknown non-linear function *f* of water quality at t_0 and possible causes (including the interactions):

$$\text{Water quality } t_1 = f(\text{Water quality } t_0, \Delta(\text{uncontrolled events}), \Delta(\text{abstractions}), \Delta(\text{emissions}), \Delta(\text{expenditure}))$$

where Δ(uncontrolled events) signifies the change that occurred between t_0 and t_1 that cannot be related to any event in the economic sphere; Δ*(abstractions)*, Δ(*emissions)*, and Δ*(expenditure)* represent causes related to the economic sphere. As a consequence, it is difficult to attribute changes in 'stocks of quality' to the direct causes. Quality accounts have, therefore, a much simpler structure than the asset accounts.

7.32. It should be noted, however, that cost-effectiveness analyses may be carried out with the help of these accounts. Let us suppose, for example, the following situation: the global quality at t_0 was 6.6, there were no major natural events during the accounting period, no less emissions and no more abstractions on this particular stretch. If measuring the quality at t_1 shows that it has increased to 7.0,

this change of 0.4 could be attributed to the environmental expenditures that were made (for instance, to restore the self-purification capacity of the ecosystem), and derive a cost-effectiveness estimate as the ratio 0.4/Δ*(expenditure)*. But this does not imply that the quality increase would have been 0.8, had the expenditures doubled in value.

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 and 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.

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. This is especially the case for pesticides, of which a few dozens can be accurately quantified among several hundreds of active substances in use. The same problem occurs when considering biological toxins (with special mention to cyanotoxins) and endocrine disruptors. Large numbers of chemicals, such as toxic hydrocarbons derivatives, are hardly soluble in water and pose considerable problems when attempting to make reliable samples.

7.35. 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 inability to compare 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.

Table 7.6: Number of determinands per chemical group in different assessment systems

Determinand group	Number of determinands: 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). .

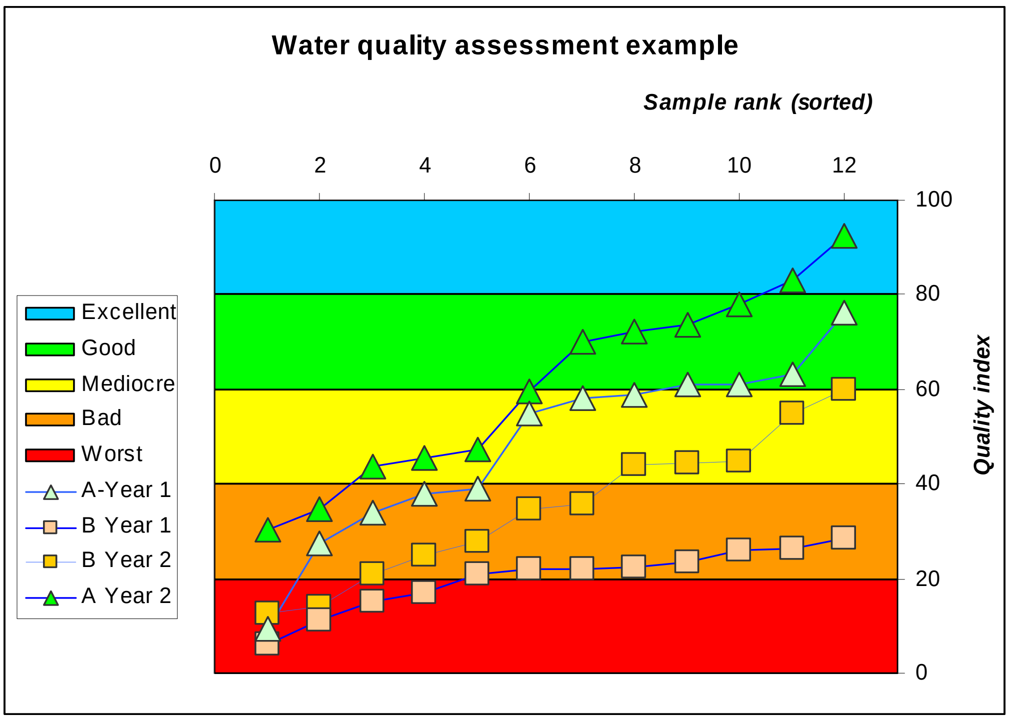
Source: Philippe Crouzet (based on Canadian Council of Ministers of the Environment, 2001, Oudin and Maupas, 1999, Department of Water Affairs and Forestry, 1996).

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' (or "one out, all out"), 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 or chemical, as recommended by the WFD) or a combination. This rule has different justifications. Applied to one determinand or indicator computed from multiple samples, this rule reflects the fact that a peak pollution has more detrimental effects than average pollution. Applied to several indicators or several uses, the rule means that all indicators or uses must be taken into account equally. It is the first instance of this rule which is problematic, as is shown in Figure 7.1 for 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 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 monitoring period (Oudin 2001).

7.40. An alternative for the ‘rule of the worst’ is exemplified by the Canadian federal system (Canadian Council of Ministers of the Environment (CCME), 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 equal to 100 minus the length of the 3 dimensional vector [S,F,E] normalised to 0-100. This means that CCME Water Quality Index is 100 (best quality) when the length of the vector [S,F,E] is zero. 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 spatial aggregation and each corresponds to a different need.

7.43. **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.

7.44. **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.

7.45. The River Quality Generalised Index (RQGI) is a weighted average of quality class G_j according to SRU, S_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 number of quality classes.

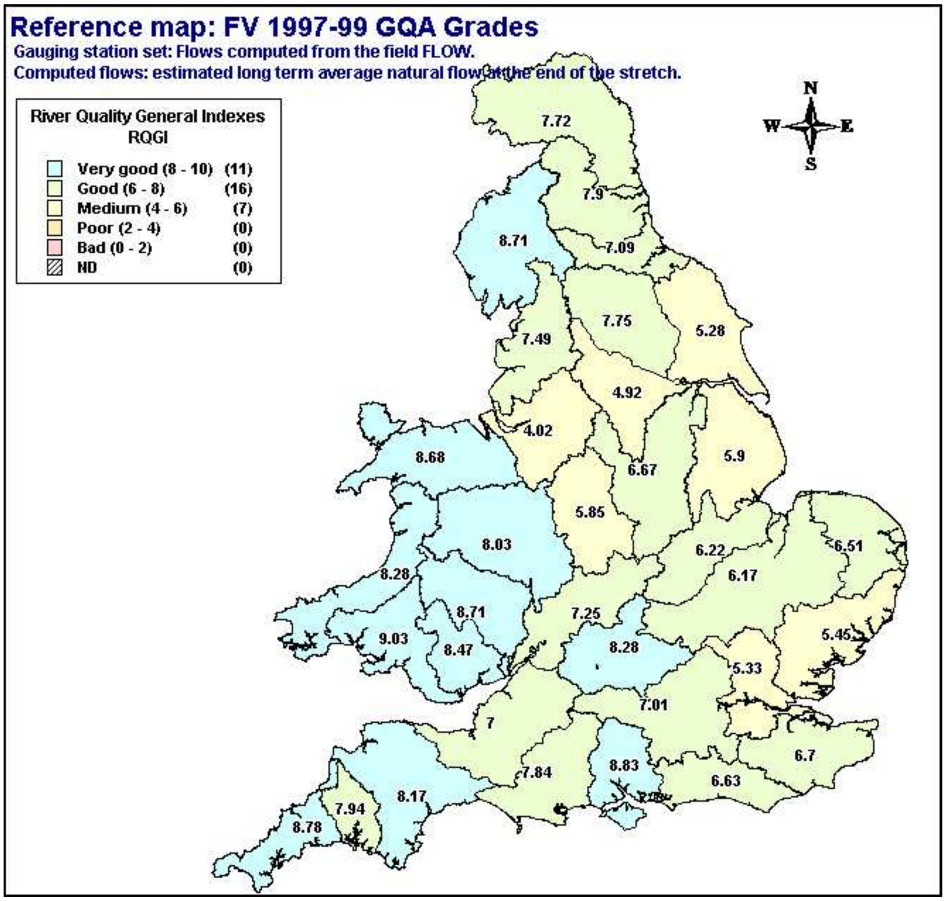


Figure 7.2: Global river quality in England and Wales in 1997-1999

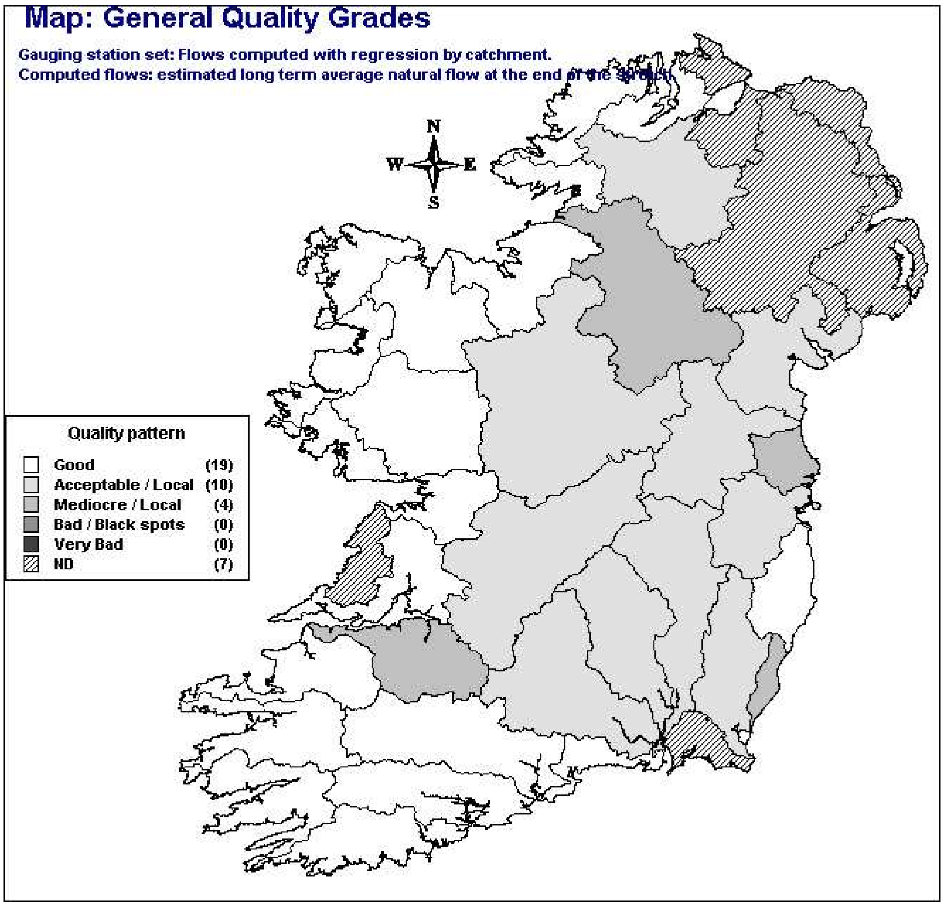
Source: Data collected by EPA England and Wales (European Environment Agency, 2001b). Original data published in (European Environment Agency, 1998)

7.46. As an application, Figure 7.2 shows RQGI score per river basin in England and Wales in 1997/1999 (European Environment Agency, 2001b). The overall index for all the reviewed catchments improved from 6.50 in 1990 up to 7.47 in 1997/1999.

7.47. 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: Pattern Index for Ireland, 1990



Source: Data provided by Irish EPA, processing reported in (European Environment Agency, 2001c).

Chapter 8 Valuation of water resources

A. Introduction

8.1. The national accounts value water like all other products: water is valued at price of its transactions. Unlike many other products, however, the prices charged often provide only a poor and 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 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, *Water collection, treatment and supply*, 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 because of 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:

(a) Water as an intermediate input to production in agriculture and manufacturing;

(b) Water as a final consumer good;

(c) 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 the 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. Section 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, *Support activities for crop production-operation of agricultural irrigation equipment*, and 36, *Water collection, treatment and supply*, 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, *Sewerage*, 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 and 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 (Office of Management and Budget, 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).

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.

> 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.’

Box 8.1: Shadow prices

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.

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.

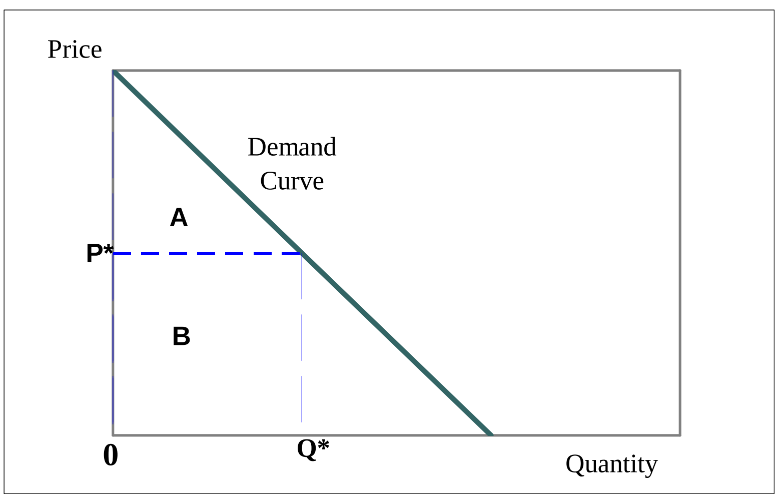


Figure 8.1: Demand curve for water

Note: The value of water for human survival is likely to be infinite and is not included in this graph.

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).

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.

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 hydroelectric power, 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.

Box 8.2: Categories of economic values for water

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. (1997) 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., 1997; Gibbons, 1986; Young, 1996). The reader should keep in mind that some important attributes affecting the value of water 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 the 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. They are 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 as 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.

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 use 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	

Box 8.3: Calculating residual value: an example from Namibia

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 a 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. 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 measures the marginal value of water rather the average value obtained with the residual value approach.

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).

Box 8.4: Adjusting the residual value of water for market distortions

8.43. Young (1996) notes that the change in the 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.

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

Box 8.5: Marginal value of water by industry in Canada, 1991

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 the 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.

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

Box 8.6: Linear programming approach to valuing irrigation water

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 uses. 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).

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.

Box 8.7: Hedonic valuation of irrigation water quantity and quality

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 cubic metres) (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 the 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 charged, 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).

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

Box 8.8 : Two approaches to measure the value of domestic water in Central America

Source: Adapted from Walker et al. (2000).

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.

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) and 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 (Korea Environment Institute, 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.

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).

Box 8.9: Marginal cost of water degradation

Source: Adapted from Hajkowicz and Young (2002).

Chapter 9 Examples of applications of water accounts

A. Introduction

9.1. Global freshwater resources are under pressure from an 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 illnesses 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 Peevor, 2004). Some 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 (European Parliament and Council, 2000) 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 (Millennium Project Task Force on Water and Sanitation, 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. Annex III 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), OECD (Environmental Indicators) and the second World Water Development Report (UN and WWAP, 2006).

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 on 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. Countries generally start with physical supply and use tables, emission accounts and asset accounts and add monetary accounts at a later stage of implementation depending on the policy concerns and data

availability. Most examples of policy applications utilize accounts for the supply and use of water emission accounts 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 as 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 in chapter 2. 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.

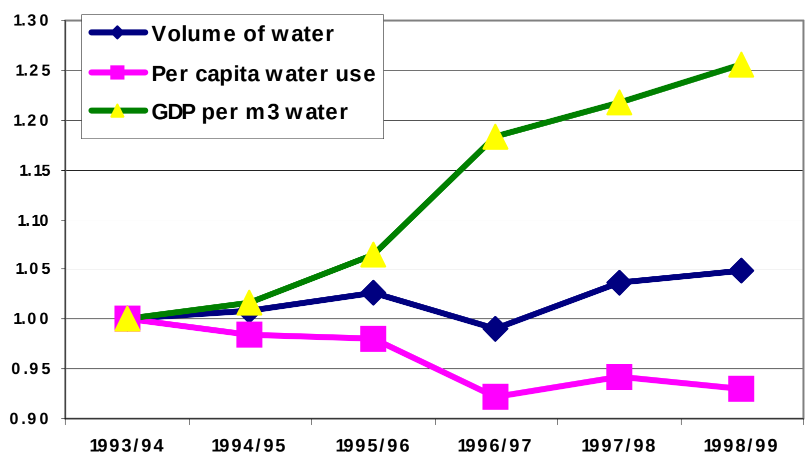
1. Sources of pressure on water resources

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, from 1993 to 1998, in Botswana, per capita water use declined and water productivity (measured by GDP per cubic meter of water used) increased, so that the volume of total water use increased only 5 percent (Figure 9.1) even though GDP grew more than 25 percent. For a water scarce country, this is a positive trend.

9.15. 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)

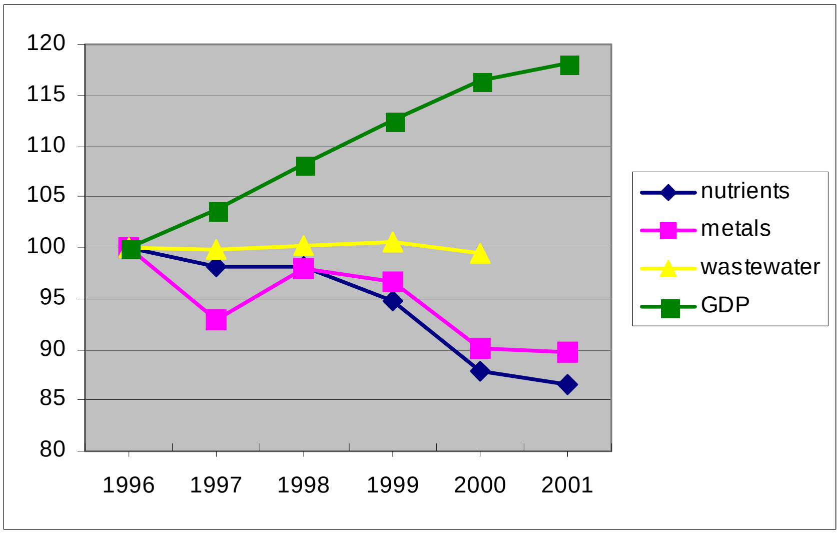


Note: These indicators can be derived from the physical supply and use table described in Chapter 3.

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).

9.16. 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%

Note: *less than 1%, ** Tap water refers to water distributed by the water supply industry, ISIC 36, *Water collection, treatment and supply*. 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, *Water*	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: Australian Bureau of Statistics (2004).

Comparing environmental and socio-economic performance of industries

9.17. 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.

9.18. In Australia, for example, Agriculture accounts for 67% of total water use, but less than 2% of gross value added (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 (from hybrid supply and use tables in Chapter 5).

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/ Megalitres 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%**	

Note: Na: not applicable. This table can be derived from the hybrid supply and use table described in Chapter 5.

Source: Based on Australian Bureau of Statistics (2004).

9.19. 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 cubic metres 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 Department of Water Affairs (2005) and Lange forthcoming (2006).

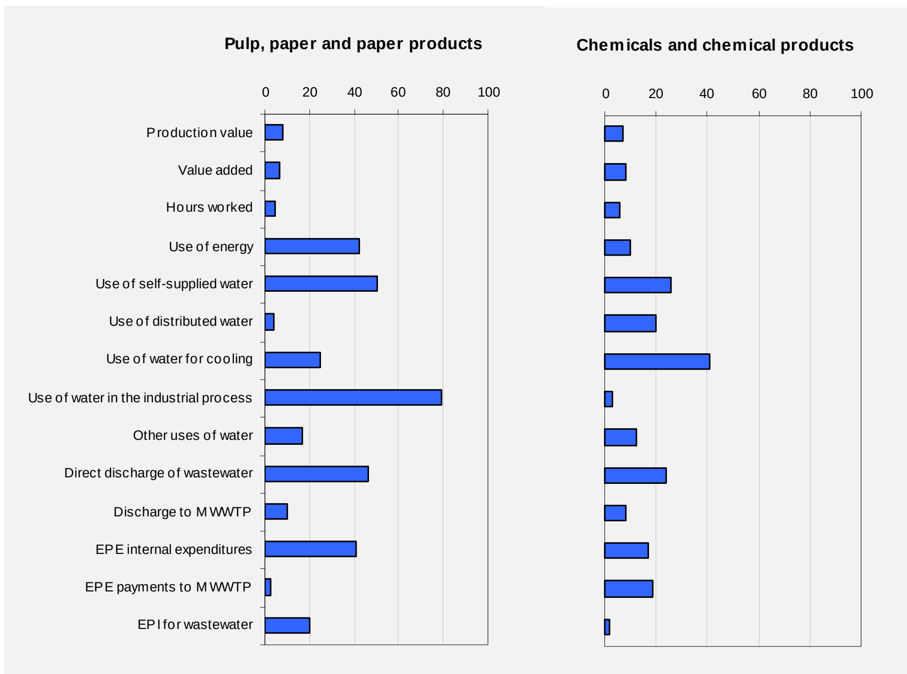


Figure 9.3: Environmental-economic profiles for some Swedish industries, 1995

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.

9.20. 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.

9.21. 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.

9.22. 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 litres per dollar of output, 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, and others were much higher. 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.

Table 9.5: Water intensity and total domestic water requirements by industry in Namibia, 2001-2002

	Percent of water use	Water intensity (direct):	Total domestic water requirements:

		litres/N$ output	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: *less than 0.1%. Na: not applicable. 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.

Source: Based on Department of Water Affairs (2005) and Lange forthcoming (2006).

9.23. 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 designing development policies.

9.24. 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 1,800 gigalitre 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 gigalitre (Lenzen and Foran, 2001).

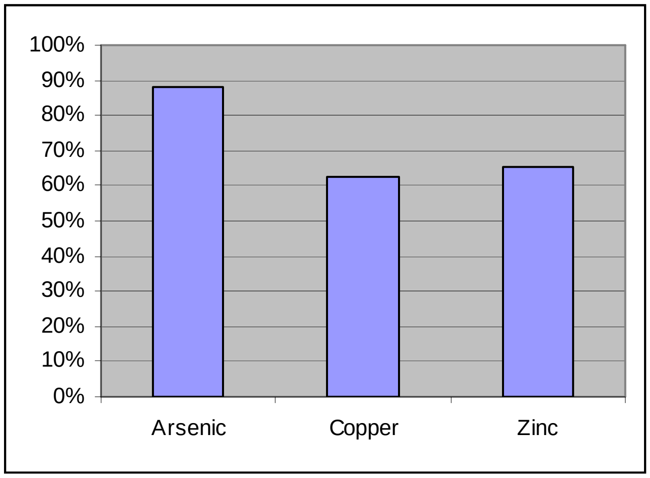
9.25. This principle of measuring the ‘upstream’ water requirements can be applied to each product or category of final demand using hybrid input-output tables, which are input-output tables augmented by water accounts (described in Chapter 5). The hybrid input-output tables can be used to calculate the total water requirement (direct and indirect) per unit of industry output and compare it to the direct water requirement per unit of industry output (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

9.26. 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

9.27. 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 the 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

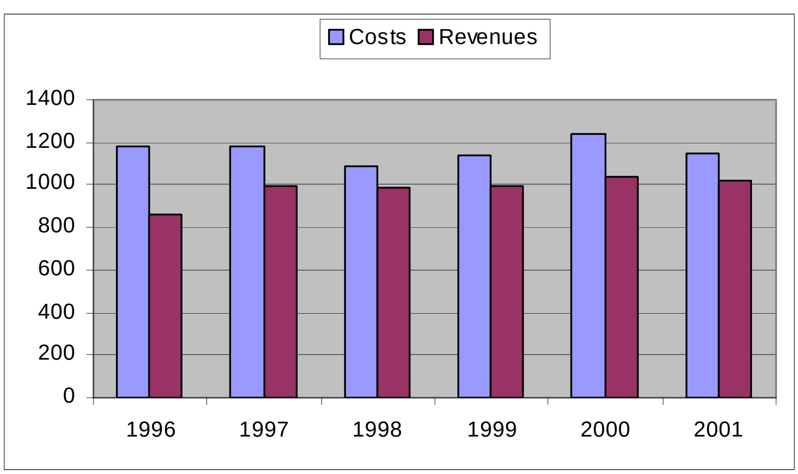
9.28. Water pricing is important for financial sustainability - a system must be able to recover its costs - and also for environmental sustainability because of the incentive pricing provides for efficient resource utilization. Except for the minimum amount of water necessary for human survival, people 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.

9.29. 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 own 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.

9.30. 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 hybrid supply and use tables presented in Chapter 5.

Source: van der Veeren et al. (2004).

9.31. Once supply costs and price have been calculated, the implicit subsidy by sector can be calculated. 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

9.32. In assessing sustainability of water use, the volume of water use must be compared to the availability of water in the environment, based on an assessment of stocks or estimated by renewable water resources. 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. Similarly annual accounts may hide seasonal variability. Water management requires similar figures at a more spatially and temporally disaggregated level.

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**

Note: *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

9.33. 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 would be the social and economic impact of pricing reform for water and wastewater?

- What is the impact of trade on water use and pollution?
- What are the opportunities for water demand management and other water conservation measures? Can economic growth be ‘decoupled’ from growth in water use?
- 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?

9.34. 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.

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 table.

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).

Box 9.1: Water accounts and input-output analysis

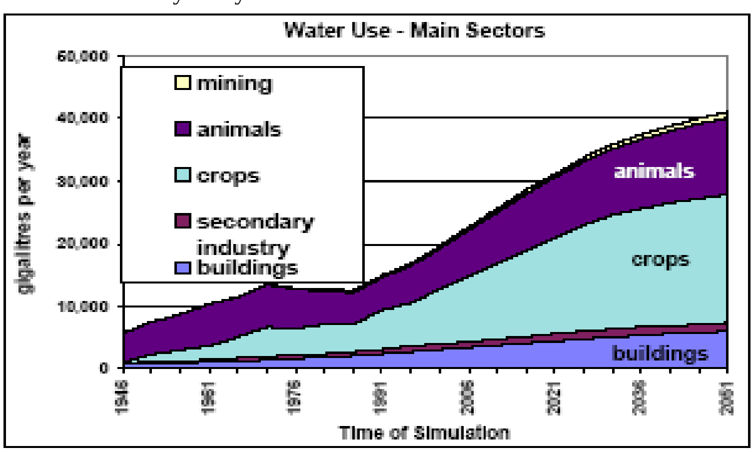
9.35. The number and range of potential policy applications of water accounts are vast and it is not possible to provide a comprehensive review in this chapter; rather, a selection of examples based on water accounts is provided. These examples address projecting future water demand, the socio-economic 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

9.36. 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).

9.37. In Australia, the water accounts have been used extensively for water planning at the regional and national levels (see Vardon and Peevor, 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 af 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.

CSIRO, a major Australian research centre, undertook a study of future water use (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 more of embodied water than it imports. This is about the same amount used each year by urban Australia.



Box 9.2: Projecting water use in Australia

Source: Foran and Poldy (2002).

2. Social and economic gains from water policy reform

9.38. 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.

(i) Social and economic benefits of water reallocation

9.39. 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.

9.40. 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 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., Centre for International Economics, 2004; Lenzen and Foran, 2001).

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

Box 9.3: Evaluating agricultural water use on a catchment basis in South Africa

Source: Adapted from Hassan (2003).

9.41. 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.

9.42. 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 (e.g. GDP). If pollution and pollution abatement costs or damage costs are included, the levels and costs of pollution are also calculated.

(ii) Consequences of water pricing reform

9.43. 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.

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 that result in more water efficient technology and reallocation of water among sectors. For irrigated agriculture, they found that water use efficiency 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 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	
	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

Box 9.4: Impact on GDP of water price increases in Australia

Source: Based on Centre for International Economics (2004).

9.44. 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.

9.45. 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.

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 the 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. The net benefit of wastewater treatment was estimated to be 3.48 Million of US dollars.

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

Box 9.5: Benefits of wastewater treatment in Wuxi, China

Source: Based on Zhang (2003).

3. Trade and the environment: water use and pollution

9.46. 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.

(i) Trade in virtual water

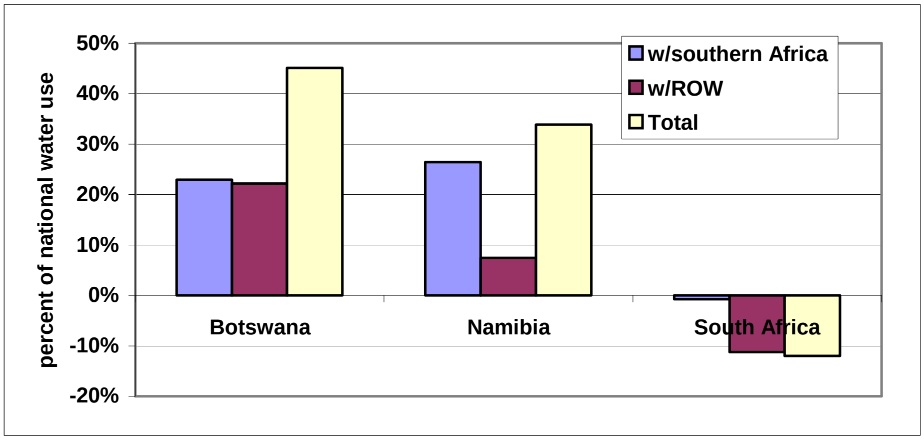
9.47. Global water availability and use are characterized by large regional imbalances, but water itself is not a widely traded commodity. Trade in products allows trade in 'virtual water,' that is, the water used for the production of goods and services. Trade in virtual water allows a country to overcome 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).

9.48. 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 plus 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.

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



Box 9.6: Trade and the environment: the water content of trade in Southern Africa

Source: Based on Lange and Hassan (2002).

(ii) Impact of trade policy on water allocation

9.49. 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.

9.50. 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

9.51. 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 to 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

9.52. 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 within many countries. Factors that drive water use, such as

population, economic activity and land use, also vary within a country and may not be distributed where water resources are most abundant.

9.53. One of the important principles of 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.

9.54. 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.

9.55. 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 of water flows and discharges of pollutants, i.e. spatial identification of establishments, waste water treatment plants, etc.

9.56. 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. Box 9.7 shows the profiles for two of Sweden's sea basins. The accounts can also be used for modeling at the regional level.

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 sub-models (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)

District/Sea Basin	Water use in 2000	Projected water use in 2015	
		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.

* NACE is the Statistical Classification of Economic Activities in the European Community.

Box 9.7: Forecasting water use at the district level in Sweden

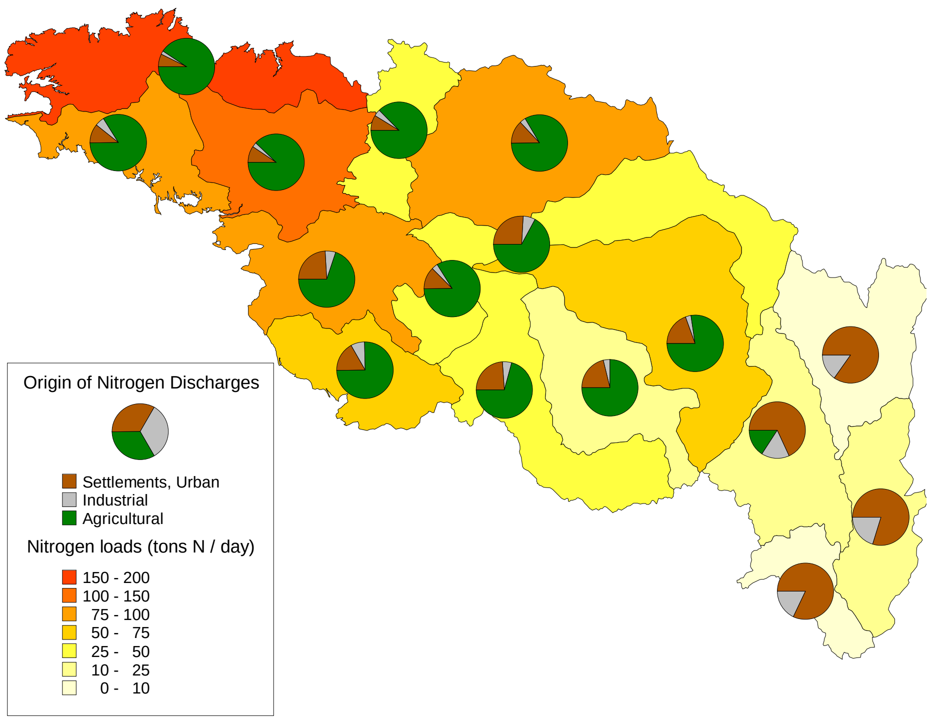
Source: Statistics Sweden (2004).

9.57. 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.

9.58. 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 French Institute for the Environment results – RBDE meeting, 14 March 2001.

2. Temporal dimension

9.59. 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 (Millennium Project Task Force on Water and Sanitation, 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.

9.60. 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.

9.61. 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.

9.62. 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)

9.63. 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 SEEAW framework has an advantage over other water databases because it is part of a more general environmental-economic accounting framework, SEEA-2003 (UN *et al*. 2003), designed for comprehensive representation of all important natural resources, not just water. The SEEA-2003 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.

9.64. 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 SEEAW for water accounting are likely to address these broader issues.

Dependence of water resources on other resources

9.65. 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 do consider salinity.

9.66. 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.

9.67. 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. 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

9.68. 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. SEEAW standard tables

This annex shows the set of standard tables that have been presented in more details throughout the SEEAW.

Standard physical supply and use tables for water (Chapter 3)

Table I.A Physical use table

Physical units

		Industries (by ISIC categories)							Households	Rest of the world	Total
		1-3	5-33, 41-43	35	36	37	38,39, 45-99	Total			
From the environment	**1. Total abstraction** (=1.a+1.b=1.i+1.ii)										
	1.a. Abstraction for own use										
	1.b. Abstraction for distribution										
	1.i. From water resources:										
	1.i.1 Surface water										
	1.i.2 Groundwater										
	1.i.3 Soil water										
	1.ii. From other sources										
	1.ii.1 Collection of precipitation										
	1.ii.2 Abstraction from the sea										
Within the	**2. Use of water received from other economic units**										
3. Total use of water (=1 + 2)											

Table I.B Physical supply table

Physical units

		Industries (by ISIC categories)							Households	Rest of the world	Total
		1-3	5-33, 41-43	35	36	37	38,39, 45-99	Total			
Within the economy	**4. Supply of water to other economic units**										
	of which:										
	4.a. Reused water										
	4.b. Wastewater to sewerage										
To the environment	**5. Total returns** (=5.a+5.b)										
	5.a. To water resources										
	5.a.1. Surface water										

	5.a.2. Groundwater				
	5.a.3. Soil water				
	5.b. To other sources (e.g. sea water)				
6. Total supply of water (=4+5)					
7. Consumption (=3-6)					

Note: Grey cells indicate zero entries by definition.

Emission accounts (Chapter 4)

Table II. A Gross and net emissions

physical units

Pollutant	Industries (by ISIC categories) 1-3	5-33, 41-43	35	36	37	38,39, 45-99	Total	Households	Rest of the world	Total
1. Gross emissions (=1.a+1.b)										
1.a. Direct emissions to water (=1.a.1+1.a.2=1.a.i+1.a.ii)										
1.a.1 Without treatment										
1.a.2 After on-site treatment										
1.a.i To water resources										
1.a.ii To the sea										
1.b. To Sewerage (ISIC 37)										
2. Reallocation of emission by ISIC 37										
3. Net emissions (=1.a+2)										

Table II.B Emissions by ISIC 37

physical units

Pollutant	ISIC 37
4. Emissions to water (=4.a+4.b)	
4.a After treatment	
To water resources	
To the sea	
4.b Without treatment	
To water resources	
To the sea	

Hybrid supply and use tables (Chapter 5)

Table III. A Hybrid supply table

Physical and monetary units

	Output of industries (by ISIC categories)								Imports	Taxes less Subsidies on products	Trade and transport margins	Total supply at purchaser's price
	1-3	5-33, 41-43	35 Total	35 *of which*: Hydro	36	37	38,39, 45-99	Total output, at basic prices				
1. Total output and supply (Monetary units)												
of which: 1.a Natural water (CPC 1800)												
1.b Sewerage services (CPC 941)												
2. Total supply of water (Physical units)												
2.a Supply of water to other economic units												
of which: 2.a.1- Wastewater to Sewerage												
2.b Total returns												
3. Total (gross) emissions (Physical units)												

Note: Grey cells indicate zero entries by definition.

Table III. B 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	Total			
	1-3	5-33, 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					
1. Total intermediate consumption and use (Monetary units)																
of which: 1.a Natural water (CPC 1800)																
1.b Sewerage services (CPC 941)																
3. Total use of water (Physical units)																
3.a (U1) Total Abstraction																
of which: 3.a.1- Abstraction for own use																
3.b - Use of water received from other economic units																
1. Total intermediate consumption and use (Monetary units)																

Note: Grey cells indicate zero entries by definition.

Table IV. Hybrid account for supply and use of water

Physical and monetary units

	Industries (by ISIC categories) 1-3	5-33, 41-43	35 Total	35 of which: Hydro	36	37	38,39, 45-99	Total industry	Rest of the world	Taxes less subsidies on products, trade and transport margins	Actual final consumption: Households	Actual final consumption: Government	Capital Formation	Total
1. Total output and supply (Monetary units)														
of which: 1.a. Natural water (CPC 1800)														
1.b. Sewerage services (CPC 941)														
2. Total intermediate consumption and use (Monetary units)														
of which: 2.a. Natural water (CPC 1800)														
2.b. Sewerage services (CPC 941)														
3. Total value added (gross) (= 1-2) (Monetary units)														
4. Gross fixed capital formation (Monetary units)														
of which: 4.a. For water supply														
4.b. For water sanitation														
5. Closing Stocks of fixed assets for water supply (Monetary units)														
6. Closing Stocks of fixed assets for sanitation (Monetary units)														
7. Total use of water (Physical units)														
7.a. Total Abstraction														
*of which:*7. a.1- Abstraction for own use														
7.b. Use of water received from other economic units														
8. Total supply of water (Physical units)														
8.a. Supply of water to other economic units														
of which: 8.a.1- Wastewater to Sewerage														
8.b. Total returns														
9. Total (gross) emissions (Physical units)														

Note: Grey cells indicate zero entries by definition.

Table V. Hybrid account for water supply and sewerage for own use

Physical and monetary units

		Industries (by ISIC categories) 1-3	5-33, 41-43	35 Total	35 of which: Hydro	36	37	38,39, 45-99	Total	Households	Total industry
Water supply for own use	**1. Costs of production** (=1.a+1.b) (Monetary units)										
	1. a. Total intermediate consumption										
	1.b. Total value added (gross)										
	1.b.1 Compensation of employees										
	1.b.2 Other taxes less subsidies on production										
	1.b.3 Consumption of fixed capital										
	2. Gross fixed capital formation (Monetary units)										
	3. Stocks of fixed assets (Monetary units)										
	4. Abstraction for own use (Physical units)										
own use	**1. Costs of production** (=1.a+1.b) (Monetary units)										
	1.a. Total intermediate consumption (Monetary units)										
	1.b. Total value added (gross)										
	1.b.1 Compensation of employees										

	1.b.2 Other taxes less subsidies on production			
	1.b.3 Consumption of fixed capital			
	2. Gross fixed capital formation (Monetary units)			
	3. Stocks of fixed assets (Monetary units)			
	4. Return of treated water (Physical units)			

Note: Grey cells indicate zero entries by definition.

Table VI. Government accounts for water-related collective consumption services

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. Costs of production (=1.a+1.b)				
1. a. Total intermediate consumption				
1.b. Total value added (gross)				
1.b.1 Compensation of employees				
1.b.2 Consumption of fixed capital				

Table VII.A National expenditure accounts for wastewater management

Monetary units

	USERS/BENEFICIARIES					
	Producers		Final consumers			
	Specialised producers (ISIC 37)	Other producers	Households	Government	Rest of the world	Total
1. Use of Wastewater services (CPC 941 and CPC 91123)						
1.a Final consumption						
1.b Intermediate consumption						
1.c Capital formation	nr	Na				Na
2. Gross Capital Formation						
3. Use of connected and adapted products						
4. Specific transfers						
5. Total domestic uses (=1.+2.+3.+4.)						
6. Financed by the rest of the world						
7. National expenditures (=5.-6.)						

Note: Grey cells indicate non relevant or zero entries by definition, nr not recorded to avoid double counting; Na not applicable in the case of wastewater management.

Table VII.B National expenditure accounts for water management and exploitation

Monetary units

	USERS/BENEFICIARIES			
	Producers	Final consumers	Rest of	Total

	Specialised producers (ISIC 36)	Other producers	Households	Government	the world	
1. Use of Wastewater services (CPC 941 and CPC 91123)						
1.a Final consumption						
1.b Intermediate consumption						
1.c Capital formation	nr	Na				Na
2. Gross Capital Formation						
3. Use of connected and adapted products						
4. Specific transfers						
5. Total domestic uses (=1.+2.+3.+4.)						
6. Financed by the rest of the world						
7. National expenditures (=5.-6.)						

Table VIII.A Financing accounts for wastewater management

Monetary units

	USERS/BENEFICIARIES					
	Producers		Final Consumers			
FINANCING SECTORS:	Specialised producers (ISIC 37)	Other producers	Households	Government	Rest of the world	Total
1. General government						
2. NPISHs						
3. Corporations						
3.a Specialised producers						
3.b Other producers						
4. Households						
5. National expenditure						
6. Rest of the world						
7. Domestic uses						

Note: Grey cells indicate non relevant or zero entries by definition.

Table VIII. B Financing accounts for water management and exploitation

Monetary units

FINANCING SECTORS:	USERS/BENEFICIARIES					
	Producers		Final Consumers			
	Specialised producers (ISIC 36)	Other producers	Households	Government	Rest of the world	Total
1. General government						
2. NPISHs						
3. Corporations						
3.a Specialised producers						
3.b Other producers						
4. Households						
5. National expenditure						
6. Rest of the world						
7. Domestic uses						

Asset accounts (Chapter 6)

Table IX. Asset accounts

Physical units

	EA.131 Surface water						
	EA.1311 Artificial Reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow, Ice and Glaciers	EA.132 Groundwater	EA.133 Soil water	Total
1. Opening Stocks							
Increases in stocks							
2. Returns							
3. Precipitation							
4. Inflows							
4.a. From upstream territories							
4.b. From other resources in the territory							
Decreases in stocks							
5. Abstraction							
6. Evaporation/Actual evapotranspiration							
7. Outflows							
7.a To downstream territories							
7.b To the sea							
7.c To other resources in the territory							
8. Other changes in volume							
9. Closing Stocks							

Note: Grey cells indicate non relevant or zero entries by definition.

Annex II. SEEAW supplementary tables

Supplementary information (in italics) to the physical supply and use tables (Chapter 3)

Physical use table

Physical units

		Industries (by ISIC categories)							Households	Rest of the world	Total
		1-3	5-33, 41-43	35	36	37	38,39, 45-99	Total			
From the environment	**1. Total abstraction** (=1.a+1.b=1.i+1.ii)										
	1.a. Abstraction for own use										
	Hydroelectric power generation										
	Irrigation water										
	Mine water										
	Urban runoff										
	Cooling water										
	Other										
	1.b. Abstraction for distribution										
	1.i. From water resources:										
	1.i.1 Surface water										
	1.i.2 Groundwater										
	1.i.3 Soil water										
	1.ii. From other sources										
	1.ii.1 Collection of precipitation										
	1.ii.2 Abstraction from the sea										
Within the economy	**2. Use of water received from other economic units**										
	of which:										
	2.a. *Reused water*										
3. Total use of water (=1 + 2)											

Physical supply table

Physical units

		Industries (by ISIC categories)							Households	Rest of the world	Total
		1-3	5-33, 41-43	35	36	37	38,39, 45-99	Total			
Within the economy	**4. Supply of water to other economic units**										
	of which:										
	4.a. Reused water										
	4.b. Wastewater to sewerage										
	4.c. *Desalinated water*										
To the environment	**5. Total returns** (=5.a+5.b)										
	Hydroelectric power generation										
	Irrigation water										
	Mine water										
	Urban runoff										
	Cooling water										
	Losses in distribution because of leakages										
	Treated wastewater										
	Other										
	5.a. To water resources(=5.a.1+5.a.2+5.a.3)										
	5.a.1. Surface water										
	5.a.2. Groundwater										

	5.a.3. Soil water 5.b. To other sources (e.g. sea water)				
6. Total supply of water (=4+5)					
7. Consumption (=3-6) *of which:* 7.a. Losses in distribution not because of leakages					

Note: Grey cells indicate zero entries by definition.

Matrix of flows of water within the economy

Physical units

User ⇨ / Supplier ⇩		Industries (by ISIC categories) 1-3	5-33, 41-43	35	36	37	38,39, 45-99	Total	Households	Rest of the world	Supply of water to other economic units
Industries (by ISIC categories)	1-3										
	5-33, 41-43										
	35										
	36										
	37										
	38,39, 45-99										
	Total										
Households											
Rest of the world											
Use of water received from other											

Supplementary information to the emission accounts (Chapter 4)

Table A. Gross and net emissions

physical units

Pollutant	Industries (by ISIC categories)							Households	Rest of the world	Total
	1-3	5-33, 41-43	35	36	37	38,39, 45-99	Total			
1. Gross emissions (=1.a+1.b)										
1.a. Direct emissions to water (=1.a.1+1.a.2=1.a.i+1.a.ii)										
1.a.1 Without treatment										
1.a.2 After on-site treatment										
1.a.i To water resources										
Surface water										
Groundwater										
1.a.ii To the sea										
1.b. To Sewerage (ISIC 37)										
2. Reallocation of emission by ISIC 37										
3. Net emissions (=1a+2)										

Table B. Emissions by ISIC 37

physical units

Pollutant	ISIC 37
4. Emissions to water (=4.a+4.b)	
4.a After treatment	
To water resources	
Surface water	
Groundwater	
To the sea	
4.b Without treatment	
To water resources	
Surface water	
Groundwater	
To the sea	

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)							
			35					
	1	2-33, 41-43	total	*of which*: hydro	36	37	38,39, 45-99	Total industry
Labour input								
Number of workers								
Total hours worked								

National expenditure accounts for the

Protection and remediation of soil, groundwater and surface water

Monetary units

	USERS/BENEFICIARIES					
	Producers		Final consumers			
	Specialised producers (ISIC 37)	Other producers	Households	Government	Rest of the world	Total
1. Use of EP services						
1.a Final consumption						
1.b Intermediate consumption						
1.c Capital formation						
2. Gross Capital Formation (for EP activities)						
3. Use of connected and adapted products						
4. Specific transfers (implicit subsidies,)						
5. Total domestic uses (=1.+2.+3.+4)						
6. Financed by the rest of the world						
7. National expenditures (=5.-6.)						

Note: Grey cells indicate non relevant or zero entries by definition,

Financing accounts for the

Protection and remediation of soil, groundwater and surface water

Monetary units

	USERS/BENEFICIARIES					
	Producers		Final Consumers			
FINANCING SECTORS:	Specialised	Other	Households	Government	Rest of the world	Total

	producers (ISIC 37)	producers				
1. General government						
2. NPISHs						
3. Corporations						
3.a Specialised producers						
3.b Other producers						
4. Households						
5. National expenditure						
6. Rest of the world						
7. Domestic uses						

Note: Grey cells indicate non relevant or 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	Outflows to other resources in the territory
	EA.1311 Artificial Reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow, Ice and Glaciers			
EA.1311 Artificial Reservoirs							
EA.1312 Lakes							
EA.1313 Rivers							
EA.1314 Snow, Ice and Glaciers							
EA.132 Groundwater							
EA.133 Soil water							
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 accounts provide a very powerful tool for improved water management as they provide basic information for the derivation of many water-related indicators and a structured database for economic and hydrologic information. Therefore the advantage of deriving indicators from such a framework is the ensured consistency of the indicators and the ability to study further the interlinkages and causes of changes as well as scenarios modeling

The section addresses more thoroughly the link between the water accounts and water indicators. Section 1 draws together the wide range of indicators that can be derived from the accounts to show how, together, they provide a comprehensive set of indicators for water and sanitation policy appropriate for Integrated Water Resource Management (IWRM). Section 2 links the indicators proposed in the World Water Development Report (United Nations and World Water Assessment Programme, 2006) to the water accounts, in particular, by looking at which indicators from the World Water Development Report can be derived from the SEEAW.

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 derived from the water accounts cover many critical aspects of water management under an IWRM approach, such as:

- 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.

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 also 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 and ecological water requirements. Treatment of water availability in the water accounts is addressed in chapters 6 and 7. Table III.1 provides a list of selected indicators on the status of water resources in the environment and indicators on the pressure exerted by human activities. 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. Note that these indicators do not provide information on the qualitative status of water resources.

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. .

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 FAO/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.

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.

Total Natural Renewable Resources 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 6.4, this indicator could be obtained from Table 6.4.

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.

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 in Table III.1 reflect pressure on water resources from population, total water use, and vulnerability to depletion.

Table III.1: Selected indicators of water resource availability and pressure on water derived from the water accounts

Indicator	**Definition and Source**
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)

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).

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 measures 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.

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 increased 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.

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.

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.

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).

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 III.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 III.2: Selected indicators of water intensity and water productivity

1. Water use and pollution intensity (physical units)		
	m^3 water use / 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 generated / unit of physical output	
2. Water and pollution intensity (monetary units)		
	m^3 water use / value added	Water use or tons of pollution emitted per unit of value added measured in currency units
	Tons of pollution/value added	
3. Water productivity ratios		
	GDP/ m^3 water used	
	Value-added by industry/m^3 water used	
4. Water 'pollutivity' ratios		
	Industry share of pollution/industry share of value added	

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 III.3.

Table III.3: Indicators of opportunities to increase effective water supply

1. Return flows	
Quantity of return flows by source	May distinguish 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 supplied by ISIC 36, *Water collection, treatment and supply*
3. Losses	
Losses in distribution as share of total water supply	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 III.4 presents examples of indicators that can be derived from the hybrid accounts in Chapter 5.

Table III.4: Indicators for costs and price of water and wastewater treatment services

1. Cost and price of water	
Implicit water price	Supply cost divided by volume of water purchased
Average water price per m^3 by industry	Actual payments by that industry divided by
Average water supply cost per m^3 by industry	Cost of supply to that industry divided by volume
Subsidy per m^3 by industry	Average water price minus average water supply

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 m^3 by industry	Volume of wastewater divided by treatment cost for that industry
Average wastewater treatment price per m^3 by industry	Volume of wastewater divided by actual payments for treatment by that industry
Subsidy per m^3 by industry	Average wastewater price minus average wastewater supply cost

2. *Links between indicators in the WWDR and the SEEAW*

Several indicators can be derived from the water accounts. Examples of how countries have disseminated these indicators and used the information derived from the accounts for designing policies were discussed primarily in Chapter 9. This section focuses on the list of indicators proposed in the second World Water Development Report (WWDR)[15] and links them, 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 62 indicators suggested have undergone an extensive review and evaluation by UN agencies, 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 III.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[16] (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 core water accounts, they can be presented side-by-side with the accounts in supplementary tables to allow for integrated analyses.

Table III.5 presents, in the first three columns, a brief description of the indicator, its relevance for water policy, and details on the calculation methods. This information is based on the *Indicator*

[15] 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.
[16] 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.

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[17] 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 these 12 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 hydroelectric power generation) are not part of the water accounts.

[17] 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 III.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 (km^3/yr) I = industrial water use (km^3/yr) A = agricultural water use (km^3/yr) Q = renewable freshwater resources (km^3/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 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 (km^3/yr) I = industrial water demand (km^3/yr) A = agricultural water demand (km^3/yr) Q = renewable freshwater resources (km^3/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 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 $m^3/yr/person$) 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	

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.

Challenge Area	**Indicator** Description based on the Indicator profile sheet of the second WWDR.	**Status**[1]	**Indicator**	**Link with the water accounts**
Global	**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: $\tau_R = 0.67 * \text{Max Capacity} / Q$ $\text{TE} = 1 - (0.05 * \Delta\tau_{R^{0.5}})$ 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 (km^3/yr) _I = upstream industrial water demand (km^3/yr) _A = upstream agricultural water demand (km^3/yr) Q = renewable freshwater resources (km^3/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.

Challenge Area	**Indicator** Description based on the Indicator profile sheet of the second WWDR.	Status[1]	Indicator	Link with the water accounts
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 km^3/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) $10^9 m^3/km^3$	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 is exploiting its groundwater water resources in terms of groundwater abstraction as a percent of the groundwater recharge. Groundwater abstraction is the quantity of groundwater resources used by major sectors (municipal, agricultural, industrial). Groundwater recharge is a component 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).

Challenge Area	**Indicator** Description based on the Indicator profile sheet of the second WWDR.	**Status**[1]	**Indicator**	**Link with the water accounts**
Resources	**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.

Challenge Area	**Indicator** Description based on the Indicator profile sheet of the second WWDR.	**Status**[1]	**Indicator**	**Link with the water accounts**
Agriculture	**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).

Challenge Area	**Indicator** Description based on the Indicator profile sheet of the second WWDR.	**Status[1]**	**Indicator**	**Link with the water accounts**
	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 Pi = productivity of water used in industry i Vi = Total annual value added by industry i (US $/year) Wi = Annual water withdrawal by industry i (m^3/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 Ce = Carbon intensity of electrical production 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).

Challenge Area	**Indicator** Description based on the Indicator profile sheet of the second WWDR.	**Status**[1]	**Indicator**	**Link with the water accounts**

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.

Challenge Area	**Indicator** Description based on the Indicator profile sheet of the second WWDR.	**Status**[1]	**Indicator**	**Link with the water accounts**

Valuing	**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: the amount of water that is removed from any source, either permanently or temporarily, in a given period of time for final consumption and production activities. Water used for hydroelectric power generation is also considered as abstraction. Total water abstraction can be broken down according to the type of source (i.e. Water Resources and Other sources) 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 (paras. 9.97, and 9.3, 1993 SNA).

Aquifer: A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs (USGS)

Artificial Reservoirs: man-made reservoirs used for storage, regulation and control of water resources. (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)

Cooling water: water which is used to absorb and remove heat.

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. (para. 7.36, SEEA-2003)

Economic unit: a unit that engages in production and/or consumption activities.

Emission to water: direct release of a pollutant to water as well as the indirect release by transfer to an off-site wastewater treatment plant. (based on the European Commission, 2000 (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. (para. 9.94, 1993 SNA)

Fresh water resources: naturally occurring water having a low concentration of salt. (EDG)

Glaciers: 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)

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. (para. 10.32, 1993 SNA)

Groundwater: water which collects in porous layers of underground formations known as aquifers (SEEA-2003)

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)

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 generation, water use for: 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. It includes inflows from other territories/countries and inflows from other resources within the territory. (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. (para 6.147, 1993 SNA)

Irrigation water: water artificially applied 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's surface. (EDG)

Mine water (syn. Mining water use): water used for the extraction of naturally occurring minerals including coal, ores, petroleum, and natural gas. It 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. It includes outflows to other territories/countries, to the sea and outflows to other resources within the territory. (EDG)

Perennial river: river which flows continuously all through the year. (Based on UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992).

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 Non-profit institutions serving households (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. (para 8.99, 1993 SNA)

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. (para. 8.128, SEEA-2003)

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. It includes: artificial reservoirs, lakes, rivers and streams, glaciers, snow and ice. (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. (para 6.110, 1993 SNA)

Transboundary waters: 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. (UNECE, 1992, available online at http://www.unece.org/env/water/pdf/watercon.pdf)

Transport margin: transport charges paid separately by the purchaser in taking delivery of the goods at the required time and place. (para. 15.40, 1993 SNA)

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.

Use of water received from other economic units: the amount of water that is delivered to an economic unit from another economic unit. (EDG)

Water body: mass of water distinct from other masses of water. (UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992)

Watercourse: natural or man-made channel through or along which water may flow. (UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992)

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 through leakages and evaporation between a point of abstraction and a point of use, and between points of use and reuse. Water lost due to leakages is recorded as a return flow as it percolates to an aquifer and is available for further abstraction, and water lost due to evaporation is recorded as water consumption. When computed as a difference between the supply and use of an economic unit, it may include also illegal tapping. (EDG).

Water returns: water that is returned into the environment by an economic unit 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: water leaving/flowing-out from an economic unit. Water supply is the sum of water supply to other economic units and water supply to the environment. (EDG)

Water supply to the environment: see Water returns.

Water supply within the economy: water which is supplied by an economic unit to another. Water supply within the economy is net of losses in distribution. (EDG)

Water use: water intake of economic unit. Water Use is the sum of water use within the economy and water use from the environment. (EDG)

Water use within the economy: water intake of economic unit, which is distributed by another economic unit. (EDG)

Water use from the environment: water abstracted from water resources, seas and oceans, and precipitation collected by an economic unit including rainfed agriculture. (EDG)

REFERENCES

Acquay, H. (2001). Integrated land and water management: the Global Environment Facility's perspective. In J. Gash, E. Odada, L. Oyebande, and R. Schulze (eds) *Freshwater Resources in Africa*. BAHC International Project Office: Potsdam, Germany.

Al-Weshah, R. (2000). Optimal use of irrigation water in the Jordan Valley: a case study. *Water Resources Management* 14:327-338.

Appels, D., Douglas, R. and Dwyer, G. (2004). Responsiveness of demand for Irrigation Water: A focus on the Southern Murray-Darling Basin. Productivity Commission Staff Working Paper. http://www.pc.gov.au/research/swp/watertrade/index.html.

Australian Bureau of Statistics (2000). Water Account for Australia 1993-94 to 1996-97. ABS Cat. No. 4610.0. ISBN 0 642 25662 4, Canberra.

_____ (2004). Water Account, Australia 2000-01. ABS Cat. no. 4610.0. ISBN 0 642 47942 9. Summary at: http://www.abs.gov.au/ausstats/ABS@.nsf/mf/4610.0.

Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality, Volume 1, The Guidelines (Chapters 1-7)* Paper No. 4 – Vol. 1, ISBN 09578245 0 5 (set), ISSN 1038 7072 http://www.deh.gov.au/water/quality/nwqms/volume1.html.

Bate, R. and W. Dubourg (1997). A net-back analysis of irrigation water demand in East Anglia. *Journal of Environmental Management* 49, 311-322.

Bouhia, H. (2001). *Water in the Macro Economy*. Ashgate Publishing Company: Aldershott, UK.

Brehm, M. and J. Quiroz (1995). The market for water rights in Chile. World Bank Technical Paper No. 285. World Bank: Washington, D.C.

Canadian Council of Ministers of the Environment (2001). "Canadian water quality guidelines for the protection of aquatic life: CCME Water Quality Index 1.0, technical report". in *Canadian environmental quality guidelines*, *1999*. (Edited by Canadian Council of Ministers of the Environment), Winnipeg.

Centre for International Economics (2004). Implications of water reforms for the national economy. Report to the National Program for Sustainable Irrigation. CIE: Canberra, Australia.

Champagain, Y. and A. Hoekstra (2004). *Water Footprints of Nations*. UNESCO-IHE: Delft, the Netherlands.

Clean Water Act, http://www.epa.gov/r5water/cwa.htm, http://www.cleanwateract.org.

Commission of the European Communities, International Monetary Fund. Organisation for Economic Co-operation and Development, United Nations and World Bank (1993). *System of National Accounts 1993*. Sales No. E.94.XVII.4. Luxembourg, Washington DC, Paris, New York.

Department of Water Affairs and Forestry (1996). *South African Water Quality Guidelines*. *Volume 1-8.* Edition 2. Pretoria. http://www.dwaf.gov.za/iwqs/wq_guide.

Department of Water Affairs (2005). Water accounts for Namibia: technical report. Draft report by DWA: Windhoek, Namibia.

Diao, X. and T. Roe (2000). The win-win effect of joint water market and trade reform on interest groups in irrigated agriculture in Morocco. In Dinar, A. (ed.) *The Political Economy of Water Pricing Reforms*. Published for the World Bank by Oford University Press: New York.

Di Matteo I., A. Alfieri and I. Havinga (2005). Links between Water Accounting and UNSD/UNEP and OECD/Eurostat Questionnaires on Water Resources - Towards the Harmonization of Water Statistics and Accounting. Paper presented at the International Work Session on Water Statistics. Vienna, Austria, 20-22 June 2005.

Easter, K.W., N. Becker and Y. Tsur (1997). Economic mechanisms for managing water resources: pricing, permits and markets. In A. Biswas (ed.) *Water Resources: Environmental Planning, Management and Development*. McGraw-Hill: New York.

European Commission (2000). Guidance Document for EPER implementation. ISB 92-894-0279-2. Luxemburg: Office for Official Publications of the European Communities, 2000. Available online at http://eper.cec.eu.int/eper/documents/guidance%5Fhtml or http://www.eper.cec.eu.int/eper/documents/eper_en.pdf.

European Parliament and Council (1986). Directive 86/278/EEC - *Official Journal L 181 , 04/07/1986 P. 0006 - 0012*. Available online at http://europa.eu.int/eur-lex/lex/LexUriServ/LexUriServ.do?uri=CELEX:31986L0278:EN:HTML.

European Parliament and Council (2000). Directive 2000/60/EC - *Official Journal of the European Communities* 22 12 2000. Available online at http://europa.eu.int/comm/environment/water/water-framework/index_en.html.

European Environment Agency (1998). *The State of the Environment of England and Wales: Fresh Waters*. London. The Stationery Office.

_____ (2000) Calculation of nutrient surpluses from agricultural sources available on the web at: http://reports.eea.eu.int/Technical_report_No_51/en/tech51.pdf

_____ (2001a). “Reporting river quality using the Water Quality Accounts methodology. Application within the Eurowaternet process”. (*Draft, written by Philippe Crouzet*) Copenhagen.

_____ (2001b). “Test application of quality water accounts in England and Wales”. (*written by BETURE-CEREC, ordered by* 'EEA-IEPA England and Wales') Copenhagen.

_____ (2001c). “Test application of quality water accounts in the republic of Ireland”. (*written by BETURE-CEREC, ordered by* 'EEA-Irish EPA') Copenhagen.

European Topic Centre- Inland waters, (2000). “Comparative Analysis of River Quality Classification Schemes in Europe”, *written by Steve Nixon, Anne Gendebien et al., n° PO25/97/3, ordered by* 'European Environment Agency', Medmenham.

Eurostat (1994). *The European System for the Collection of Information on the Environment. SERIEE 1994 Version*, Luxembourg: Office for Official Publications of the European Communities.

_____ (2001). Collection Statistics in focus, theme Environment and Energy – n° 6/2001 – ‘Water resources, abstraction and use in European countries’

_____ (2002). *Accounts for Recreational and Environmental Functions of Forests*. Luxembourg: Office of the European Communities

_____ (2002a). *SERIEE Environmental Protection Expenditure Accounts – Compilation Guide*, Luxembourg: Office for Official Publications of the European Communities. Cat. No. KS-BE-02-001-EN-N

_____ (2002b). *SERIEE Environmental Protection Expenditure Accounts – Results of Pilot Compilations*, Luxembourg: Office for Official Publications of the European Communities.

_____ (2002c). *Water Accounts — Results of pilot studies*. Luxembourg: Office for Official Publications of the European Communities, 2002. ISBN 92-894-4526-2.

Food and Agricultural Organization of the United Nations (2001). Statistics on Water Resources By Country In Fao’s Aquastat Programme. Working Paper No. 25. Joint ECE/Eurostat Work

Session on Methodological Issues of Environment Statistics (Ottawa, Canada, 1-4 October 2001).

_____ AQUASTAT Online Glossary (http://www.fao.org/ag/agl/aglw/aquastat/glossary/index.jsp).

Foran, B. and F. Poldy (2002). The future of water. CSIRO Sustainable Ecosystems Working Paper Series 02/01, Canberra, Australia.

Førsund, Finn (1985). Input-output models, national economic models, and the environment, in Kneese, A.V. and Sweeney, J.L. (eds.) *Handbook for Natural Resource and Energy Economics*, Vol. 1, 325-341, Elsevier Publishing Co.: New York.

Frederick, K, T. VandenBerg and J. Hanson (1997). Economic values of freshwater in the United States. Resources for the Future Discussion Paper 97-03. RFF: Washington, D.C.

French Institute for the Environment (1999) “The accounts of the quality of the watercourses”.

_____ (2000). Environmental accounts in France. NAMEA pilot study for France Phase III – Extract on Wastewater accounts. Final Report to Eurostat Subvention 98/778/3040/B4/MM.

Garrido, A. (2003). The economics of water allocation and the feasibility of water markets in agriculture. In OECD, *Sustainable Management of Water in Agriculture*. OECD: Paris.

Gascó G., A. Saa, F Guerrero and A Gascó (2005). Influence of salt concentration and topographical position on water resource quality: The Spanish Case Study. Water SA. Vol. 31 No. 2. Available online at http://www.wrc.org.za

Gibbons, D. (1986). *The Economic Value of Water*. Resources for the Future: Washington, D.C.

Gleick, P. ed. (1993). *Water in Crisis: A Guide to the World’s Freshwater Resources*. Oxford University Press: New York.

Global Water Partnership (2000). Integrated water resources management. TEC Background Paper 4. GWP: Stockholm.

Global Water Partnership (2004). Catalyzing Change**:** A handbook for developing integrated water resources management (IWRM) and water efficiency strategies. GWP: Stockholm. http://www.gwpforum.org/gwp/library/Catalyzing_change-final.pdf.

Hajkowicz, S.A. and M.D. Young (eds.) (2002). Value of returns and costs of resource degradation. Consulting Report to the National Land and Water Resources Audit. CSIRO Land and Water Division, Canberra, Australian Capital Territory.

Hanley, N. and C. Spash (1993). *Cost-Benefit Analysis and the Environment*. Edward Elgar: Cheltenham, UK.

Hassan, R. (2003). Economy-wide benefits from water-intensive industries in South Africa; quasi input-output analysis of the contribution of irrigation agriculture and cultivated plantations in the Crocodile River catchment. *Development Southern Africa* 20(2): 171-195.

Hearne, R. and W. Easter. (1995). Water allocation and water markets: an analysis of gains from trade. World Bank Technical Paper No. 315. World Bank: Washington, D.C.

Heldal, J. and Østdahl, T. (1984). "Synoptic monitoring of water quality and water resources. A suggestion on population and sampling approaches". *Statistical Journal Of the United Nations*. Vol ECE2. pp. 393-406.

Institut Français de l'Environnement (1999). *The Accounts of the quality of the watercourses - Implementation of a simplified method, on-going development*.

International Monetary Fund (2001). *Government Finance Statistics Manual 2001* (*GFSM 2001*). International Monetary Fund: Washington, D.C.

Johansson, R. (2000). Pricing irrigation water: a literature survey. World Bank: Washington, D.C.

Koundouri, P., and Pashardes, P. (2002). Hedonic Price Analysis and Selectivity Bias, in "*Economics of Water Resources, Theory and Policy*" (eds. P. Pasharades, T. Swanson and A. Xepapadeas), Kluwer: The Netherlands, pp. 69-80. ISBN 1-4020-0542-3

Korea Environment Institute (KEI) (1998). *Pilot Compilation of Environmental-Economic Accounts*. KEI and UNDP: Seoul, Korea.

Kristensen, P. and Bogestrand, J. (1996), *Surface water quality monitoring. Topic Report. Inland Waters* n^0 2/1996, Copenhagen EEA.

Lange, G. (1997). An approach to sustainable water Management using Natural Resource Accounts: the use of water, the economic value of water, and implications for policy. Directorate of Environmental Affairs. Research Discussion Paper No. 18.

_____ (2002). Estimating the value of water in agriculture: case studies from Namibia. Paper presented at the Biennial Conference of the International Society for Ecological Economics. 6-9 March. Souse, Tunisia.

_____ (2003). Water resource accounting in Namibia. In J. Arntzen, R. Hassan and G. Lange, *Groundwater and Water Accounting in Southern Africa Within the Perspective of Global Climate Change*. Report to START. Centre for Applied Research: Gaborone, Botswana.

_____ (2004). Water valuation case studies in Namibia, in G. Lange and R. Hassan, *The Economics of Water Management in Southern Africa: An Environmental Accounting Approach*. Edward Elgar Publishing: Cheltenham, UK

_____ (2005). Economic analysis of the Namibian water accounts. Draft Chapter 5 in Department of Water Affairs, *Namibian Water Accounts: Technical Report*. DWA: Windhoek, Namibia.

_____ (forthcoming 2006). Water accounts in Namibia. In (Lange, G. and R. Hassan) *The Economics of Water Management in Southern Africa: An Environmental Accounting Approach.* Edward Elgar: Cheltenham, UK.

Lange, G. and R. Hassan (1999). *Natural Resource Accounting as a Tool for Sustainable Macroeconomic Policy: Applications in Southern Africa*. Policy Brief of IUCN Regional Office for Southern Africa. IUCN-ROSA: Harare, Zimbabwe.

_____ (2002). Trade and the environment in Southern Africa: the impact of the user-pays principle for water on exports of Botswana, Namibia, and South Africa. Paper presented at the Conference of the International Input-Output Association. 10-15 October. Montreal, Canada.

Lange, G., R. Hassan, and M. Jiwanji (2003). Water accounts: an economic perspective on managing water scarcity. In Lange, G., R. Hassan, and K. Hamilton *Environmental Accounting in Action: Case Studies from Southern Africa*. Edward Elgar: Cheltenham, UK.

Lange, G., J. MacGregor, S. Masirembu (2000). The Economic Value of Groundwater: Case Study of Stampriet, Namibia. Paper presented at the Workshop of the Resource Accounting Network of East and Southern Africa. Pretoria, South Africa, 4-8 June 2000.

Lenzen, M. and B. Foran (2001). An input-output analysis of Australian water usage, *Water Policy* 3:321-340.

Margat J. (1986). Le compte des eaux continentales. Chapter 5 de l'ouvrage collectif "Les comptes du patrimoine naturel". pp. 281-414. Ed INSEE, les collections de l'INSEE No. 535-536, Sér. D No. 137-138, 552 p., Paris

Margat J. (1996). Les ressources en eau. Manuels & Méthodes No. 28. Ed. FAO/BRGM. Rome, Orléans.

Millennium Ecosystem Assessment (2005). *Ecosystems and Human Well-Being: Wetlands and Water Synthesis*. World Resources Institute, Washington, DC.

Millennium Project Task Force on Water and Sanitation (2003). Background paper on water and sanitation. Report to United Nations Secretary General and UN Development Group.

Miller, R. and P. Blair (1985). *Input-Output Analysis: Foundations and Extensions*. Prentice-Hall, Inc: Englewood Cliffs, New Jersey.

National Oceanic and Atmospheric Administration (1993). Report of the NOAA Panel on contingent valuation. *Federal Register 58 (10)*, 4601-14.

National Statistical Coordination Board (1998). Environmental and Natural Resources Accounting, vol. 1 Philippine Asset Accounts, and, vol. 2, Environmental Degradation due to Economic Activities and Environmental Protection Services. NSCB: Manila, Philippines.

Office of Management and Budget (2003). Draft 2003 report to United States' Congress on the costs and benefits of federal regulations. Federal Register, vol. 68, No. 22, February 3, pp. 5492-5527.

Oudin, L. C. and Maupas, D. (1999). *Système d'évaluation de la qualité des eaux des cours d'eau, SEQ-eau. Version 1, Les études des agences de l'eau n° 64.* Paris. Office International de l'eau.

Oudin, L. C. (2001). *River Quality Assessment System in France*, http://www.mtm-conference.nl/mtm3/docs/Oudin2001.pdf

Pearson, P. (1989). Proactive energy-environment policy strategies: a role for input-output analysis? *Environment and Planning A*, 21, 1329-1348.

Preux D. and B.Fribourg-Blanc (2005). Overview of emissions to water existing data collections. Paper prepared for the International Work Session on Water Statistics, Vienna 20-22 June 2005. Available on the web at http://unstats.un.org/unsd/environment/envpdf/pap_wasess4b1france.pdf

Renzetti, S. and D. Dupont. (2003). The value of water in manufacturing. University of East Anglia CSERGE Working Paper ECM 03-03.

Schiffler, M. (1998). *The Economics of Groundwater Management in Arid Countries*. Frank Cass Publishers: London and Portland, Oregon.

Shiklomanov I.A. (1999). *World Water Resources: Modern Assessment and Outlook for the 21st Century*, (Summary of World Water Resources at the Beginning of the 21st Century, prepared in the framework of the IHP UNESCO). Federal Service of Russia for Hydrometeorology & Environment Monitoring, State Hydrological Institute, St. Petersburg http://www.unep.org/vitalwater/05.htm

Statistics Denmark. (1999). NAMEA with water extraction and use. Environmental Accounting Project Report to European Community Project, DG XVI ERDF file n° 97/01/57/009. Statistics Denmark: Copenhagen, Denmark.

_____ (2004). The Danish Environmental Accounts 2002. Statistics Denmark: Copenhagen.

Statistics Sweden (1999). Water Accounts: physical and monetary data connected to abstraction, use and discharge of water in the Swedish NAMEA. Statistics Sweden: Stockholm.

_____ (2003). Water accounts 2000 with disaggregation to sea basins. Statistics Sweden: Stockholm.

_____ (2004). Prognos över vattenuttag och vattenanvändning med redovisning på vattendistrikt (Forecast of water abstraction and water use until 2015 by Water district). Statistics Sweden: Stockholm.

Train, R. E. (1979). *Quality Criteria for water*. London. Castle House Publications Ltd.

Turner, K., S. Georgiou, R. Clark, and R. Brouwer (2004). Economic valuation of water resources in agriculture.FAO Water Reports 27.

United Nations Education, Scientific and Cultural Organization and World Meteorological Organization (1989) Comparative Hydrology: an Ecological Approach to land and water resources.

_____ (1992). *International Glossary of Hydrology*, 2nd Edition.

United Nations (1992). *Agenda 21: Programme of Action for Sustainable Development*, United Nations Conference on Environment and Development, Rio de Janeiro, Brazil, 3-14 June 1992. Sales No.E.93.I.11

_____ (1993). Handbook of National Accounting on Integrated Environmental and Economic Accounting, Series F, No. 61, New York

_____ (2000). *Integrated Environmental and Economic Accounting - An Operational Manual*, Handbook of National Accounting, Studies in Methods Series F, No. 78, New York.

_____ (2000b) Classifications of expenditure according to purpose: Classification of the Functions of Government (COFOG); Classification of Individual Consumption According to Purpose (COICOP); Classification of the Purposes of Non-Profit Institutions Serving Households (COPNI); Classification of the Outlays of Producers According to Purpose (COPP)ST/ESA/STAT/SER.M/84.

_____ (2001). Indicators of Sustainable Development: Guidelines and Methodologies

_____ (2004). International Standard Industrial Classification of All Economic Activities. Revision 3.1. Statistical Papers. Series M No. 4 Rev. 3.1. New York.

_____ (2006a). Central Product Classification (CPC) Version 2.0. (Draft March 2006). New York. United Nations and United Nations Environmental Programme

_____ (2006b). International Standard Industrial Classification of All Economic Activities. Revision 4. (Draft March 2006). New York.

_____ (2006c) Report of the Secretary-General on environmental accounting. Statistical Commission on its thirty-seventh session (7-10 March 2006) E/CN.3/2006/9

_____ (2006d) Statistical Commission Report on the thirty-seventh session (7-10 March 2006). E/2006/24 and E/CN.3/2006/32

United Nations, Commission of the European Communities, International Monetary Fund, Organisation for Economic Co-operation and Development, and World Bank (2003). *Handbook of National Accounting on Integrated Environmental and Economic Accounting 2003*. Sales No. New York.

United Nations and the World Water Assessment Programme (2003). *UN World Water Development Report: Water of people, Water for Life*. Paris, New York and Oxford, UNESCO and Berghahn Books.

_____ (2006). *UN World Water Development Report 2: Water a shared responsibility*. Paris, New York and Oxford, UNESCO and Berghahn Books.

United Nations Economic Commission for Europe (1992). *Convention on the Protection and Use of Transboundary Watercourses and International Lakes*. (available online at http://www.unece.org/env/water/pdf/watercon.pdf).

Van der Veeren R., R. Brouwer, S. Schenau, R. van der Stegen (2004). *NAMWA: A new integrated river basin information system*. RIZA rapport 2004.032. ISBN 9036956900. Available on the internet at http://www.rws.nl/rws/riza/home/publicaties/riza_rapporten/rr_2004_032.html Central Bureau of Statistics: Voorburg, Netherlands.

Vardon, M. and S. Peevor. (2004). Water accounting in Australia: use and policy relevance. Paper presented to the London Group on Environmental Accounting, Copenhagen, Denmark.

Walker, I., F. Ordoñez, P. Serrano, and J. Halpern (2000). Pricing, subsidies and the poor: demand for improved water services in Central America. World Bank: Washington, D.C.

Wang, H. and S. Lall. (1999). Valuing water for Chinese industries: a marginal productivity approach. Paper for the World Bank Development Research Group. World Bank: Washington, D.C.

World Health Organization (2004) Joint Monitoring Project. Meeting the MDG water and sanitation target: a midterm assessment of progress.

World Health Organization and United Nations Children's Fund (2000). Water Supply and Sanitation Collaborative Council. Global Water Supply and Sanitation Assessment, 2000 Report, Geneva and New York. (pp. 77- 78).

World Meteorological Organization (WMO) (1992). *Dublin Statement and Report of the Conference. International Conference on Water and the Environment: Development Issues for the 21st Century*. Geneva, Switzerland, WMO.

Young, R. (1996). Measuring economic benefits for water investments and policy. World Bank Technical Paper No. 338. World Bank: Washington, D.C.

Zhang, F. (2003). Marginal opportunity cost pricing for waste water disposal: a case study of Wuxi, China. Research report of the Environmental Economics Program for Southeast Asia