Economic & Social Affairs

# SEEA-Water

## System of Environmental-Economic Accounting for Water


United Nations

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**Department of Economic and Social Affairs**
Statistics Division

# System of Environmental-Economic Accounting for Water

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# Preface

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

The preparation of the *Handbook of National Accounting: Integrated Environmental and Economic Accounting 2003*, commonly referred to as SEEA-2003, provided a challenging opportunity to develop methodologies for water accounts. Although country experiences in water accounts were limited at the time that SEEA-2003 had been prepared, commonalities in the various approaches to compiling water accounts emerged. Chapter 8 of SEEA-2003 constituted the first attempt to develop harmonized methodologies for water accounts.

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

The Eurostat Task Force on Water Satellite Accounting has been a major contributor in the development of harmonized concepts, definitions, classifications and sets of standard tables. The Subgroup on Water Accounting of the previously mentioned London Group, which had been established at the 8th meeting of the London Group, held in Rome in November 2003, contributed text and country examples, reviewed the various versions of the draft manuscript and assisted in its finalization. The Subgroup comprised approximately 20 experts from various countries, academia and international organizations.

Draft chapters were discussed at several meetings, including the 8th and 9th meetings of the London Group, held in Rome in 2003 and in Copenhagen in 2004, respectively. The final draft was discussed and reviewed during a meeting of the Subgroup in New York from 11 to 13 May 2005. During that meeting, the Subgroup agreed to include in the manuscript a set of standard tables for the compilation of water accounts which countries would be encouraged to compile. The final draft of SEEA-Water was presented at the preliminary meeting of the United Nations Committee of Experts on Environmental-Economic Accounting (UNCEEA), held in New York from 29 to 31 August 2005.

The revised draft was presented at the User-producer Conference: Water Accounting for Integrated Water Resources Management held in Voorburg, the Netherlands, from 22 to 24 May 2006, which had been organized by UNSD under the auspices of UNCEEA. The Conference, which gathered together major users and producers of water information, endorsed SEEA-Water, recognizing that it provides a much-needed conceptual framework for organizing hydrological and economic information in support of integrated water resources management. The Conference recommended the adoption of SEEA-Water as the international standard for water statistics.

In the light of the recommendations of the Conference, the discussion during the first meeting of UNCEEA on 22 and 23 June 2006 in New York and a subsequent e-consultation among UNCEEA members, the final text of SEEA-Water was revised to conform to the content and style of an international statistical standard; a fictitious dataset was also developed to populate the standard tables.

As a result of the e-consultation among UNCEEA members, SEEA-Water has been divided into two parts. Part one includes internationally agreed concepts, definitions, classifications, standard tables and accounts covering the framework, physical and hybrid supply and use tables and asset accounts (chaps. II-VI). Part two consists of those accounts that are considered to be of high policy relevance but still experimental because an internationally accepted best practice did not emerge (chaps. VII-IX). It also covers the quality accounts, the economic valuation of water beyond the 2008 *System of National Accounts* (SNA) and examples of SEEA-Water applications.

UNCEEA recommended that SEEA-Water be submitted to the United Nations Statistical Commission (UNSC) for adoption. The UNSC, at its thirty-eighth session from 27 February to 2 March 2007, adopted part one of SEEA-Water as an interim international statistical standard—subject to re-evaluation upon adoption of the revised SEEA 2003, expected in 2012. The UNSC also encouraged implementation of SEEA-Water in national statistical systems.

Since the adoption of SEEA-Water in 2007, a new edition of the SNA has been adopted (2008 edition). Attempts have been made to make SEEA-Water consistent with the 2008 SNA.

# Acknowledgements

The present version of SEEA-Water was prepared under the responsibility of the United Nations Statistical Division (UNSD). Coordination was carried out by Ilaria DiMatteo, moderator of the Subgroup on Water Accounting of the London Group on Environmental Accounting, with supervision provided by Alessandra Alfieri (UNSD) and under the overall responsibility of Ivo Havinga (UNSD). Draft chapters were prepared by Ms. Alfieri, Ms. DiMatteo (UNSD), Bram Edens (formerly with UNSD) and Glenn-Marie Lange (World Bank, formerly with Columbia University, United States of America). Philippe Crouzet (European Environment Agency), Anton Steurer (Eurostat), Gérard Gié and Christine Spanneut (consultants to Eurostat) and Jean-Michel Chéné (formerly with the United Nations Division for Sustainable Development (UNDSD)) contributed to an earlier draft. The development of the framework greatly benefited from discussions with Jean-Louis Weber (formerly with the French Institute for the Environment and currently with the European Environment Agency) and Gulab Singh (UNSD).

An electronic discussion group on terms and definitions used in water accounting was established and moderated by UNSD in cooperation with UNDSD. In this regard, the contributions of Aslam Chaudhry and Mr. Chéné were invaluable and are acknowledged with gratitude.

The many contributions, comments and reviews by the members of the Subgroup on Water Accounting of the London Group on Environmental Accounting and by the participants in the meeting of the Subgroup in New York in May 2005 are also acknowledged with gratitude. They include the following experts: Michael Vardon (formerly with UNSD); Martin Lemire and François Soulard (Canada); Wang Yixuan (China); Thomas Olsen (Denmark); Mr. Crouzet and Mr. Weber; Christian Ravets (Eurostat); Jean Margat (France); Christine Flachmann (Germany); Mr. Gié; Osama Al-Zoubi (Jordan); Marianne Eriksson (Sweden); Riaan Grobler and Aneme Malan (South Africa); Leila Oulkacha (Morocco); Sjoerd Schenau and Martine ten Ham (Netherlands); Jana Tafi (Moldova); Mr. Lange; Mr. Chéné; and Saeed Ordoubadi (formerly with the World Bank).

SEEA-Water also benefited greatly from the comments of the following experts: Roberto Lenton (Global Water Partnership), Nancy Steinbach (formerly with 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.

Mr. Vardon and Lisa Lowe (formerly with UNSD) proofread the manuscript. Ricardo Martinez-Lagunes (UNSD) contributed to the final adjustments of the document prior to its publication.

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# Abbreviations

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| **CEPA** | Classification of Environmental Protection Activities and Expenditure |
| **CNI** | change in net income (approach) |
| **COFOG** | Classification of the Functions of Government |
| **CPC** | Central Product Classification |
| **EDG** | electronic discussion group (on terms and definitions for SEEA-Water) |
| **GCF** | gross capital formation |
| **GDP** | gross domestic product |
| **ISIC** | International Standard Industrial Classification of All Economic Activities |
| **IWRM** | integrated water resources management |
| **NAMEA** | National Accounting Matrix including Environmental Accounts |
| **NAMWA** | National Accounting Matrix including Water Accounts |
| **NPISHs** | non-profit institutions serving households |
| **OECD** | Organization for Economic Cooperation and Development |
| **SEEA-Water** | System of Environmental-Economic Accounting for Water |
| **SERIEE** | European System for the Collection of Information on the Environment |
| **SNA** | System of National Accounts |
| **SRU** | standard river unit |
| **UNCEEA** | United Nations Committee of Experts on Environmental-Economic Accounting |
| **UNDSD** | United Nations Division for Sustainable Development |
| **UNDP** | United Nations Development Programme |
| **UNEP** | United Nations Environment Programme |
| **UNESCO** | United Nations Educational, Scientific and Cultural Organization |
| **UNSC** | United Nations Statistical Commission |
| **UNSD** | United Nations Statistics Division |
| **USGS** | U.S. Geological Survey |
| **WMO** | World Meteorological Organization |

Chapter I

# Overview of the System of Environmental-Economic Accounting for Water

## A. Introduction

1.1. Water is essential for life. It is a key component in growing food, generating energy, producing many industrial products and other goods and services, as well as in ensuring the integrity of ecosystems. Increasing competition for freshwater use in the agricultural, urban and industrial sectors, including through population growth, has resulted in unprecedented pressures on water resources, with many countries experiencing conditions of water scarcity, or facing limits to their economic development. Moreover, water quality continues to worsen, further limiting the availability of freshwater resources.

1.2. The integral role of water in the development process is widely recognized. It is not surprising that water is very high on the national and international development agendas, with several international agreements specifying targets for water supply and sanitation. The most notable of these is the inclusion of two indicators, namely, "proportion of population using an improved water source" and "proportion of population using an improved sanitation facility", for target 7.C of the Millennium Development Goals, which aims to "halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation".[1]

1.3. Because water is critical to life and intimately linked with socio-economic development, it is necessary for countries to move away from sectoral development and the management of water resources to the adoption of an integrated overall approach to water management.[2]

1.4. The *System of Environmental-Economic Accounting for Water* (SEEA-Water) provides a conceptual framework for organizing hydrological and economic information in a coherent and consistent manner. The SEEA-Water framework is an elaboration of the *Handbook of National Accounting: Integrated Environmental and Economic Accounting*,[3] 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 SEEA-2003 and SEEA-Water use as a basic framework the *System of National*

1 See http://mdgs.un.org/unsd/mdg/Host.aspx?Content=Indicators/OfficialList.htm.

2 United Nations and the World Water Assessment Programme, *United Nations World Water Development Report 2: Water a Shared Responsibility* (United Nations publication, Sales No. E.06.II.A.4).

3 United Nations, *Handbook of National Accounting: Integrated Environmental and Economic Accounting: An Operational Manual*, Series F, No. 78, Rev.1 (United Nations publication, Sales No. E.00. XVII.17) (hereinafter referred to as the *Handbook of National Accounting*).

*Accounts, 2008*,[4] which is widely known as the 2008 SNA. It is the standard system for the compilation of economic statistics and the derivation of economic indicators, the most notable being gross domestic product (GDP).

1.5. Complementing the SEEA-Water conceptual framework is a set of standard tables focusing on hydrological and economic information. SEEA-Water also includes a set of supplementary tables covering information on social aspects; these tables enable the analysis of interactions between water and the economy. The 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 policymakers, or for which compilation is still experimental or not directly linked with the 2008 SNA. The set of tables, standard and supplementary, was designed with the objective of facilitating the compilation of the accounts in countries and collecting 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. Policymakers effecting decisions on water need to be aware of the likely consequences of their decisions 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 of their policies on water resources and the environment in general.

1.7. Section B of the present chapter presents the main features of SEEA-Water and discusses the relationship of SEEA-Water to the 2008 SNA and SEEA-2003, as well as the advantages of using the accounting framework of SEEA-Water to organize information on water resources.

1.8. Section C introduces the concept of "integrated water resources management" (IWRM), the internationally agreed and recommended strategy for the management of water resources, and discusses how SEEA-Water can be used as an information system in support of IWRM.

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

## B. Objective and features of the System

1.10. SEEA-Water was developed with the objective of standardizing concepts and methods in water accounting. It provides a conceptual framework for organizing economic and hydrological information, enabling a consistent analysis of the contribution of water to the economy and of the impact of the economy on water resources. SEEA-Water further elaborates the framework presented in SEEA-2003 to cover in more detail all aspects related to water.

1.11. Both SEEA-2003 and SEEA-Water are satellite systems of the 2008 SNA, which, as mentioned previously, is the statistical standard used for the compilation of economic statistics. As such, they have a similar structure to the 2008 SNA and share common definitions and classifications. They provide a set of aggregate indicators to monitor environmental-

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4 Commission of the European Communities, International Monetary Fund, Organization for Economic Cooperation and Development, United Nations and World Bank, *System of National Accounts, 2008* (United Nations publication, Sales No. E.08.XVII.29) (hereinafter referred to as the *System of National Accounts, 2008* in footnotes and "the 2008 SNA" in the text).

economic performance, both at the sectoral and macroeconomic levels, as well as a detailed set of statistics to guide resource managers towards policy decision-making.

1.12. There are two features that distinguish SEEA-2003 and SEEA-Water from other information systems related to the environment. First, SEEA-2003 and SEEA-Water directly link environmental data and, in the case of SEEA-Water, water data, to the economic accounts through a shared structure and set of definitions and classifications. The advantage of these linkages is that they provide a tool to integrate environmental-economic analysis and to overcome the tendency to divide issues along disciplinary lines, when analyses of economic issues and of environmental issues are carried out independently of one another.

1.13. Second, SEEA-2003 and SEEA-Water cover all the important environmental-economic interactions, a feature that makes them ideal for addressing cross-sectoral issues, such as IWRM. 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 SNA, both SEEA-2003 and SEEA-Water are linked to a full range of economic activities with a comprehensive classification of environmental resources. SEEA-2003 includes information about all critical environmental stocks and flows that may affect water resources and be affected by water policies.

1.14. While SEEA-2003 reports best practices and, wherever possible, presents harmonized approaches, concepts and definitions, SEEA-Water 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 call by the Statistical Commission of the United Nations Economic and Social Council to elevate SEEA-2003 to the level of an "international statistical standard" by 2010,[5] as had been recommended by the United Nations Committee of Experts on Environmental-Economic Accounting.[6]

1.15. SEEA-Water includes, as part of its standard presentation, information on the following:

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

(*b*) Pressures imposed on the environment by the economy in terms of water abstraction and emissions added to wastewater and released into the environment or removed from wastewater;

(*c*) The supply of water and its use as an 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 its users;

(*f*) The financing of these costs, that is, who is to pay for the water supply and sanitation services;

(*g*) The payment of permits for access to abstract water or to use it as a sink for the discharge of wastewater;

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5 See *Official Records of the Economic and Social Council, 2006, Supplement No. 4* (E/2006/24) and document E/CN.3/2006/9.

6 The United Nations Committee of Experts on Environmental-Economic Accounting (UNCEEA) was created by the United Nations Statistical Commission at its thirty-sixth session in March 2005. More information about UNCEEA is available from the United Nations Statistics Division website at http://unstats.un.org/unsd/envaccounting/ceea/default.asp.

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

1.16. SEEA-Water 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 SEEA-Water for the sake of completeness. However, these modules are still experimental; they are presented in terms of implementation issues and illustrated by country practices rather than by providing guidelines on compilation.

1.17. SEEA-Water 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. SEEA-Water is an important tool for policymakers; it provides them with (*a*) indicators and descriptive statistics to monitor the interaction between the environment and the economy, and the progress being made towards meeting environment goals; and (*b*) a database for strategic planning and policy analysis in order to identify more sustainable development paths and the appropriate policy instruments for achieving these paths.

1.18. Water resources and their management are very much linked to spatial considerations. SEEA-Water takes into account the recommendation contained in Agenda 21[7] that the river basin constitutes the internationally recognized unit of reference for IWRM and that a river basin district is the obligatory management unit of the European Union Water Framework Directive.[8] 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 SEEA-Water, it should be recognized that economic accounts are generally not compiled at the river basin level but at the level of administrative regions.

1.19. An agreed terminology related to water accounting, presented in the glossary at the end of this publication, is used throughout SEEA-Water. Water accounting is multidisciplinary and spans many fields, such as hydrology, national accounting and environmental statistics. Hydrologists, national accountants and environmental statisticians need to be able to communicate using a common language. An achievement of SEEA-Water is to have 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[9] on terms and definitions used in water accounting was established and moderated by the United Nations Statistics Division (UNSD) in cooperation with the United Nations Division for Sustainable Development in order to reach agreement on the terms and definitions relevant to water accounts. The recommendations of the group served as important input in achieving a consensus on terms and definitions and constitute the basis of the SEEA-Water glossary.

7 *Report of the United Nations Conference on Environment and Development, Rio de Janeiro, 3-14 June 1992*, vol. I, *Resolutions Adopted by the Conference* (United Nations publication, Sales No. E.93.I.8 and corrigendum), resolution 1, annex II (hereinafter referred to as *Report of the Conference*).

8 The official title is Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy. It entered into force on 22 December 2000.

9 The group's work was based in particular on a review of the following glossaries: 2001 UNSD questionnaire on water resources; 2002 OECD/Eurostat joint questionnaire on water resources; 2001 FAO/Aquastat questionnaire; UNESCO/WMO *International Glossary of Hydrology*, 2nd ed., 1992; FAO/Aquastat Glossary online; Working copy of the terminology of water management: Flood protection TERMDAT; and *United Nations Glossary of Environment Statistics, Studies in Methods*, Series F, No. 67, 1997.

## C. Integrated water resources management and the System

1.21. IWRM is based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good, the quantity and quality of which 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 the need 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.[10]

1.22. Under IWRM, the sustainable management of water resources is called for to ensure that there would be enough water for future generations and that the water would meet high standards of quality. The IWRM approach promotes the coordinated development and management of water, land and related resources in order to maximize 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 water and groundwater; (*c*) river basins and their coastal and marine environment; and (*d*) upstream and downstream interests.[11]

1.23. For policymaking and planning, taking the IWRM approach requires that (*a*) policies and priorities take into account water resource implications, including the two-way relationship between macroeconomic policies and water development, management and use; (*b*) cross-sectoral integration take place in policy development; (*c*) stakeholders be given a voice in water planning and management; (*d*) water-related decisions made at the local and river basin levels be in line with, or at least do not conflict with, the achievement of broad national objectives; and (*e*) water planning and strategies be integrated into broader social, economic and environmental goals.[12]

1.24. SEEA-Water is a useful tool that functions 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, SEEA-Water can assist policymakers in making informed decisions on:

(*a*) **Allocating water resources efficiently.** SEEA-Water shows the quantity of water used for various purposes, including agriculture, mining, hydroelectric power generation and manufacturing, as well as the quantity of wastewater and emissions generated as a result of production processes. It also shows, side-by-side with the physical information, information on the value added by industries. This allows for the derivation of indicators of water efficiency and productivity. SEEA-Water becomes increasingly important for planning 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;

(*b*) **Improving water efficiency.** Water efficiency can be improved from the demand as well as the supply side. On the demand side, policymakers are faced with

10 *Report of the Conference*, para. 18.8.

11 Global Water Partnership, *Catalyzing Change: A Handbook for Developing Integrated Water Resources Management (IWRM) and Water Efficiency Strategies* (Stockholm, GWP, 2004). Available from http://www.gwpforum.org/gwp/library/Catalyzing_change-final.pdf.

12 Ibid.

making decisions about which economic instruments to put in place in order to change the behaviour of the user. On the supply side, policymakers can encourage the efficiency of water supply or irrigation systems, as well as the reuse of water. SEEA-Water produces 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 produces 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. SEEA-Water provides policymakers with a database that can be used to analyse the impact on water resources of the introduction of new regulations throughout the economy;

(*c*) **Understanding the impacts of water management on all users.** Policymakers are faced with making decisions that would have impacts broader than those on the water sector only. In this regard, it becomes increasingly important to plan water resources development, allocation and management in an integrated manner. SEEA-Water, because it is rooted in the 2008 SNA, functions as the basic information system for evaluating the tradeoffs of different policy options on all users;

(*d*) **Getting the most value for money from investing in infrastructure.** Investment in infrastructure needs to be based on the evaluation of long-term costs and benefits. Policymakers need information on the economic implications of infrastructure maintenance, water services and potential cost recovery. The water accounts furnish information on the current costs of maintaining existing infrastructure, the service charges paid by users and the cost structure of the water supply and sewerage industries. Therefore, they can be used in economic models to evaluate the potential costs and benefits of putting new infrastructure in place.

(*e*) **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. SEEA-Water furnishes information on stocks of water resources and on all changes in those stocks resulting from natural causes, such as inflows, outflows and precipitation, and from human activities, such as abstraction and returns. Further, it disaggregates water abstraction and returns by industry, thus facilitating the management of such water;

(*f*) **Making available a standardized information system, which is capable of harmonizing information from different sources, is accepted by 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, such as irrigation, water supply and sanitation. 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. SEEA-Water brings together information from different sources in an integrated system with common concepts, definitions and classifications. This enables the identification of inconsistencies and gaps in the data. The implementation of such an integrated system ultimately leads to more efficient and consistent data-collection systems. It is aimed at producing consistency over time, which is of utmost importance in developing comparable time-series estimates that are necessary in the policy process. In addition, the accounting framework enables the introduction of checks and balances in the data, thus producing data of higher quality. Policymakers will find that the development of an integrated coherent and consistent information system would add value to individual sets of data collected to respond to sectoral policy needs. The implementation of an integrated data system would also accommodate the derivation of consistent indicators across countries and over time, which would be accepted by all stakeholders since they are derived from a common framework;

(*g*) **Getting stakeholders involved in decision-making.** SEEA-Water is a transparent information system. It should be used by Governments to make informed decisions and by interest groups and communities to argue their position on the basis of sound information.

1.25. As mentioned previously, SEEA-Water focuses on the interactions between the economy and the environment. It may therefore be necessary to complement it with social indicators. To the extent possible, such indicators should be analysed in conjunction with SEEA-Water information in order to facilitate the design of integrated policies.

## D. Overview of the accounting system

1.26. SEEA-Water is a satellite system of the 2008 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 2008 SNA, hydrological data on the volume of water used and discharged back into the environment by the economy, as well as the quantity of pollutants added to the water. Bringing the physical information on water into the accounting framework introduces checks and balances into 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 (chap. III) 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 (chap. IV) provide information by economic activity and households on the quantity of pollutants which have been added to or removed from the water (by treatment processes) during its use.

1.29. **Category 2: Hybrid and economic accounts.** This category of accounts (chap. V) aligns physical information recorded in the physical supply and use tables with the monetary supply and use tables of the 2008 SNA. These accounts are referred to as "hybrid" flow accounts in order to reflect the combination of different types of measurement units in the same accounts. In these accounts, physical quantities can be compared with matching economic flows, for example, linking the 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 2008 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. Those elements of the 2008 SNA also furnish information on financing, that is, the amount that users pay for the services of wastewater treatment, for example, and the extent to which those services are subsidized by the Government and other units. These accounts are particularly useful for cost-recovery policies and water-allocation policies; they can also be compiled for activities aimed at the protection and management of water resources so as to obtain information on national expenditure and financing by industries, households and the Government.

1.31. **Category 3: Asset accounts.** This category of accounts (chap. VI) comprises accounts for water resource assets measured mostly in physical terms. Asset accounts measure stocks at the beginning and the end of the accounting period and record the changes in the stocks that occur during the period. They describe all increases and decreases of the stock due to natural causes, such as precipitation, evapotranspiration, inflows and outflows, and human activities, such as abstraction and returns. These accounts are particularly useful because they link water abstraction and return to the availability of water in the environment, thus enabling the measurement of the pressure on physical water induced by the economy.

1.32. **Category 4: Quality accounts.** This category of accounts describes the stock of water in terms of its quality (chap. VII). It should be noted that the quality accounts are still experimental. Quality accounts describe the stocks of water resources in terms of quality: they show the stocks of certain qualities at the beginning and the end of an accounting period. Because 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 SEEA-Water accounts comprises the valuation of water and water resources (chap. VIII). With regard to the quality accounts, this category of accounts is still experimental; there is still no agreement on a standard method for 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. Therefore, it is expected that in the future the resource rent for water would be positive and thus the value of the water stocks would be included in the balance sheets of a country.

1.35. The valuation of water resources is included in SEEA-Water because of its policy relevance. However, since no agreement has yet been reached on how to value water (consistent with 2008 SNA valuation concepts), SEEA-Water presents only the valuation techniques commonly used in economic analyses, which may go beyond the value of the market transactions recorded in the 2008 SNA, and their relationship to the concepts of the 2008 SNA, while discussing the advantages and disadvantages of different techniques.

## E. Structure of the System

1.36. SEEA-Water is divided into two parts. Part one (chaps. II-VI) contains those accounts for which there is considerable practical experience and for which 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. Part two (chaps. VII-IX) discusses those modules which are still experimental, that is, for which it was not possible to reach an agreement on concepts nor on how to implement them because of a lack of practical experience, scientific knowledge, consistency with the 2008 SNA or a combination of those reasons. The second part of SEEA-Water also provides examples of applications of the water accounts in countries (chap. IX).

1.37. As an aid for understanding the relationships among the various accounts, a fictitious but realistic database has been developed, called “SEEA-Water-land”. Each chapter presents the tables populated with data sets from that database.

1.38. The following section affords a brief overview of each chapter of SEEA-Water. At the beginning of each chapter a more extensive "road map" describes the objectives of the chapter and presents a brief description of its contents.

## 1. Part one

1.39. **Chapter II: The water accounts framework.** SEEA-Water links the water resource system with the economy. The water resource system and the hydrological cycles, as well as the relations of the system with the economy, are described in detail.

1.40. Because SEEA-Water is rooted in the 2008 SNA, chapter II provides an overview of the whole accounting system and describes how SEEA-Water expands the 2008 SNA accounting framework. The chapter also describes in great detail the classifications used in SEEA-Water, which form the backbone of the accounting framework and the interconnections between the different accounts.

1.41. Since water resources possess spatial and temporal characteristics, which are usually not addressed in standard accounts, chapter II describes how SEEA-Water can be adapted to compile information which is spatially and temporally disaggregated, without disrupting the accounting structure.

1.42. Chapter II may be read at the outset as a preliminary overview of what is to follow or as a synoptic review of the interconnections between the accounts and tables presented in the subsequent chapters.

1.43. **Chapter III: Physical water supply and use tables.** Chapter III 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 2008 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 into 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 within the purview of the 2008 SNA. The SNA measures flows of water and wastewater within the economy. It shows water that is used to produce other goods and services (intermediate consumption) and to satisfy current human wants (final consumption), as well as water that is exported (a small part since water is a bulky good). Flows from the economy into the environment consist of discharges of wastewater back into the environment.

1.46. Chapter III describes the supply and use tables for physical flows of water. It furnishes standard tables as well as more detailed supplementary tables for compilation. The detailed tables are presented as numerical examples, and they are part of the previously mentioned SEEA-Water-land database.

1.47. **Chapter IV: Emission accounts.** Chapter IV describes the pressure that the economy puts on the environment in terms of emissions into water. Emission accounts describe the quantity of pollutants that is added to wastewater as a result of production and consumption activities and that is released into the environment. These accounts also describe the quantity of pollutants 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 SEEA-Water-land data sets for use in the emission accounts tables.

1.49. **Chapter V: Hybrid and economic accounts for activities and products related to water.** Chapter V 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 infrastructure and the cost of maintaining it. These flows are captured within the 2008 SNA and need to be separately identified.

1.50. Chapter V shows how a standard SNA supply and use table can be juxtaposed with the corresponding part of the physical table described in chapter III. The result is conventional national accounts presented together with physical information on water abstraction, supply and use 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. The linkage between physical and monetary information afforded by hybrid accounts is particularly useful for relating to particular industries the abstraction of water resources, the generation of wastewater and the emission of pollutants.

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; they may also 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 in order to 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 water use: the users often benefit from transfers from other economic units, generally the Government, as such units bear part of the costs. Similarly, investments in infrastructure can be partly financed by different units. The financing of water and water-related products is described in chapter V.

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 grant property rights over water resources to designated users. The recording of these monetary transactions in the accounting framework is also presented in the 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 SEEA-Water-land data sets and are linked with the physical flows presented in the previous chapters.

1.55. **Chapter VI: The asset accounts.** Chapter VI looks at water assets and discusses how to account in physical terms for changes in these accounts as a result of natural processes 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 describes the classification of water resources and furnishes standard tables for compilation. It also presents the compilation of asset accounts for transboundary waters.

## 2. Part two

1.57. **Chapter VII: Quality accounts.** 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, because quality is an important characteristic of water ecosystems and limits water's use, SEEA-Water covers quality accounts.

1.58. Chapter VII furnishes basic concepts concerning the measurement of quality and describes different approaches to defining quality classes and constructing quality accounts.

1.59. **Chapter VIII: Valuation of water resources.** The need to treat water as an economic good has been widely recognized. The 2008 SNA records the value of transactions involving water within the economy. The prices charged for water in the market often do not reflect its full economic value owing to certain characteristics unique to water. Water is a collective good, heavily regulated and subject to multiple uses. The price charged often does not reflect even its cost of production, and property rights are often absent. Economists have developed techniques for estimating the value of water which are not consistent with the 2008 SNA.

1.60. Chapter VIII describes background concepts in the economic valuation of water and the valuation principles of SNA. It furnishes an overview of different valuation techniques, their strengths and weaknesses as well as their relevance to particular policy questions.

1.61. **Chapter IX: Examples of applications of water accounts.** Water accounts are a relatively new tool for organizing water-related information. Therefore, these accounts need to be promoted among both the users and the producers of water information. Chapter IX links the accounts to applications for water policy by showing how the accounts have been used in countries for the derivation of indicators for monitoring and evaluating policies and for scenario-modelling so as to estimate, for example, the impact of water pricing reforms or project future demands.

1.62. Although the applications presented are derived from the techniques and tables contained in the previous chapters, chapter IX is a stand-alone chapter. It can be read at the outset because it furnishes an overview of the possible applications of the accounts and can assist in setting implementation priorities: deciding on a set of priority indicators will lead to a set of tables that should be compiled 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 supply and use, and pollution. It presents indicators at the national level and then more detailed indicators and statistics that shed light on the sources of pressure on water resources, the opportunities for reducing the pressure, the 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 levels and discusses the possibility of introducing a more flexible temporal dimension. It then discusses the links between water accounts and other resource accounts in SEEA in support of IWRM.

1.65. **Annexes.** SEEA-Water contains three annexes. Annex I includes the standard tables which are presented and discussed in chapters III to VI. The standard tables constitute the minimum data set that all countries are encouraged to compile. Annex II contains supplementary tables which cover items that should be considered by countries in which information would, in their particular cases, be of interest to analysts and policymakers, or for which compilation is still experimental and not directly linked to the 2008 SNA. In particular, the supplementary tables afford a more detailed level of disaggregation of the standard tables, tables on still experimental quality accounts and tables linking SEEA-Water to social aspects.

1.66. Annex III links the water accounts to indicators. In particular, section 1 of that annex draws together the wide range of indicators that can be derived from the accounts presented in SEEA-Water to show how, together, they supply a comprehensive set of water-related indicators. Section 2 links the water accounts to the indicators proposed in the previously mentioned *World Water Development Report 2*.[13] It also describes the indicators that can be derived from SEEA-Water, including the particular module of the water accounts.

1.67. **Glossary.** The glossary provides agreed terminology for water accounting. It combines (*a*) hydrological terms, which were agreed upon by the previously mentioned electronic discussion group; (*b*) environmental-economic accounting terms, which were drawn from the glossary of SEEA-2003; and (*c*) economic terms drawn from the glossary of the 2008 SNA. The hydrological terms were drawn from international questionnaires, international glossaries and selected country reports on water accounts and adapted to the needs of SEEA-Water.

1.68. The glossary standardizes terms and definitions from the hydrological and the economic spheres in an agreed set of definitions. Its purpose is to facilitate the collection of consistent data on water, based on existing international statistical standards, such as the 2008 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 information for the asset accounts and the physical supply and use tables, in order to (*a*) identify the sources of pressure on the environment and (*b*) design possible allocation strategies for the competing uses of water. In contrast, countries facing problems involving water pollution often start with the emission accounts and hybrid supply and use tables, which enable the formulation of policies aimed at reducing the emissions into water resources and the evaluation of the costs that would be incurred in reducing such emissions.

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

1.71. A group of researchers carried out an analysis of the consistency of international questionnaires on water resources and the water accounting standard tables.[14] Their analysis concluded that the concepts used in the questionnaires on water resources are in general consistent with those used in water accounts.[15] This is mostly due to two parallel initiatives that were aimed at reconciling the questionnaires with water accounting. One of the initiatives was undertaken by Eurostat during the last revision of the OECD/Eurostat joint questionnaire, and the other was undertaken by UNSD during the preparation of SEEA-Water. An important outcome was broad consistency in international data-collection activities with SEEA-Water: physical information on water resources can now be linked to the monetary accounts with only minor additions/modifications to the existing international data-collection activities.

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13 *United Nations World Water Development Report 2*, op. cit.

14 These include the UNSD/UNEP and the OECD/Eurostat questionnaires on water resources and the FAO-Aquastat questionnaire.

15 See Ilaria Di Matteo, Alessandra Alfieri and Ivo Havinga, "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, 20-22 June 2005.

## G. Areas of future work in water accounts

1.72. Although many countries have already implemented, or are in the process of implementing, water accounts, the implementation of SEEA-Water needs to be promoted in countries that have not yet done so. Producers and users of water information have to become acquainted with the features of SEEA-Water and the advantages of an integrated information system rooted in the 2008 SNA in support of IWRM.

1.73. SEEA-Water standardizes the concepts and methods used in water accounting and related statistics. However, countries still need to gain experience and do further work in the following areas: the quality accounts, the valuation of water resources, the expansion of the framework to include social aspects and the impacts of natural disasters. Quality accounts have been implemented in relatively few countries; enough experience has yet to be gained to draw conclusions on best practices. It is expected that additional standardized methods for defining quality classes are likely to emerge as a result of the implementation of the mandatory obligations of the previously mentioned European Union Water Framework Directive[16] and other initiatives.

1.74. Valuation of water resources is widely applied by resource economists; however, this is rarely done in the context of national accounts. Valuation of natural resources, which includes valuation of water, has been placed on the research agenda for revision of SEEA-2003. The research agenda was established to meet the request of the United Nations Statistical Commission to elevate SEEA-2003 to the level of a standard by 2010. Valuation of environmental goods and services remains a controversial issue and will be the subject of further discussion in the years ahead.

1.75. By focusing on the integration between the economy and the environment, SEEA-Water does not fully develop the link with the various social aspects related to water. While some social aspects can be included by disaggregating, for example, the household sector on the basis of sociodemographic characteristics, such as rural versus urban, and income, and by 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 SEEA-Water standard and supplementary tables, a need that emerges is to develop a structure for assessing the quality of water statistics by comparing country practices with best practices, including internationally accepted methodologies such as SEEA-Water. 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 SEEA-Water data quality framework.

16 The directive 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 to adhere to the general principle of non-deterioration of water bodies.

# PART ONE

Chapter II

# The framework of the System of Environmental-Economic Accounting for Water

## A. Introduction

2.1. SEEA-Water offers a systematic framework for the organization of water information to enable the study of the interactions between the economy and the environment. It is a further elaboration of the SEEA-2003 framework, focusing exclusively on water resources. As with SEEA, SEEA-Water expands the 2008 SNA by identifying separately information related to water in the 2008 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 furnishes a description in diagrammatic form of the interactions between the hydrological system and the economy. It describes in a non-technical way the hydrological system, the economic system (as measured by the 2008 SNA) and the interactions between these systems.

2.3. Section C introduces the SEEA-Water framework as a satellite system of the 2008 SNA and describes how SEEA-Water expands the 2008 SNA in order to address water-related concerns. Section D presents the accounting framework in more detail: it describes the various accounts in the SEEA-Water framework and presents the concepts, definitions and classifications that are used in SEEA-Water. Section E introduces two cross-cutting issues in the compilation of water accounts, namely, the identification of the temporal and spatial references.

## B. Water resource system and the economy

2.4. Water is needed in all aspects of life. It is essential for meeting basic human needs, for enabling the achievement of socio-economic development and for ensuring the integrity and survival of ecosystems. Water resources furnish material inputs to and services for the economy and for humankind outside of the economy, as well as for other living beings. Water resources supply the following: (*a*) material input for activities involving production and consumption; (*b*) sink functions for waste materials, such as wastewater discharged into water resources; and (*c*) habitat for all living beings, including humans. SEEA-Water focuses on water as a material input for activities involving production and consumption and as a "sink" for waste. Accounts for water as a provider of ecosystem habitat are discussed here only in terms of the quality of water and the links to the various uses of water.

2.5. SEEA-Water furnishes an integrated information system for studying the interactions between the environment and the economy. Currently, integration with the social dimension, which is particularly important for the management of water resources, is not systematically included in the SEEA-Water framework. However, information on some crucial social aspects of water, such as access to safe drinking water and sanitation, are included in supplementary tables in order to facilitate the analysis of the social impacts of water policies. Other social aspects of water can be made explicit in SEEA-Water: for example, by disaggregating the household sector according to specific characteristics, such as income, or rural versus urban residence. Further methodological research and practical experience are needed to extend the framework to the social dimension.

2.6. The framework of SEEA-Water is presented in simplified diagrammatic form in figure II.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 inside 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 and among them. The economy of a territory consists of resident[17] water users that abstract 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 II.2 in order to describe the main flows within each system and the interactions between the two systems.

2.7. The inland water resource system and the economy of a given territory, which can be a country, an administrative region or a river basin, can exchange water with those of other territories through imports and 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).

2.8. Figure II.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 SEEA-Water accounting framework.

2.9. The economy uses water in different ways. It can physically remove water from the environment for activities involving production and consumption or use water without physically removing it from the environment. In the first case, the economy abstracts water from the inland water bodies or the sea, uses the precipitation (in situ use of precipitation in figure II.1) through rain-fed agriculture or water harvesting, and uses water for generating hydroelectric power. 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 on the quality of the water also. 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 because they do not involve 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.

2.10. In addition to abstracting water, the economy returns water into the environment. As shown in figure II.1, returns can be either into 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 such 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 into the water system, as returned water then becomes available for other uses.

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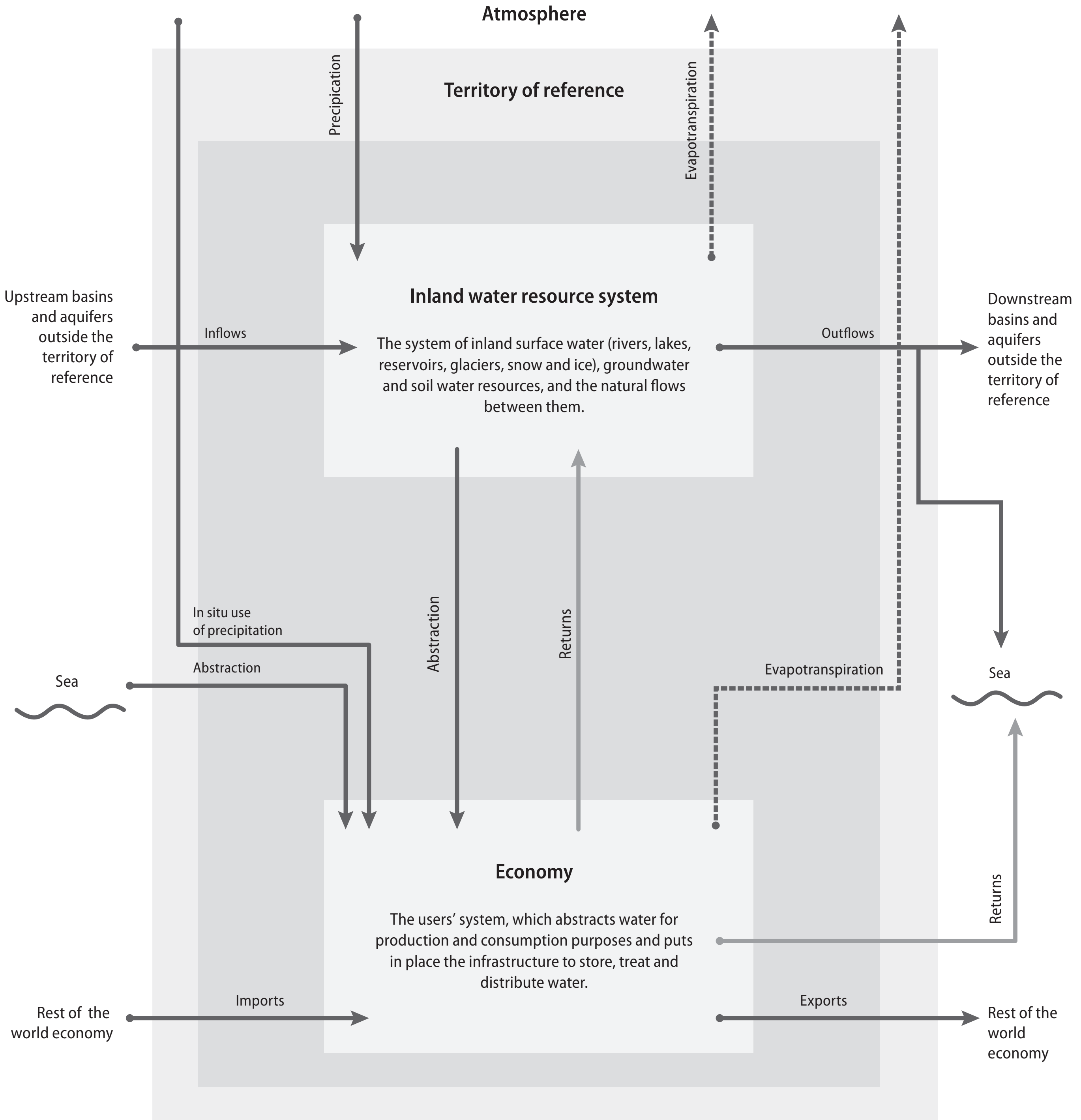
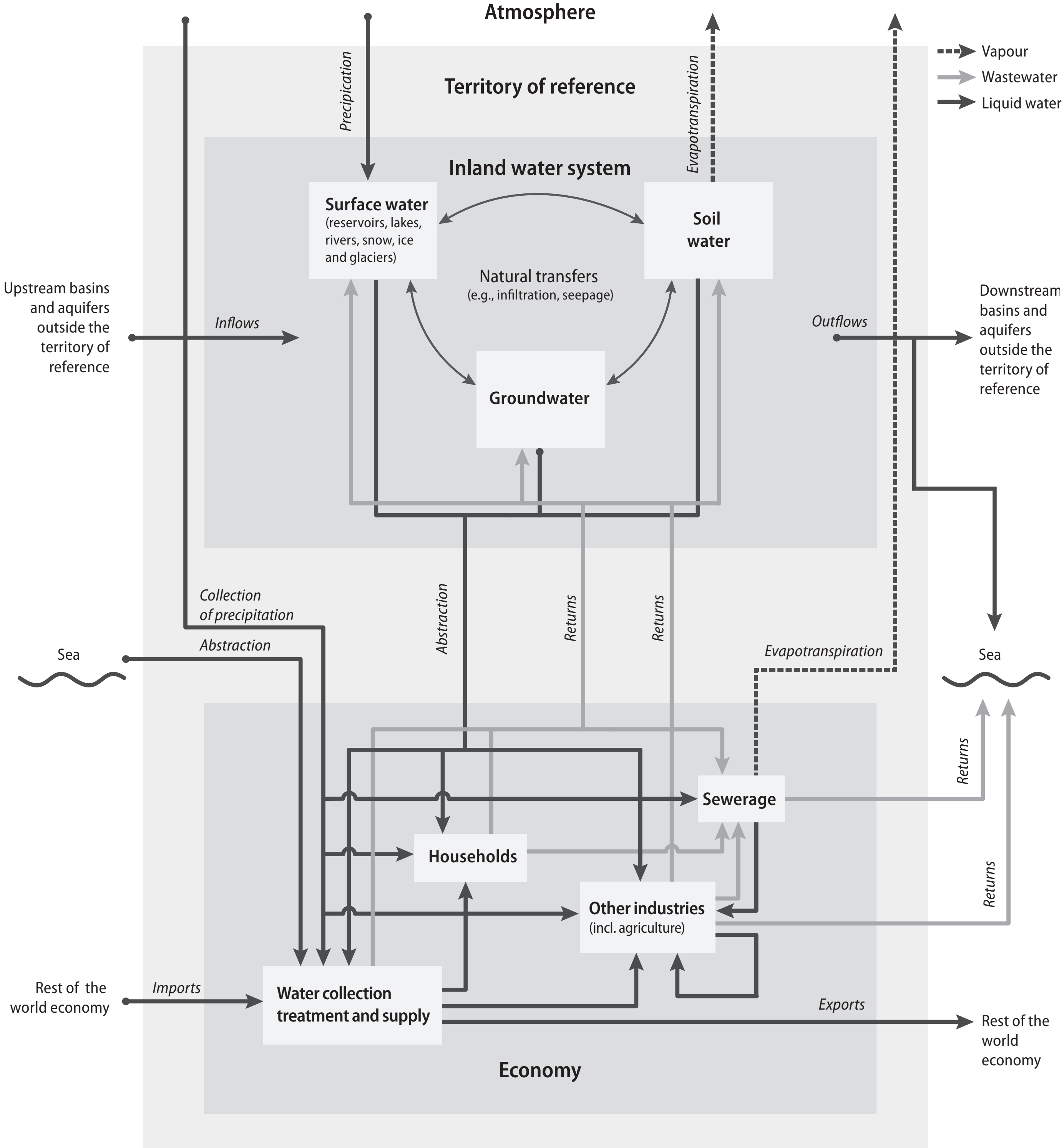
17 The concept of residence follows that of the 2008 SNA, according to which "the residence of each institutional unit is the economic territory with which it has the strongest connection, in other words, its centre of predominant economic interest" (*System of National Accounts, 2008*, op. cit., para. 4.10). This concept can be applied also to geographical boundaries other than national ones.

Figure II.1
**Flows between the economy and the environment**




2.11. Figure II.2 shows in greater detail the flows of the inland water resource system and the economy to illustrate 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 II.2
**Main flows within the inland water resource system and the economy**




## 1. The inland water resource system

2.12. Water is in continuous movement. Solar radiation and gravity keep water moving from land and oceans into the atmosphere in the form of vapour (evapotranspiration) which falls back to the Earth in the form of precipitation. The inland water resource system is composed of the following: (*a*) all inland water resources from which water is, or can be, abstracted; (*b*) water exchanges between water resources within the territory of reference, such as infiltration, run-off and percolation; and (*c*) water exchanges with water resources of other territories, that is, inflows and outflows. Exchanges of water between the water resources are also referred to as natural transfers.

2.13. 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 VI. 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 outside the territory. Human activities decrease and increase water stocks through abstraction and returns.

2.14. The asset accounts module of SEEA-Water 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 the end of the accounting period and the 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

2.15. As mentioned in previous paragraphs, water resources support several functions not only for humankind, which uses water for survival and activities involving production and consumption, but also for 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 and among water resources and the economy, where the economy is thought of as the system which abstracts water for activities involving consumption and production, and which puts into place the infrastructure to mobilize, store, treat, distribute and return water into the environment.

2.16. In figure II.2, the box representing the economy has been expanded to show the main economic agents related to water. In particular, the following are identified:

(*a*) The industry primarily involved in the collection, treatment and supply of water to households, industries and the rest of the world;

(*b*) The industry involved primarily in the collection, treatment and discharge of sewage (sewerage);

(*c*) Other industries which use water as an input in their production processes;

(*d*) Households, which use water to satisfy their needs or wants.

2.17. It should be noted that households are identified separately only as final consumers of water. If water is used by households as an input in the production of agricultural products, for example, 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 activity.

2.18. The box representing the economy in figure II.2 describes, in simplified format, 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 the figure. Additional information, which is an integral part of SEEA-Water, includes the following:

(*a*) Monetary transactions related to water exchanges: (i) the costs of collection, treatment and supply of water and that of sanitation services; (ii) fees and taxes paid for water and sanitation services; (iii) payments for access to the resource (e.g., water rights) as well as for discharging wastewater; and (iv) the financing of these services, that is, the sectors bearing the costs of the services;

(*b*) Costs for environmental protection and resource management. These costs describe the economy's efforts to prevent environmental degradation or eliminate part, or all, of the effects after degradation has taken place. They include the actual expenses incurred (current and capital) by industries, households and the Government, as well as the financing of such expenditures;

(*c*) Investments in infrastructure. This describes the cost of new investments, the depreciation of old investments, the cost of maintaining the water-related infrastructure, and the financing of these investments;

(*d*) The emission of pollutants into the environment. This information enables the identification of pressures on the environment caused by various economic agents, namely, industries, households and the Government.

2.19. Sources of water for the whole economy of a given territory include the following: inland water resources in the environment of the territory of reference; precipitation, which is either collected or used directly, such as rain-fed agriculture; sea water, which can be used directly, such as for cooling purposes, or after desalinization; and imports of water from other economies (the rest of the world). Once water enters an economy, it is used, returned 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.

2.20. Each economic unit either abstracts water directly from the environment or receives it from other industries. Once water has been used, it can be discharged directly into the environment, supplied to other industries for further use (reused water), or supplied to a treatment facility, which in figure II.2 is denoted by the box entitled "sewerage".

2.21. During use, some water may be retained in the products generated by the industry, or some of it may have evapotranspired during use. It should be noted that in most industrial activities water is lost mainly as a result of evaporation as opposed to the situation in agriculture, where water is consumed as a result of evaporation and transpiration by plants and crops. In this example, water is considered to have been "consumed" by the industry. The term consumption often has 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 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 another industry or is directly abstracted. The term "water consumption" is used in the hydrological sense; this term may create confusion among national accountants who tend to consider the terms "consumption" and "use" as synonymous.

2.22. It should be noted that figures II.1 and II.2 are aimed at showing in a simple way situations that are more complex in reality; therefore, they do not contain all the flows that occur in reality and that are recorded in the accounts. For example, in figure II.2 flows of water lost during distribution are not shown explicitly, but such losses often occur and at times in significant quantities. Although not shown explicitly in the figures, these losses are recorded in SEEA-Water.

## C. The frameworks of the two systems

2.23. SEEA-Water has been designed to link economic information with hydrological information in order to provide users with a tool for integrated analysis. SEEA-Water takes the perspective of the economy and looks at the interaction of the economy with the hydrological system. SEEA-Water was developed as a satellite account of 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 account of the 2008 SNA, SEEA-Water has a similar structure to the 2008 SNA; it uses concepts, definitions and classifications consistent with the 2008 SNA while not violating the fundamental concepts and laws of hydrology. SEEA-Water expands the central accounting framework by:

(*a*) Expanding the 2008 SNA asset boundary to include all water assets and their quality and explicitly identifying produced assets that are used for mobilizing water resources. The 2008 SNA includes only "surface and groundwater resources used for extraction to the extent that their scarcity leads to the enforcement of ownership and/or use rights, market valuation and some measure of economic control".[18] SEEA-Water expands the 2008 SNA asset boundary by including all water resources found in the territory, namely, surface water, groundwater and soil water. It may be noted, however, that the extension of the 2008 SNA asset boundary in respect of water resources relates only to recording such an asset in physical terms. In physical terms the water asset accounts 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 SEEA-Water in terms of their quality, as the degradation of the quality of water resources is often a limiting factor in the use of water. Quality accounts describe the quality of the stocks of water at the beginning and the end of the accounting period. Quality can be defined in terms of a single pollutant, a combination of pollutants, or in terms of physical characteristics, such as the salinity level of water. Asset accounts for infrastructure, such as pumps and dams, related to water and sanitation are already included in the 2008 SNA; however, they are often not identified separately from other produced assets. SEEA-Water enables 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;

(*b*) Expanding the 2008 SNA by juxtaposing physical information with the monetary accounts. In the 2008 SNA, the stocks or assets used in production processes and the flow of products are measured only in monetary terms, even if underlying physical information may be used in the compilation of the monetary accounts. SEEA-Water enables the compilation of the accounts in physical terms. In the case of water, physical flows include the quantity of water used for activities involving production and consumption 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 the water-related and wastewater-related taxes paid and subsidies received by industries and households;

18 *System of National Accounts, 2008*, para. 10.184.

(*c*) Introducing information on the relationship between the economy and the environment in terms of abstractions, returns and emissions, thus enabling analysis of the impact on natural assets caused by the activities of industries, households and government as they involve production and consumption. Such activities affect both the quality and quantity of water resources. By introducing information on the abstraction and discharge of water by industry, households and the Government, as well as information on the emission of pollutants into water resources, SEEA-Water enables the study of the impacts of these activities both in terms of the quantity and the quality of the water resources;

(*d*) Separately identifying expenditures for the protection and management of water resources. The 2008 SNA already includes implicitly expenditures for the protection of the environment and the management of resources. SEEA-Water reorganizes this information in order to make it more explicit, thus enabling the separate identification of the expenditures for the protection and management of water, as well as the identification of taxes, subsidies and financing mechanisms.

2.24. The strengths of using the national accounting framework to describe the interactions between the environment and the economy are manifold. First, the 2008 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 2008 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 the use of concepts, definitions and classifications consistent with those of SNA, thus ensuring the consistency of environmental and economic statistics, and facilitating and improving the analysis of the interrelations between the environment and the economy.

2.25. 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 the data. Organizing environmental and economic information into an accounting framework offers the advantage of improving basic statistics.

2.26. Third, the accounting structure also enables 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 with the use of loose sets of indicators, using indicators that are derived from the accounts offers the advantage of enabling further analyses of interlinkages and the causes of change, completed by scenarios and prognoses on the basis of scientific macroeconomic models.

2.27. In short, the existence of an underlying integrated data system is essential for conducting integrated economic and environmental analyses: it allows for cost-effectiveness, scenario modelling, economic and environmental forecasting and the evaluation of trade-offs by enabling the user to no longer have to view sectoral policies in isolation but in a comprehensive economic and environmental context.

## D. The framework of the System of Environmental-Economic Accounting for Water

2.28. SEEA-Water consists of two parts. Part one describes the accounts for which countries have gained considerable practical experience and reached agreement on how to compile the accounts. This part presents a set of standard tables; these constitute the minimum data set that countries are encouraged to compile. It also presents supplementary tables which are a further disaggregation of the standard tables; they consist of items that should be considered by countries in which information would, in their particular cases, be of interest to analysts and policymakers. Part one of SEEA-Water expands what is presented in SEEA-2003 by (*a*) presenting agreed concepts, definitions and classifications related to water; and (*b*) providing standard compilation tables. Part two describes modules that are more experimental and for which not enough country experience exists; it also furnishes examples of applications of the water accounts. Part two includes quality accounts, valuation of water and examples of applications of the accounts; these are discussed in chapters VII, VIII and IX, respectively. Chapters VII and VIII discuss issues relating to the compilation of those accounts, illustrating them by presenting country experiences and presenting supplementary tables for which compilation is still experimental or not directly linked with the 2008 SNA. Part two does not contain recommendations on how to compile those modules of the accounts. The SEEA-Water framework consists of the accounts described below.

## 1. Flow accounts

2.29. The central framework of the 2008 SNA contains detailed supply and use tables in the form of matrices that record how supplies of goods and services originate from domestic industries and imports, and how those supplies are allocated among intermediate and final uses and exports. The SEEA-Water flow accounts furnish 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.

### *(a) Physical supply and use tables*

2.30. The physical supply table is divided into two parts: the first part describes the flows of water within the economy, such as the distribution of water from one industry to another or to households, and with the rest of the world; the second part describes flows from the economy to the environment, such as discharges of water into the environment.

2.31. The physical use table is also divided into two parts: the first part describes flows from the environment to the economy, such as water abstraction by industries and households; the second part describes flows within the economy, such as water received from other industries, households and the rest of the world. Physical supply and use tables are presented in chapter III.

### *(b) Emission accounts*

2.32. Emission accounts provide information by industry, households and government on the amount of pollutants added to wastewater, which is discharged into the environment, with or without treatment, or discharged into a sewage network. Emission accounts are presented in chapter IV.

### *(c) Hybrid and economic accounts*

2.33. Hybrid accounts present, in a consistent manner, physical and monetary information on the supply and use of water by juxtaposing the standard (monetary) 2008 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 constitute a useful tool for obtaining a comprehensive picture of the economics of water and for deriving consistent sets of indicators, such as intensity and productivity indicators.

2.34. For analytical purposes, it is useful to identify the governmental expenditures related to water, such as those for the management of water supply and sanitation. 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 governmental expenditure on water-related activities and hybrid accounts for the "collection, treatment and supply of water" as well as "sewerage" carried out as a principal and secondary activity or for own use furnish this kind of information, which is useful for compiling expenditures on resource management and environmental protection.

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

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

## 2. Asset accounts

2.37. Asset accounts measure stocks at the beginning and the 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.

### *(a) Produced assets*

2.38. Produced assets related to water include infrastructure put into place to abstract, distribute, treat and discharge water. They are included in the 2008 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; special surveys may be necessary to identify separately those produced assets related to water. Large parts of these assets are owned by water companies or water authorities, but they could 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 resulting from 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 (discovery of assets or recognition of their value, the unanticipated destruction or disappearance of assets, changes in classification, etc.) and changes in prices.[19] Asset accounts for produced assets related to water provide information on the ability of an economy to mobilize and treat water, including information on investments in infrastructure and on the depreciation of the infrastructure. Accounts for these assets are not dealt with explicitly in SEEA-Water because these accounts follow the structure of conventional accounts.[20]

### *(b) Water resources*

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

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19 Based on the *System of National Accounts, 2008*, op. cit., para. 13.8.

20 Interested readers should refer to chaps. 10, 12 and 13 of the *System of National Accounts, 2008*, op. cit.

2.40. The SEEA-Water asset boundary of water resources is very broad and includes, in principle, all inland bodies of water, 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 SEEA-Water 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).

2.41. A small part of water resources is already included in the 2008 SNA asset boundary: its category AN.214, water resources, includes surface and groundwater resources used for extraction to the extent that their scarcity leads to the enforcement of ownership or use rights, market valuation and some measure of economic control.

2.42. 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: only very rarely does water have a positive resource rent, because it is often provided free of charge or at prices that do not reflect the costs of providing the related services. Physical asset accounts are presented in chapter VI.

#### *(c) Quality accounts*

2.43. 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 VII.

### 3. Valuation of non-market flows

2.44. This component presents techniques for the economic valuation of water beyond market prices and their applicability in answering specific policy questions. The valuation of water resources and consequently their depletion remain controversial issues because of the fundamental importance of the resource to basic human needs and the lack of a real market for water. This being the case, SEEA-Water does not discuss the calculation of macroeconomic aggregates adjusted for depletion and degradation costs, which nevertheless are discussed in SEEA-2003. Chapter VIII of SEEA-Water presents a review of the valuation techniques that are used for water resources and discusses their consistency with the SNA valuation.

### 4. Classification of economic activities and products

2.45. The economy is composed of five institutional sectors: the non-financial corporation sector, the financial corporation sector, the general governmental sector, the non-profit institutions serving household sectors and the household sector. These sectors are themselves composed 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.[21]

2.46. Institutional units in their capacity as producers are referred to as enterprises. They can be involved in a diverse range of productive activities which may be very different from each other with respect to the type of production processes carried out, and the goods and services produced. Therefore, in order to study production, it is more useful to work with groups of producers that are engaged in essentially the same kind of production. These are called estab-

21 *System of National Accounts, 2008*, op. cit., para. 4.2.

lishments 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.

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

2.48. ISIC is a United Nations system for classifying economic data according to type of economic activity in a number of fields; it is 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 characteristic of the unit according to which it is grouped with other units to form industries. An industry is defined as a set of all production units engaged primarily in the same or similar kinds of productive economic activity.[22]

2.49. In the ISIC system, no distinction is drawn according to the kind of ownership, the type of legal organization or the 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 incorporated enterprises or part of such enterprises, individual proprietors or government, or whether the parent enterprise consists of more than one establishment. Further, ISIC does not distinguish between formal and informal or legal and illegal production, or between market and non-market activity.

2.50. Because an establishment, as 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, that is, principal and secondary products, respectively, is produced for sale on the market, for provision to users 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 that activity which 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.

2.51. In the 2008 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. However, there are 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 such cases, the establishment should be subdivided so that the secondary activity would be treated as taking place within an establishment separately from that in which the principal activity would take place and be classified accordingly. SEEA-Water follows the same principle.

2.52. Box II.1 provides a summary of the economic activities, classified according to ISIC Rev. 4,[23] which are primarily related to water in the sense that they furnish either water or water-related services. Even though the simplified standard tables of SEEA-Water present only two of the activities in box II.1, that is, class 3600 (collection, treatment and supply of water) and ISIC class 3700 (sewerage), for analytical purposes it is useful to identify explicitly in the accounting tables all water-related activities.

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22 Ibid. para. 5.41.

23 United Nations, *International Standard Industrial Classification of All Economic Activities, Revision 4*, Statistical Papers, Series M, No. 4/Rev. 4 (United Nations publication, Sales No. E.08.XVII.25).

2.53. It should be noted that structural changes were introduced in ISIC Rev. 4 that modify its previous version, ISIC Rev. 3.1.[24] In particular, for activities related to water, two major changes were introduced in ISIC Rev. 4:

(*a*) In order to reflect the fact that activities involving abstraction, purification and distribution of water are often carried out in the same enterprise as activities of wastewater treatment and disposal, ISIC Rev. 4 combines under the same section (section E) activities of "collection, purification and distribution of water" and "sewerage", which were previously classified under different sections in ISIC Rev. 3.1;

(*b*) Given the importance of activities aimed at the decontamination of water resources and wastewater management, a division was introduced in ISIC Rev. 4 (division 39) to identify these activities explicitly.

2.54. The correspondence of codes between ISIC Rev. 4 and Rev. 3.1 is presented in this chapter together with a detailed description of the categories relevant to water accounting. In the remaining chapters, reference to a particular category is made according to ISIC Rev. 4. The main activities related to water are described below.

2.55. Activities related to the **operation of agricultural irrigation systems** in support of crop production include, among various support activities for crop production, all water mobilization activities corresponding to agricultural uses, including groundwater abstraction, the construction of dams and 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 corresponds to **class 0140** of ISIC Rev. 3.1. Class 0161 of ISIC Rev. 4 does not include the provision of water in class 3600 of ISIC Rev. 4 or any construction involved in the provision of this service. However, it should be noted that special surveys often must be undertaken to disaggregate information on class 0161 of ISIC Rev. 4 in order to identify explicitly activities for the operation of irrigation systems.

2.56. Activities for the **collection, treatment and supply of water** (class 3600 of ISIC Rev. 4), include the following: collection of water from various sources (abstraction from rivers, lakes, wells, etc., and collection of rainwater); purification of water for supply purposes; and distribution of water through water mains, by truck or by other means for meeting domestic and industrial needs. This class also includes the activity of desalinizing seawater or groundwater in order to produce freshwater. The operation of irrigation canals is also included; however, the provision of irrigation services through sprinklers, as well as similar agricultural support services, is classified under the class 0161 of ISIC Rev. 4. Class 3600 of ISIC Rev. 4 corresponds to class 4100 of ISIC Rev. 3.1.

2.57. **Sewerage** activities (class 3700 of ISIC Rev. 4) include the following: 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 run-off 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, such as dilution, screening, filtering and sedimentation; the emptying and cleaning of cesspools and septic tanks, sinks and pits of sewage; and the servicing of chemical toilets. This class also includes activities involving the maintenance and cleaning of sewers and drains. It should be noted that an economic unit engaged in the collection and treatment of wastewater (class 3700 of ISIC Rev. 4), can also redistribute water and wastewater to specific users for further use.

24 United Nations, *International Standard Industrial Classification of All Economic Activities. Revision 3.1*, Statistical Papers, Series M, No. 4/Rev. 3.1 (United Nations publication, Sales No. E.03.XVII.4).

2.58. Class 3700 of ISIC Rev. 4 corresponds to part of the activities classified in class 9000 of ISIC Rev. 3. The remaining activities classified under class 9000 of ISIC Rev. 3 relate to remediation activities and are explicitly identified in classes 3800 and 3900 of ISIC Rev. 4. Class 3800 of ISIC Rev. 4 is entitled "waste collection, treatment and disposal activities and materials recovery". Since these activities refer to solid waste, they are not discussed further in SEEA-Water.

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

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

2.61. Activities involving the **transport of water** are identified in ISIC classes 4923 and 4930, depending on whether the transport is by road, such as by tanker truck, 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.

2.62. 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 class 8412 of ISIC Rev. 4), are classified together with the administration of a number of other programmes in health, education, sport, etc. Thus, when compiling water accounts, the point of interest relates only to the information on the part of class 8412 of ISIC Rev. 4 that is relevant to water, which has to be identified through special surveys. Class 8412 of ISIC Rev. 4 corresponds to class 7512 of ISIC Rev. 3.1.

2.63. It should be noted that division 84 of ISIC Rev. 4 includes activities normally carried out by 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 governmental units that are specifically attributable to other divisions of ISIC should be classified under the appropriate division of ISIC but not under division 84 of ISIC Rev. 4. Often there is a tendency to allocate to class 8412 of ISIC Rev. 4 activities for the collection, purification and distribution of water (class 3600 of ISIC Rev. 4) and for activities related to 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 accounts of the local government are not sufficiently detailed 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 that enable the community to function properly, but it does not include the actual operation of facilities, such as waterworks. Some activities in this division may be carried out by non-governmental units.

2.64. Monetary supply and use tables are constructed for the products associated with the industries listed in box II.1; they provide information on the value of the outputs produced (supplied) and their use for intermediate or final consumption and export purposes.

Box II.1
**Main activities related to water in an economy under the International Standard Industrial Classification of All Economic Activities**

**ISIC class 0161: Support activities for crop production** (*corresponds to class 0140 of ISIC Rev. 3.1*)

Among the various support activities for crop production, this class includes the following:

- Operation of agricultural irrigation equipment

**ISIC class 3600: Water collection, treatment and supply** (*corresponds to class 4100 of ISIC Rev. 3.1*)

This class includes water collection, treatment and distribution activities for domestic and industrial needs. It includes the collection of water from various sources, as well as its distribution by various means. The operation of irrigation canals is also included; however, the provision of irrigation services through sprinklers, as well as similar agricultural support services, is not included. This class includes the following:

- Collection of water from rivers, lakes, wells, etc.
- Collection of rainwater
- Purification of water for the purposes of water supply
- Desalinization of sea water or groundwater to produce freshwater as the principal product of interest
- Distribution of water through mains, by truck or other means
- Operation of irrigation canals

This class excludes the operation of irrigation equipment for agricultural purposes (see class 0161); treatment of wastewater in order to prevent pollution (see class 3700); and (long-distance) transport of water via pipelines (see 4930).

**ISIC class 3700: Sewerage** (*part of class 9000 of ISIC Rev. 3.1*)

This class includes the following:

- The operation of sewer systems or sewer treatment facilities
- The collection and transport of human and industrial wastewater from one or several users, as well as rainwater by means of sewerage networks, collectors, tanks and other means of transport (sewage vehicles, etc.)
- The emptying and cleaning of cesspools and septic tanks, sinks and pits of sewage; and the servicing of chemical toilets
- The treatment of wastewater by means of physical, chemical and biological processes, such as dilution, screening, filtering and sedimentation
- The treatment of wastewater in order to prevent pollution, for example, from swimming pools and industry
- The maintenance and cleaning of sewers and drains
- The cleaning and rodding of sewers

**ISIC class 3900: Remediation activities and other waste management services** (*part of class 9000 of ISIC Rev. 3.1*)

This class includes the following:

- Decontamination of soil and groundwater at the place of pollution, either in situ or ex situ, using, for example, mechanical, chemical or biological methods
- Decontamination of industrial plants or sites, including nuclear plants and sites
- Decontamination and clean-up of surface water following accidental pollution, for example, through the collection of pollutants or through the application of chemicals
- Clean-up of oil spills and other forms of pollution on land, in surface water, and in oceans, and seas, including coastal areas
- Abatement of asbestos, lead-based paint and other toxic materials
- Other specialized pollution-control activities

Box II.1

**Main activities related to water in an economy under the International Standard Industrial Classification of All Economic Activities** (*continued*)

This class excludes the treatment and disposal of non-hazardous waste (see class 3821); treatment and disposal of hazardous waste (see class 3822); and outdoor sweeping and watering of streets, etc. (see class 8129).

**ISIC class 4923: Freight transport by road** (*corresponds to class 6023 of ISIC Rev. 3.1*)

This class includes:

- All freight transport operations by road (e.g., haulage of logs and other bulk items, including haulage in tanker trucks)

This class excludes, among other things, distribution of water by truck (see class 3600).

**ISIC class 4930: Transport via pipeline** (*corresponds to class 6023 of ISIC Rev.3.1*)

This class includes:

- Transport of gases, liquids, water, slurry and other specialized commodities via pipeline
- Operation of pumping stations

This class excludes the distribution of natural or manufactured gas, water or steam (see classes 3520, 3530, 3600) transport of water, liquids, etc. by truck (see class 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 of ISIC Rev. 3.1*)

This class also includes the administration of:

- Potable water supply programmes
- Waste collection and disposal operations
- Environmental protection programmes

**Source:** United Nations, *International Standard Industrial Classification of All Economic Activities (ISIC), Rev. 4*, Statistical Papers, Series M, No. 4, Rev. 4 (United Nations publication, Sales No. E.08.XVII.25).

In national accounts, products are classified according to the Central Product Classification (CPC) Version 2.[25] CPC constitutes a comprehensive classification of all goods and services; it classifies products based on their physical properties and intrinsic nature, as well as according to the principle of industrial origin. CPC and ISIC are both general-purpose and interrelated classification systems, with ISIC representing the activity side and CPC the product side. It should be noted, however, that a one-to-one correspondence between CPC and ISIC is not always possible as the output of an industry, no matter how narrowly defined, tends to include more than a single product. Similarly, a product can be produced by industries classified under different categories. In general, however, each CPC subclass consists of goods or services that are predominantly produced in a specific class or classes of ISIC Rev. 4.

2.65. The main products related to water, which are identified in CPC Version 2, are described in box II.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; it is treated in the same way as other beverages, such as soft drinks, beer and wine. While the SEEA-Water standard tables do not explicitly record the physical and monetary exchanges of these products within an economy, they can be easily expanded to add such information. However, they do record information on the volumes of water used and discharged during the production of such beverages.

25 United Nations, Central Product Classification (CPC) Version 2 (United Nations and United Nations Environment Programme, December 2008). Available from http://unstats.un.org/unsd/cr/registry/cpc-2.asp.

Box II.2

**Main products related to water according to the Central Product Classification Version 2**

| Product code | ISIC reference |
|---|---|
| CPC 18000: natural water | ISIC class 3600: collection, treatment and supply of water |
| Transport services which include the following subclasses:<br>• CPC 65112: road transport services of freight by tank trucks or semi-trailers<br>• CPC 65122: railway transport services of freight by tanker cars<br>• CPC 65139: transport services via pipeline of other goods | ISIC class 4923: freight transport by road: ISIC class 4912: freight rail transport; ISIC class 4930: transport via pipeline |
| Water distribution services which include the following subclasses:<br>• CPC 69210: water distribution through mains, except steam and hot water (on own account)<br>• CPC 69230: water distribution, except through mains (on own account)<br>• CPC 86330: water distribution services through mains (on a fee or contract basis)<br>• CPC 86350: water distribution services, except through mains (on a fee or contract basis) | ISIC class 3600: water collection, treatment and supply |
| Operation of irrigation systems for agricultural purposes, which constitutes part of CPC 86119 (other support services to crop production) . The class CPC 86119 includes a number of activities necessary for agricultural production, ranging from the preparation of fields to harvesting. The supply and use table reports only the part of this class that is relevant for water. | ISIC class 0161: support activities for crop production |
| Water-related administrative services, which are part of CPC 91123 (public administrative services related to housing and community amenities). The class CPC 91123 covers a number of services; the part that is relevant for water includes (*a*) public administrative services for water supply; (*b*) services provided by offices, bureaux, departments and programme units involved in developing and administering regulations concerning water supply; and (*c*) public administrative services related to refuse collection and disposal, sewage system operation and street cleaning. | ISIC class 8412: regulation of the activities of providing health care, education, cultural services and other social services, excluding social security |
| CPC 941: sewerage, sewage treatment and septic tank cleaning services. This group includes (*a*) sewerage and sewage treatment services (CPC 9411); and (*b*) septic tank emptying and cleaning services (CPC 9412). | ISIC class 3700: sewerage |
| CPC 94412: site remediation and clean-up services, surface water. This subclass includes services involved in implementing approved plans for the remediation of surface water on a contaminated site; the services must meet requirements specified by legislation or regulation. | ISIC class 3900: remediation activities and other waste management services |
| CPC 94413: site remediation and clean-up services, soil and groundwater. This subclass includes (*a*) 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; (*b*) maintenance and closure of landfills and other disposal sites; and (*c*) operation, maintenance and closure of hazardous waste disposal facilities. | ISIC class 3900: remediation activities and other waste management services |

**Source:** United Nations, Central Product Classification (CPC) Version 2, United Nations and United Nations Environment Programme, December 2008.

**Note:** The main products related to water as identified in the Central Product Classification Version 2 are presented together with references to the industry, ISIC Rev. 4, in which most of the goods or services in question are generally produced.

2.66. 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. However, it is highly recommended that they also explicitly include the other water-related products.

2.67. Although the term natural water would seem 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 water discharged back into the environment. The exact boundaries of this class are usually determined by the statistical framework that uses CPC. To reflect these different types of water flows, water accounts disaggregate the CPC class of natural water first in terms of the type of flow (from the environment to the economy, within the economy and from the economy to the environment), and second in terms of the type of water: water supplied to other economic units is further disaggregated to identify, for example, whether it consists 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 III.

2.68. 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 supply and use table records the value of the service. For example, the water supply industry, which collects, treats and supplies water, generally charges only for the service of collection, treatment and supply but not for water as a good.

## 5. Main identities of the System of National Accounts accounting framework

2.69. 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 and the generation of income to how the income is made available to various units in the economy and how it is used by those units. The 2008 SNA has identities within each account and between accounts that ensure the consistency and the integration of the system. The identities that are used frequently in SEEA-Water are described below.

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

Total supply = outputs + imports

2.71. On the other side (use), the goods 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*) industries acquiring them for future use in the production of other goods and services (capital formation); and (*d*) the economy of another territory (exports). Therefore, the following formula applies:

Total use = intermediate consumption + final consumption + gross capital formation + exports

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

2.72. Another identity of 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). It is a measure of the contribution to GDP made by an individual producer, industry or sector. When 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) is taken into account, then the net value added is obtained, using the following formulas:

Gross value added = output – intermediate consumption

Net value added = output – intermediate consumption – consumption of fixed capital

2.73. Once the value added has been generated, it is decomposed in the primary generation of income accounts for compensation of employees, taxes and subsidies on production and operating surplus, according to the following formula:

(Gross) value added = (gross) operating surplus + compensation of employees + taxes – subsidies

2.74. Another identity of SNA particularly useful in SEEA involves assets, and it links them with flows. This identity describes the stocks of assets at the beginning and the 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, such as changes in classification, discoveries and natural disasters, and changes in their price (holding gains/losses on assets), using the following formula:

Closing stocks = opening stocks + gross fixed capital formation – consumption of fixed capital + other changes in volume of asset + holding gains/losses on assets

## 6. The water accounting framework

2.75. Figure II.3 presents a simplified representation of the SEEA-Water accounting framework and links supply and use tables with the asset accounts. The framework of SEEA-Water is the same as that of SEEA-2003, but it focuses specifically on water. The unshaded boxes represent monetary accounts that are already part—explicitly or implicitly—of SNA. The grey boxes represent accounts that have been introduced in SEEA-Water but are not covered in SNA. They are measured in physical and monetary units.

2.76. The monetary supply and use tables are shown in figure II.3 with unshaded boxes. While the 2008 SNA supply table in monetary terms remains unchanged in the SEEA-Water framework, the use table in SEEA-Water contains a more detailed breakdown of the costs for water use, which are not usually explicitly available in SNA. Monetary supply and use tables for water are presented in chapter V.

2.77. Expenditure accounts are also shown in figure II.3, 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 identify these expenditures separately. Water protection and management accounts are also presented in chapter V.

2.78. Physical supply and use tables describe the water flows from abstraction, use and supply within the economy and returns into the environment; they are shown in the figure with shaded boxes because they are not part of the core national accounts. SEEA-Water also introduces supply and use tables for pollutants (emission accounts); they describe the flow of pollutants, in physical and possibly in monetary terms, generated by the economy and supplied to the environment.

2.79. The asset accounts are obtained in figure II.3 by combining the opening and closing stocks of assets with that part of the supply and use tables which affects those stocks. In particular, figure II.3 distinguishes assets related to water, which are within the asset boundary (unshaded box); such assets include the infrastructure for the storage, mobilization and use of water, as well as the assets of water, which include mainly water in the environment. It should be noted that part of the assets of water is already included in SNA, such as groundwater, but are not shown separately for two reasons. First, these assets represent a minimal part of all water assets; second, the valuation of those assets remains, in practice, a difficult exercise (even though it is theoretically possible to value them). The valuation is often embedded in the value of land.

2.80. The framework in figure II.3 can also be presented in matrix form. The matrix presentation is commonly referred to as the National Accounting Matrix including Water Accounts (NAMWA). NAMWA and more generally, the National Accounting Matrix including Environmental Accounts (NAMEA) have been developed by Statistics Netherlands and adopted by Eurostat. It should be noted that NAMWA is not a different framework; rather it is an alternative presentation of the information contained in the supply and use tables presented in figure II.3.

## E. Spatial and temporal issues in water accounting

2.81. 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 annually. Even at smaller spatial scales, there can be great variability in the availability of water: within the same river basin, some areas may be subject to water scarcity, while others may be 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.

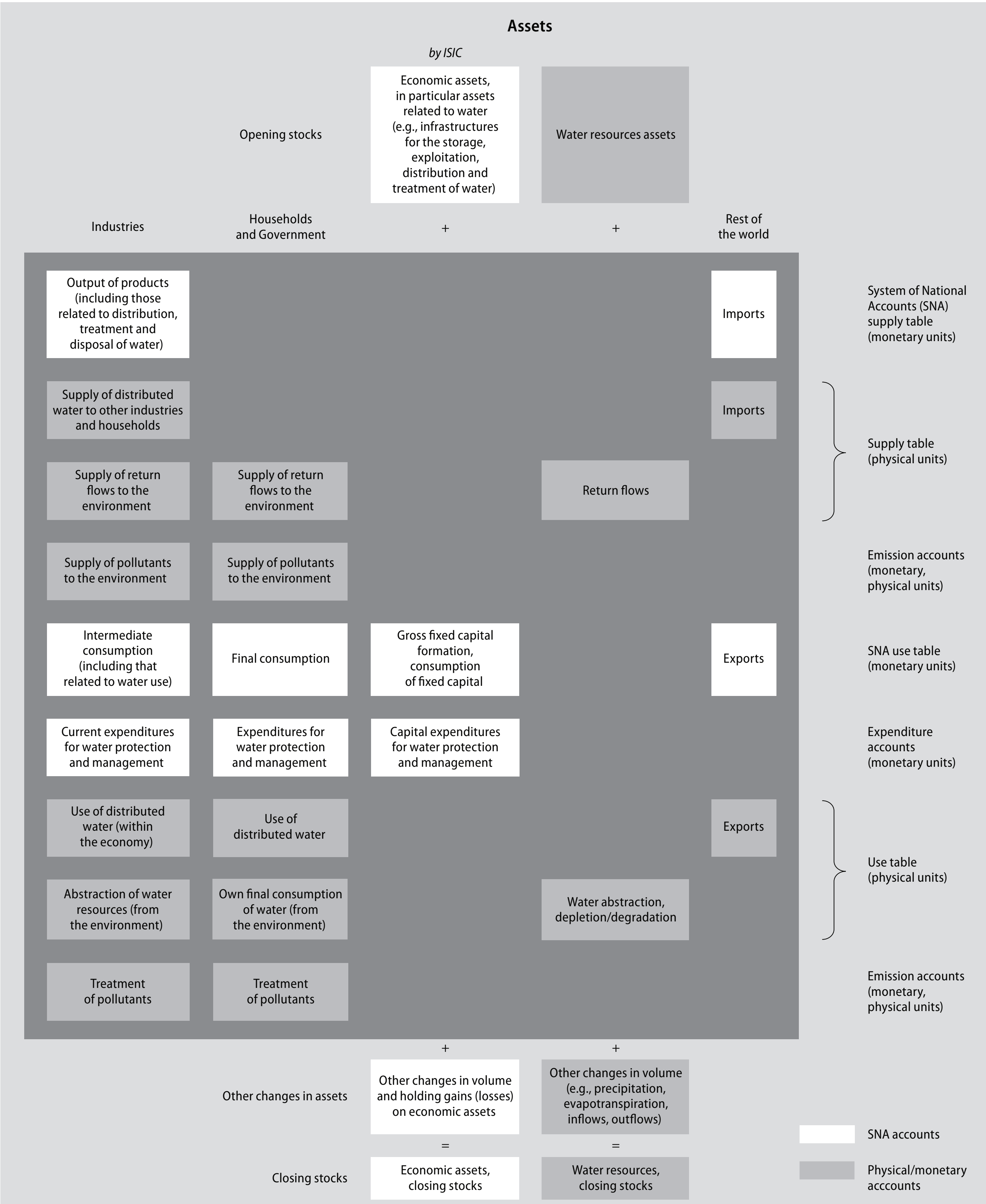
2.82. Economic information that is compiled according to SNA uses as a spatial reference the country or administrative region, and as a temporal reference the accounting year and in some cases smaller temporal references, such as quarterly accounts. Since water accounts consist of integrating hydrological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

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

### 1. Spatial dimension

2.84. The choice of the spatial reference for the compilation of the accounts ultimately depends on the objectives of the analysis. As previously mentioned, the compilation of national water accounts is important for designing and evaluating macroeconomic water policy. However, it is often more appropriate to use a finer spatial reference in order to reflect

Figure II.3
**The System of Environmental-Economic Accounting for Water framework**



better spatial differences in water use, supply, and pressure on water resources and to make decisions on the allocation of water between different users.

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

2.86. An **administrative region** is a geographical 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.

2.87. 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 IWRM (see, for example, Agenda 21[26] and the previously mentioned European Union Water Framework Directive). In particular, the Directive requires member States to formulate a river basin management plan for each river basin district[27] within their territory, and in the case of an international river basin district, member States must 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 pursued more effectively at the river basin level since all water resources within a river basin are inextricably linked to each other in terms of both quantity and quality. In this way, managers are able to gain a more complete understanding of overall conditions in an area and the factors which affect those conditions. For example, whereas emissions from a sewage treatment plant might be reduced significantly, the local river and groundwater may still suffer adverse effects if other factors in the river basin, such as polluted run-off from upstream emissions, go unaddressed.

2.88. As there are often large spatial differences in terms of the availability and use of water resources between the different river basins of a country, especially in “water stressed” countries, the use of national averages is not always sufficient for making 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 for sustaining their involvement in the water accounting process.

2.89. Increasingly, river basin agencies have been established in countries; they are usually governmental bodies endowed with their own resources and entrusted with looking after all issues (economic, hydrological and social) related to water. They are often responsible, within a clear legal and participatory framework, for collecting taxes and fees on water abstraction and discharge and for making decisions on water allocation. To support their decisions, they often collect physical and monetary data related to water resources. For instance, the Water Framework Directive requires the establishment of competent authorities in river basin districts and these are responsible for the implementation of the directive.

2.90. While the compilation of physical water accounts at the river basin level can be easily undertaken, as river basin agencies generally collect physical data at the river basin level, the compilation of monetary water accounts at the river basin level requires extra work to reconcile the spatial reference with economic information, such as output and value added,

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26 *Report of the Conference.*

27 In the Directive, the term “river basin district” refers to the area of land and sea made up of one or more neighbouring river basins together with their associated groundwaters and coastal waters. It is identified under Article 3 (1) of the Directive as the main unit for the management of river basins. It may include several river basins and their sub-basins.

which is available only at the administrative region level. Techniques to allocate economic data to river basins often involve the allocation of economic accounts at the administrative region level to the river basin on the basis of other socio-economic data.

2.91. 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 are referred to here as **accounting catchments**; they would be composed of river basins or sub-basins and would be sufficiently large for economic information to be available. An accounting catchment could consist, for example, of an administrative region and be composed of several river basins, or it could be composed of several administrative regions to cover an entire river basin.

## 2. Temporal dimension

2.92. The temporal reference of economic data generally differs from that of hydrological data: hydrological data generally refer to the hydrological year, a 12-month period during which the overall changes in storage are minimal and carry-over is reduced to a minimum;[28] economic data, 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 be the same 12-month accounting period as that of the national accounts.

2.93. 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. However, they are very data-demanding and thus are often not considered a feasible option.

2.94. 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 enable a detailed time series analysis. However, there may be cases where compiling annual accounts on water use may not provide significant information: the inter-annual variability may not be greater than the variability of the estimation procedure. Moreover, an increase in those water uses which depend heavily on climatic variations, such as agriculture, may be interpreted as a structural change in water use, while in reality the increase may be just a short-term one that occurs in response to a climatic change. An alternative could be the compilation of accounts on water use every three or five years, which would enable a sufficiently complete analysis of the water use trend.[29]

2.95. 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 of long enough duration to be stable (20 or 30 years) and provide information on the average annual water availability in the environment. These accounts could also be supplemented with accounts for a particular year, such as a 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 because, while the variability of water resources is pseudocyclical and their average

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28 For details of this definition, see *International Glossary of Hydrology*, 2nd ed., UNESCO/WMO, 1992. A more recent version is available from http://www.cig.ensmp.fr/~hubert/glu/aglo.htm.

29 Jean Margat, ed., *Les Ressources en Eau, Manuels et Méthodes, No. 28* (Rome, Food and Agriculture Organization of the United Nations, and Orléans, France, Bureau de Recherches Géologiques et Minières, 1996).

is relatively stable in the long term and in a given climatic situation (and it often forms the reference for the assessment of water resources), water use tends to change over the years due, for example, to an expanding population size and changes in the structure of the economy. Therefore, the combination of these two types of information would enable analysis of the natural water supply in relation to the evolution of human water demand.[30]

30 Ibid.

Chapter III

# Physical water supply and use tables

## A. Introduction

3.1. Physical water supply and use tables 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 and its supply and use within the economy to its final discharge back into the environment, with all entries being expressed in quantitative terms. Physical supply and use tables have the same structure as their monetary counterparts compiled as part of the standard national accounts. Chapter V presents monetary tables as well as hybrid supply and use tables, in which physical and monetary information is presented side by side. Organizing physical information, using the same framework as the monetary accounts, is one of the characteristic features of SEEA-Water.

3.2. The compilation of the physical water supply and use tables enables (*a*) assessment and monitoring of the pressure on water quantities that is exerted by the economy; (*b*) the identification of the economic agents responsible for the abstraction and discharge of water into the environment; and (*c*) the evaluation of alternative options for reducing the pressure on water. Indicators of water use intensity and productivity can be calculated in combination with monetary information on the value added.

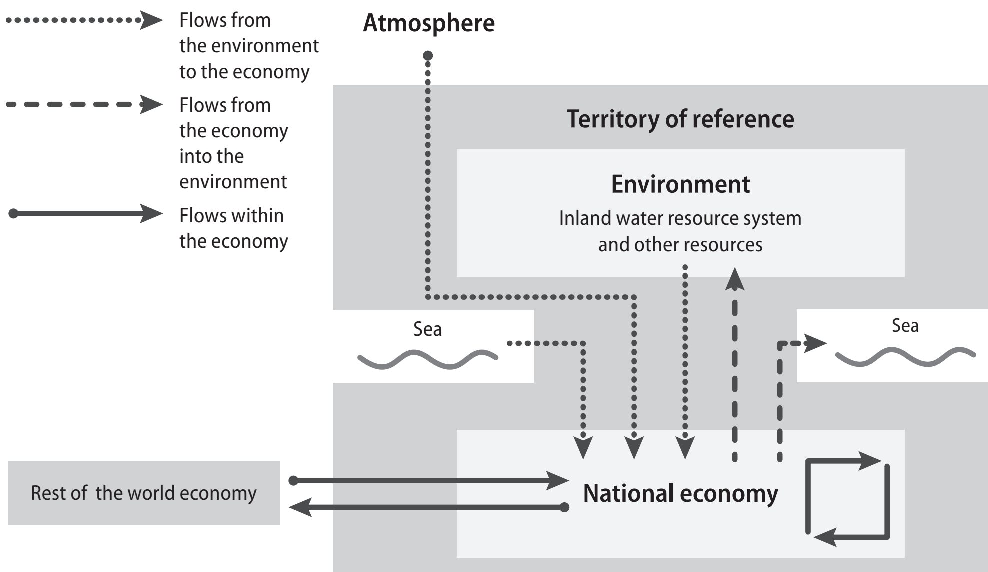
3.3. The objective of this chapter is to provide a comprehensive overview of physical supply and use tables. Section B of this chapter introduces the distinctions among flows from the environment to the economy (abstraction), flows within the economy (supply and use of water between two economic units) and flows from the economy back into the environment (returns). These distinctions are used to construct physical water supply and use tables and to demonstrate the basic accounting rules described in section C. Section C also presents the standard physical supply and use tables that countries are encouraged to compile and the supplementary tables which further disaggregate items of the standard tables and may be of interest for specific analyses and policies.

## B. Types of flow

3.4. When constructing a supply and use table for water resources, SEEA-Water implicitly takes the perspective of the economy as it describes the interactions between the environment and the economy. SEEA-Water describes (*a*) flows from the environment to the economy; (*b*) flows within the economy; and (*c*) flows from the economy to the environment, as depicted in figure III.1. It should be noted that flows within the environment are described in the asset accounts in chapter VI.

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 is, supply equals use, is satisfied.

Figure III.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 water, groundwater and soil water, as defined in the asset classification (see chap. VI), and water from other sources. Abstraction from other sources includes abstraction from the sea, for example, for direct use in cooling, or for desalination purposes, and collection of precipitation, which occurs, for example, in the case of harvesting roof water. The supplier of these flows is the environment and the user is the economy; more specifically, they are 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 in situ or passive uses of water, which do not entail its 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 the activities of abstraction and water discharge: for example, upstream overabstraction may affect navigational and recreational uses of downstream waters. Thus, when allocating water to different users, consideration is generally made of the in situ uses of water resources.

3.8. Water is abstracted either to be used by the same economic unit that abstracts it, in which case, it is referred to as “abstraction for own use”, or to be supplied, possibly after some treatment, to other economic units, which constitutes “abstraction for distribution”. The industry which abstracts, treats and supplies water as a principal activity is classified under division 36 of ISIC Rev. 4, water collection, treatment and supply. However, there may be other industries which abstract and supply water as a secondary activity.

## 2. Flows within the economy

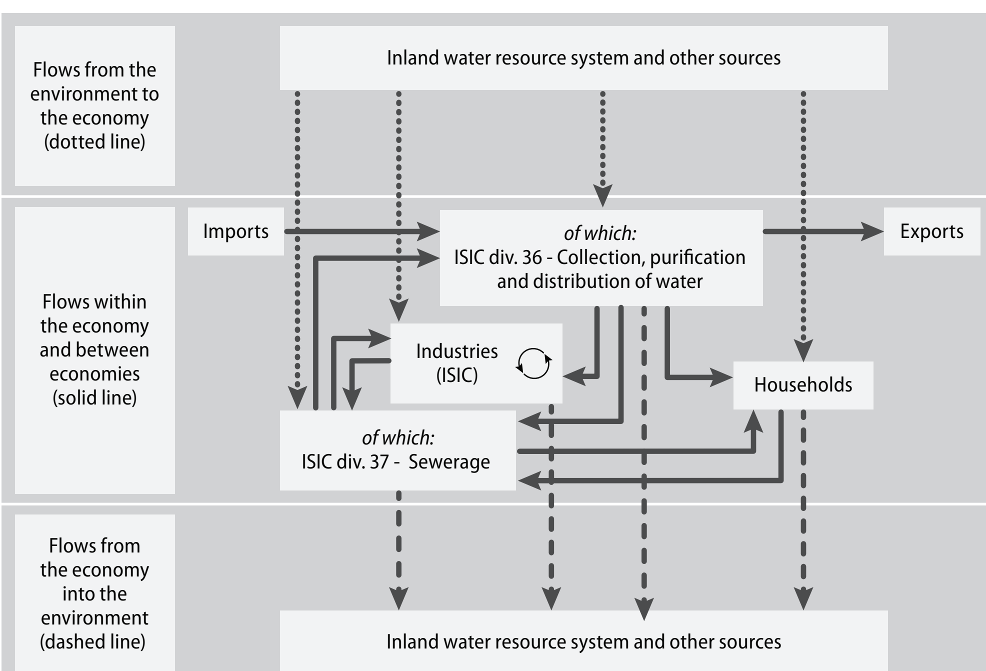
3.9. Flows within the economy involve water exchanges between economic units. Such exchanges are usually carried out through mains (pipes), but other means of transporting water are not excluded. The origin and the destination of these flows correspond to those of the monetary supply and use tables of 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 supply and use tables, which involves flows of wastewater: the industry collecting wastewater is a "user" in the physical supply and use tables while in the monetary tables that industry is a "supplier" of wastewater collection and treatment services.

3.10. Figure III.2 presents a more detailed description of water exchanges. The arrows with a solid line 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, whereas the economic unit to which the arrow points is the water user. The arrows with a dotted line represent flows from the environment to the economy and those with a dashed line represent flows from the economy into the environment.

3.11. Most of the water is generally supplied by industry ISIC division 36, water collection, treatment and supply; however, it can also be supplied by other industries and households, such as water that is supplied by industries and households for further use or that is supplied to treatment facilities before being discharged into the environment. It should be noted that the physical supply of water by households generally represents a flow of wastewater to ISIC division 37, sewerage.

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

Figure III.2
**Detailed description of physical water flows within the economy**



3.13. During the process of distributing water (between a point of abstraction and a point of use or between points of use and reuse of water), there may be losses of water.[31] Such losses may be caused by a number of factors: evaporation when water is distributed through open channels; leakages when water leaks from pipes into the ground; and illegal tapping when water is illegally diverted from the distribution network. In addition, when losses during distribution are computed as the difference between the amount of water supplied and received, there may also be errors in meter readings, malfunctioning meters, theft, etc. In the supply and use tables, the supply of water within the economy is recorded net of losses during the distribution process. Furthermore, the losses during distribution are recorded as return flows when they are due to leakages and as water consumption in all other cases.[32]

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 (export). Other economic uses of water, that is, change in inventories, are neglected, since these are usually negligible in view of the fact 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 export.

### 3. Flows from the economy back into the environment

3.16. Flows from the economy back into 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 the 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 such flows, use equals supply.

3.17. Flows from the economy into the environment are described in accounting terms in the supply table as the supply of an economic unit to the environment. Each entry represents the quantity of water generated by an economic unit and discharged into the environment; in SEEA-Water, discharges of water back into 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 water, groundwater and soil water (as specified in the asset classification in chap. VI), 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, such as hotels and restaurants.

## 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 into the environment. In particular, the use table is obtained by merging informa-

31 It should be noted that the term "water loss" may have a different meaning in different contexts. Here, the term refers to a loss of water from the economic system. Part of such losses can be seen as an actual resource from the point of view of the inland water resource system, since water, by returning to water resources, becomes available for use again.

32 See sect. C.1 for further details.

tion 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 flow that leave an economic unit: one destined for other economic units (flow within the economy) and the other destined for the environment (flow from the economy into 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 the availability of data. A simplified standard supply and use table, which countries are encouraged to compile, contains basic information on the supply and use of water and affords an overview of water flows. In addition, all the information contained in the table is balanced, that is, supply equals use. As a second step, a more detailed supply and use table can be compiled, with a more detailed breakdown of items in the simplified supply and use table.

## 1. Standard physical supply and use tables for water

3.22. Table III.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:

(*a*) ISIC divisions 1-3, which include agriculture, forestry and fishing;

(*b*) ISIC divisions 5-33 and 41-43, which include mining and quarrying, manufacturing, and construction;

(*c*) ISIC division 35: electricity, gas, steam and air-conditioning supply;

(*d*) ISIC division 36: water collection, treatment and supply;

(*e*) ISIC division 37: sewerage;

(*f*) ISIC divisions 38, 39 and 45-99, which correspond to the service industries.

3.23. ISIC divisions 35, 36 and 37 have been identified separately because of their importance in the supply and use of water and water-related services. In particular, ISIC divisions 36 and 37 are identified separately because they are key industries for the distribution of water and wastewater. Cost-recovery policies and policies aimed at improving access to safe drinking water and sanitation are examples of policies involving almost exclusively these two economic activities.

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

3.25. Table III.1 presents a detailed description of each flow of water in the simplified standard physical supply and use table.

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 the generation of hydroelectric power is also considered to be abstraction. In table III.1 water abstraction is disaggregated according to purpose (abstraction for own use and for distribution) and type of source (abstraction from inland water resources, that is, 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 previously, most of the water is abstracted for distribution under ISIC division 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 abstraction from inland water resources as well as abstraction of sea water and the direct collection of precipitation for production and consumption activities. Water is abstracted from the sea generally for cooling purposes (the corresponding wastewater flow is normally returned to the original source of water, that is, the sea or ocean) or for desalination processes. Desalinated water could be returned to the inland water resource and constitute a resource. A typical example of the collection of precipitation is the harvesting of rainwater from roofs by households.

3.29. **Abstraction from soil water** includes water use in rain-fed agriculture, which is computed as the amount of precipitation that falls onto agricultural fields. The excess of water, that is, the part that is not used by the crop, is recorded as a return flow into the environment from rain-fed agriculture. It is important to record this flow for several reasons: one reason is that it shows the relative contribution of rain-fed and irrigated agriculture to food production. In view of the importance of rain-fed agriculture worldwide (more than 60 per cent of all food production in the world is produced under rain-fed conditions), such information can be used to assess the efficiency of rain-fed agriculture, that is, to determine the 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, household or the rest of the world by another economic unit. Such water is usually delivered through mains, but other means of transport are not excluded, such as artificial open channels. It also includes the flow of wastewater to sewerage, which is identified separately along with reused water. The **use of water received from other economic units** by the rest of the world corresponds to the **export** of water. It is generally the industry under ISIC division 36 that exports water.

3.31. The **total water use** (row 3 in table III.1) of an industry is computed as the sum of the amount of water directly abstracted (row 1 in the table) and the amount of water received from other economic units (row 2 in the table). Although 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 second when it is delivered to the user—water abstracted for distribution is a water use of the distributing industry even though that industry is not the end-user of the water.

3.32. The **supply of water to other economic units** refers to the amount of water that is supplied by one economic unit 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. It should be noted 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 into several categories. However, in the standard tables only **reused water** and **wastewater to "sewerage"** are explicitly identified in view of their importance in water conservation policies.

3.34. The concept of reused water is linked to that of wastewater. **Wastewater** is water that is of no further immediate value with regard to the purpose for which it had been 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 (under ISIC division 37) (recorded as waste-

Table III.1
**Standard physical supply and use tables for water**

| **A. Physical use table** (*physical units*) | | Industries (by ISIC category) | | | | | | | 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 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 | | | | | | | | | | |
| **Within the economy** | **2. Use of water received from other economic units** | | | | | | | | | | |
| | *of which:* | | | | | | | | | | |
| | 2.a. Reused water | | | | | | | | | | |
| | 2.b. Wastewater to sewerage | | | | | | | | | | |
| | **3. Total use of water (= 1 + 2)** | | | | | | | | | | |

| **B. Physical supply table** (*physical units*) | | Industries (by ISIC category) | | | | | | | 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 | | | | | | | | | | |
| **Into the environment** | **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) | | | | | | | | | | |
| | **6. Total supply of water (= 4 + 5)** | | | | | | | | | | |
| | **7. Consumption (= 3 - 6)** | | | | | | | | | | |

**Note:** Dark grey cells indicate zero entries by definition.

water to "sewerage") or supplied to another industry for further use (reused water). Table III.1 calculates the total wastewater generated by an economic unit 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 that water which is recycled within industrial sites. It is also commonly referred to as "reclaimed wastewater". It is important to record this flow because the reuse of water can alleviate the pressure on water resources by reducing direct abstraction of water: for example, golf courses and landscaping alongside public roads can be watered with (treated) wastewater instead of surface water or groundwater. Some industries, such as power plants, can use reclaimed wastewater. A considerable volume of water is needed to cool electricity-generating equipment; using wastewater for this purpose means that the facility would not have to use higher-quality water that could be used more advantageously 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 a reuse of water in the accounting tables, but a new abstraction from the environment.

3.37. As previously mentioned, reused water excludes the recycling of water within the same industry or establishment (on site). Although information on recycled water would be very useful for the analysis of water use efficiency, generally it is not available; thus, the simplified standard tables do not report it explicitly. 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 the efficiency of water use, 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 (under ISIC division 36) before being effectively delivered to users. Such water exchanges are referred to as **intrasectoral sales**. An example is when the distribution network of one distributor/producer does not reach the water user and that network must then sell water to another distributor in order for the water to be delivered to the intended user. Such sales artificially increase the physical supply and use of water within the economy, but do not influence the global (physical) balance of water within the environment, and thus they are not recorded in the physical supply and use tables.

3.39. **Total returns** include water that is returned into the environment. Total returns can be classified according to (*a*) the receiving media, that is, inland water resources (as specified in the asset classification) and sea water, and (*b*) the type of water, such as treated water and cooling water. The standard tables report only the breakdown according to the receiving media in order to ensure that the links are maintained 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 III.1) is computed as the sum of the amount of water supplied to other economic units (row 4 in the table) and the amount of water returned to the environment (row 5 in the table).

3.41. **Storage of water**. It should be noted that water can be stored temporarily in the economy, for example, in water towers and in closed cooling or heating circuits. Therefore, when comparing the situation at the beginning and the end of the period, some changes in inventories may occur. However, those changes are generally rather small (because water is a bulky commodity and thus costly to store) in comparison with the other volumes of water; therefore, the changes in inventory are not reported in the physical supply and use tables.

3.42. Table III.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 the reduction of poverty: it is used to monitor progress towards attainment of target 7.C of the Millennium Development Goals, that is, to "halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation". Presenting all water-related information, including social information, in a common framework has the advantage of enabling consistent analyses and scenario modelling. For example, analysis of the impact that investing in water infrastructure would have on the number of people with access to improved water sources can be undertaken easily if the information is organized according to the accounting framework.

3.43. In order to gain a complete picture of the water flows within the economy, table III.1 can be supplemented with detailed information on the origin and destination of water flows by identifying who is supplying water to whom. Table III.2 presents a matrix of transfers within the economy. Each entry represents a water exchange from a supplier (by row) to a user (by column). For example, the intersection of row ISIC division 37 with the column containing ISIC division 45, wholesale and retail trade and repair of motor vehicles and motorcycles, represents the amount of water that is supplied under ISIC division 37 to ISIC division 45, which could use treated wastewater, for example, for washing cars.

Table III.2
**Matrix of flows of water within the economy** (*physical units*)

| | User | Industries (by ISIC category) | | | | | | | Households | Rest of the world | Supply of water to other economic units (row 4 of table III.1) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Supplier | | 1-3 | 5-33, 41-43 | 35 | 36 | 37 | 38, 39, 45-99 | Total | | | |
| Industries (by ISIC category) | 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 economic units (row 2 of table III.1) | | | | | | | | | | | |

## 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 the water has entered the economy but has not returned to either water resources or the sea. This happens during use because 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 III.1) and the water supply (row 6 in the table) is referred to as **water consumption**. Water consumption can be computed for each economic unit and for the whole economy. The concept of water consumption that is used in SEEA-Water is consistent with the hydrological concept. It differs, however, from the concept of consumption that is 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 follows:

> Total abstraction + use of water received from other economic units = supply of water to other economic units + total returns + water consumption

It should be noted 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 follows:

> 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 because water is generally stored only for a short period of time.

3.47. Water consumption computed for each industry 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 the difference between the use and supply by industry, using the following formula:

> Water consumption by industry *i* = total use of water by industry *i* – total supply of water by industry *i*

3.48. From the perspective of the inland water resource system, 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, by contrast, when discharged into a river, where discharged water becomes a resource for downstream uses. The concept of "inland water consumption" has been introduced in order 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 follows:

> 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 OECD/Eurostat joint questionnaire on inland waters used the concept of "freshwater consumption", which takes into consideration water that is abstracted from freshwater sources but discharged into non-freshwater sources.[33]

3.50. Since water consumption is calculated as the difference between water use and water supply, the term 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 resources. For analytical purposes it is useful to distinguish water consumption that results from evaporation and transpiration or enters into products, as a result of the production process, from water "consumption" that is the result of malfunctioning meters or illegal tapping.

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

3.51. The standard physical supply and use table in table III.1 contains aggregate flows. In practice, when compiling these accounts, a more detailed breakdown, both on the industry side and on the type of water, is often necessary for making more detailed analyses. The level of detail depends on the country's priorities and the availability of data. Table III.3 presents an example of the breakdown of water flows (shown in italics) which are useful for analytical purposes, together with a numerical example.

3.52. In Table III.3, abstraction for own use is further disaggregated into the following uses:

- Hydroelectric power generation
- Irrigation water
- Mine water
- Urban run-off
- 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, such water is directly abstracted by the power plant and returned immediately into 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.

33 The desalination of sea water, where carried out, should, on the contrary, be counted as negative consumption.

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

3.55. **Mine water** is water used for the extraction of naturally occurring minerals, including coal, mineral ore, petroleum and natural gas, and it includes water associated with quarrying, dewatering, milling and other on-site activities carried out as part of mining operations. Mine water use generally involves 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 part of abstraction. However, it is important to record this flow as it often results in the disposal of large volumes of water and the displacement of such volumes could be damaging to the environment.

3.56. **Urban run-off** is defined as that portion of precipitation in 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 storm water". It should be noted here that the term "urban areas" may also include rural residential zones. When urban run-off is collected into the sewage system, it is recorded in the use table as an abstraction from other sources (in particular from precipitation) under ISIC division 37; when it is discharged into the environment, it is recorded in the supply table as a return flow.

3.57. It is important to record the collection and discharge of urban run-off for the following reasons: (*a*) for management purposes, in order to design policies aimed at reducing the negative impacts of urban run-off on water resources, as urban run-off usually contains relatively high concentrations of pollutants, including bacteria and viruses, solid waste and toxic substances, such as heavy metals and petroleum-based compounds, which reach receiving waters; (*b*) for consistency with the monetary tables, because the value of corresponding services (collection of urban run-off) is recorded in the economic table; and (*c*) for practical reasons, in order to measure consistently the total supply and use of water under ISIC division 37. Since urban run-off ultimately merges into the return flow from ISIC division 37 into the environment, the total return of ISIC division 37 in the supply table would include urban run-off in addition to the discharge of wastewater collected from industries and households.

3.58. Although separate estimates for urban run-off 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 not only to induce thermal pollution but also to emit pollutants that are collected in the water during use, for example, when water is also used for rinsing in the manufacture of basic metals.

3.60. It should be noted that in table III.3, abstraction for own use under ISIC division 36 (water collection, treatment and supply) represents part of the total abstraction for own internal use, such as the cleaning of pipes and backwashing filters. This water is then discharged into the environment and is recorded as a return flow from ISIC division 36. In the numerical example, ISIC division 36 abstracts a total of 428.7 million cubic metres of water, of which 23.0 million cubic metres are for own use and the rest is for distribution.

3.61. Returns to the environment (row 5 of table III.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 run-off
- Cooling water
- Losses in distribution owing to leakages
- Treated wastewater

3.62. It can be relatively straightforward to collect information on the returns of **urban run-off** when a storm sewer system is in place and urban run-off is discharged separately from wastewater. In other cases, when the discharge of ISIC division 37 combines urban run-off with other wastewater discharges, estimates are necessary. In table III.3, the sewerage system collects 100 million cubic metres of urban run-off, 99.7 per cent of which is discharged into the environment.

3.63. In table III.3, 404.2 million cubic metres of water are abstracted from the environment by the industry ISIC division 35 (electricity, gas, steam and air conditioning supply), of which 300 million cubic metres are used for hydroelectric power generation and 100 million 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 III.3, the losses in distribution owing to leakage occur in the water supply of ISIC division 36, water collection, treatment and supply.

Table III.3
**Detailed physical water supply and use tables[a]**

| | | Industries (by ISIC category) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **A. Physical use table** (*millions of cubic metres*) | | 1-3 | 5-33, 41-43 | 35 | 36 | 37 | 38, 39, 45-99 | Total | Households | Rest of the world | 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 | **1 158.2** | 10.8 | | **1 169.0** |
| | 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 run-off* | | | | | *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** | **1 776.7** | **250.3** | | **2 027.0** |

| **B. Physical supply table** (*millions of cubic metres*) | | Industries (by ISIC category) | | | | | | | 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*** |
| **Into the environment** | **5. Total returns (= 5.a + 5.b)** | 65.0 | 29.4 | 400.0 | 47.3 | 483.8 | 0.7 | **1 026.2** | 4.8 | | **1 031.0** |
| | *Hydroelectric power generation* | | | *300.0* | | | | ***300.0*** | | | ***300.0*** |
| | *Irrigation water* | *65.0* | | | | | | ***65.0*** | | | ***65.0*** |
| | *Mine water* | | | | | | | ***0.0*** | | | ***0.0*** |
| | *Urban run-off* | | | | | *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** | **1 648.7** | **240.3** | | **1 889.0** |
| | **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** |

**Source:** SEEA-Water-land database.

**Note:** Dark grey cells indicate zero entries by definition; blank cells indicate cells which are non-zero, but small in the numerical example.

**a** The breakdown of water flows is shown in italics.

The remaining part of the losses in distribution, which in the table corresponds to 0.5 million cubic metres (row 7.a of table III.3), includes losses owing to evaporation and apparent losses due to illegal use and malfunctioning meters.

3.65. In addition to the breakdowns shown in table III.1, it may be useful to identify explicitly the supply of "desalinated water" (row 4.c of table III.3) for countries which rely on water desalination as a source of fresh water. It is generally under ISIC division 36 that water is desalinated and supplied within the economy. Other industries may also desalinate sea water, but often it is for their own use.

3.66. Table III.4 shows the matrix of flows associated with table III.3. This numerical example shows the origin and destination of the water flows within the economy. In particular, it can be seen that ISIC division 37, sewerage, supplies reclaimed wastewater to ISIC divisions 5-33 and 41-43, mining and quarrying, manufacturing, and construction (40.7 million cubic metres) and to ISIC divisions 1-3, agriculture, forestry and fishing (2 million cubic

Table III.4
**Matrix of water flows within the economy** (*millions of cubic metres*)

| Supplier | | Industries (by ISIC category): 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 (*row 4 of table III.3*) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Industries (by ISIC category)** | 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 economic units (row 2 of table III.1) | | 50.7 | 50.7 | 85.7 | 3.9 | 0.0 | 427.1 | **51.1** | 618.5 | 239.5 | 858.0 |

**Source:** SEEA-Water-land database.

metres). In addition, agriculture, forestry and fishing also receive reused water from mining and quarrying, manufacturing, and construction (10 million cubic metres).

## 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:

(*a*) The net supply plus the losses are shown in the amount abstracted from the environment by the suppliers of water (typically ISIC division 36);

(*b*) The losses are allocated to the supplier of water but are not explicitly shown in table III.1, although they are shown in the more detailed table III.3;

(*c*) Losses due to leakage are recorded in the return flows to the environment;

(*d*) Losses due to evaporation that occurs when, for example, water is distributed through open channels are recorded as water consumption because the losses do not return directly to water resources;

(*e*) Losses due to illegal tapping and meter malfunctioning are included under water consumption of the supplier of water.

3.68. A supplementary table can be constructed to show explicitly the losses in distribution. Table III.5 shows gross and net supplies of water within the economy as well as the losses in distribution. The data are obtained by reorganizing entries in the physical supply and use tables. Table III.5 enables the direct calculation of losses in distribution as a proportion of the gross water supply, thus producing an indicator of the efficiency of the distribution network.

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

Table III.5
**Supplementary table of losses in distribution** (*millions of cubic metres*)

| | Industries (by ISIC category) | | | | | | | 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:** SEEA-Water-land database.

3.70. There are cases where illegal tapping, that is, the illegal removal of water from the distribution network, is sufficiently significant in magnitude not only to affect the efficiency of the water distribution network but also, at times, to cause major problems within the network, such as enabling contaminants to enter into the mains via back-siphonage. Specific analyses may be required to determine the extent of this phenomenon.

3.71. For countries where illegal tapping is significant, it may be useful to identify the units (households or industries) responsible for illegally connecting to the distribution network, as well as the amount of water used by such 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 level of water use by industries and households. When linked to the monetary accounts, the information could be used in formulating pricing policies.

3.72. Consistent with the 2008 SNA, where illegal tapping is not considered to be a transaction (use) in the supply and use tables, SEEA-Water does not explicitly record such activities in its standard tables.

Chapter IV

# Water emission accounts

## A. Introduction

4.1. Emissions into water can constitute a major environmental problem and cause the quality of bodies of water to deteriorate. Different types of pollutants generated during production and consumption activities are discharged into bodies of water. Some of the pollutants emitted into water resources are highly toxic and thus negatively affect the quality of the receiving body of water 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 adversely affecting the ecological status of the receiving body of water.

4.2. Emission accounts describe the flows of pollutants added to wastewater as a result of production and consumption, and flowing into water resources directly or indirectly through the sewage network. They measure the pressure on the environment caused by human activities by presenting information on those activities responsible for the emissions, the types and amount of pollutants added to wastewater as well as the destination of the emissions, such as water resources and the sea. Emission accounts form a useful tool for designing economic instruments, including new regulations aimed at reducing emissions into water. When analysed in conjunction with the technology in place to reduce emissions and treat wastewater, such accounts 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 their scope and coverage. 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 into water refer to the direct release of pollutants into water as well as their indirect release by transfer to an off-site wastewater treatment plant.[34] In SEEA-Water, emission accounts focus only on the release of pollutants into water resources through the direct and indirect (via a wastewater treatment plant) discharge of wastewater into water resources. The direct discharge of heavy metals and hazardous waste into water resources through means other than wastewater is not covered in the water emission accounts; instead, it is covered in the waste accounts as that type of discharge involves solid waste.[35]

34 European Commission, *Guidance Document for EPER Implementation* (Luxembourg, Office for Official Publications of the European Communities, 2000). Available from http://eper.cec.eu.int/eper/documents/guidance%5Fhtml, or http://www.eper.cec.eu.int/eper/documents/eper_en.pdf.

35 In the European context, emissions to air, land and water are covered, for example, in Council Directive 96/61/EC of 24 September 1996, concerning integrated pollution prevention and control, and in Regulation (EC) No. 166/2006 of the European Parliament and of the Council of 19 January 2006, concerning the establishment of the European Pollutant Release and Transfer Register.

4.5. Emission accounts record the amount of pollutants added to water by an economic activity during a reference period (generally an accounting year); they are expressed in terms of weight (kilograms or tons), 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 III that are destined for 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 into water bodies; and (*c*) selected non-point source emissions, namely, emissions from urban run-off and agriculture. The emission accounts thus furnish descriptions, in terms of pollutants resulting from production and consumption, of the wastewater flows discussed in chapter III. Table IV.1 affords an overview of the types of emission included in the emission accounts.

## 1. 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 for which the geographical location of the discharge of the wastewater is clearly identified. They include emissions from wastewater treatment plants, power plants and 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 body of water. Pollutants are generally carried off the land by storm-water run-off or they 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 are agriculture and urban areas.

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

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 III, namely, urban run-off and irrigation water. Urban run-off is described in the emission accounts in terms of the pollutants deposited in urban areas and in the air, often as a result of transport or other economic activities. Returns from irrigation water and rain-fed agriculture are described in terms of the pollutants which are added to the return flows from agricultural land, that is, fertilizers and pesticides that spread on the soil during infiltration into groundwater or run-off to surface water.

4.9. For the sake of simplicity, as well as to maintain consistency with the water flows in the physical supply and use tables presented in chapter III, a number of non-point source emissions are excluded, although they affect the quality of water resources. In a more comprehensive approach, all emissions into water would be included in the emission accounts, for example, pollutants that reach the bodies of water after leaching from landfill sites or having passed through natural land. As precipitation passes through waste, it picks up polluting compounds, including ammonia, heavy metals, chlorides and oxygen-depleting substances which ultimately infiltrate the soil and reach a groundwater body. The same can occur when precipitation, after having absorbed pollutants contained in the air, infiltrates natural land.

Table IV.1
**Scope of emission accounts**

| Include | Exclude |
|---|---|
| Point sources:<br>Pollutants added to wastewater | Point sources:<br>Discharges of heavy metals and hazardous wastes not contained in wastewater (included in the System of Environmental-Economic Accounting for Water waste accounts)<br>Pollutants resulting from in situ use (e.g., navigation, fishing) |
| Non-point sources:<br>Urban run-off<br>Irrigation water and rain-fed agriculture | Non-point sources:<br>All non-point sources except for urban run-off, irrigation water and rain-fed agriculture (included in the quality accounts) |

## 2. Water pollutants

4.10. Before starting the compilation of emission accounts, a list of pollutants has to be defined. Most often, the list of pollutants is based on the country's environmental concerns as well as its national legislation on water and, where applicable, international agreements. For example, in the case of countries in the European Union, the previously mentioned European Union Water Framework Directive supplies, inter alia, an indicative list of pollutants, which is reported in box IV.1, as well a list of priority substances.[36]

Box IV.1
**Indicative list of the main pollutants in the European Union**

1. Organohalogen compounds and substances which may form such compounds in an aquatic environment.
2. Organophosphorous compounds.
3. Organotin compounds.
4. Substances and preparations, or their breakdown products, which have been proven to possess carcinogenic or mutagenic properties or properties which may affect steroidogenic, thyroid, reproductive 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 biochemical oxygen demand and chemical oxygen demand.

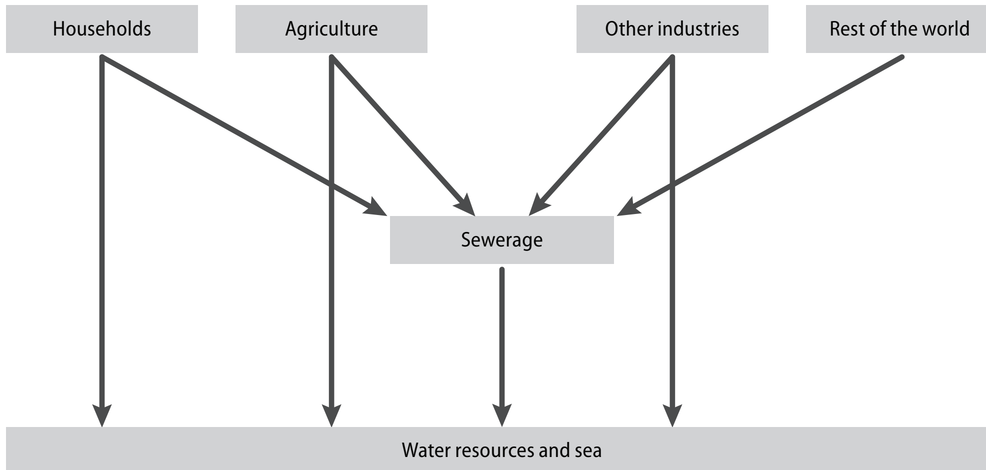
**Source:** European Parliament and Council, Directive 2000/60/EC, *Official Journal of the European Communities* 22/12/2000, annex VIII, 22 December 2000. Available from http://europa.eu.int/comm/environment/water/water-framework/index_en.html.

## 3. 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 IV.1 shows schematically the path followed by the wastewater and the associated pollutants generated by an economic unit. The economic units identified in the figure are households, agriculture, other

36 The list of priority substances, which was established by Decision No. 2455/2001/EC of the European Parliament and of the Council on 20 November 2001, lists 33 substances or groups of substances which have been shown to be of major concern for European waters.

Figure IV.1
**Wastewater and associated pollutant pathway**




**Source:** Dominique Preux and Benoît Fribourg-Blanc, "Overview of emissions to water: existing data collections", paper prepared for the Intersecretariat Working Group on Environment Statistics, Work Session on Water Statistics, Vienna, 20-22 June 2005. Available from http://unstats.un.org/unsd/environment/envpdf/pap_wasess4b1france.pdf.

industries and the rest of the world. The wastewater and associated pollutants are 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 into the environment can occur in one or two steps (directly or through a treatment plant, ISIC division 37) leads to a distinction between gross and net emissions. "Gross emissions" are the pollutants added to 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 emissions" (or "final emissions") correspond to the pollutants discharged into water resources. When wastewater is discharged directly into a body of water, gross and net emissions coincide. However, in practice, an economic activity may discharge part of its wastewater directly into water resources, thus releasing the pollutants directly, and thereafter supply the rest to a wastewater treatment plant which, after treating it, discharges the "treated" wastewater into the environment. Since treated wastewater may still contain traces of the pollutant generated by the economic activity, the net emissions of the economic unit would correspond to the sum of the directly released pollutants into water resources and that indirectly released through wastewater treatment plants.

4.13. For the whole economy, the difference between gross and net emission 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, such as that which results from agriculture.

4.14. In the calculation of the net emissions, the release of pollutants by the sewerage industry (ISIC division 37) has to be reallocated to the economic unit responsible for the discharge in the first place. This is often difficult to calculate, because industry ISIC division 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 division 37 to the economic unit originally 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 division 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, within 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 or flowing to the open sea. These are covered in the quality accounts in chapter VII.

## 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 into the river is $y$ kg, only $(y - x)$ kg is recorded, as it represents the quantity of pollution generated by the industry. This has several implications for the measurement of emissions: the level of emissions is not that of the pollutants contained in the outgoing flows of water, but is measured by calculating the difference between the pollutant content of the incoming and outgoing flows. Although the pollutant content of drinking water should normally be negligible, the pollutant content of the incoming water for some other uses, such as cooling, or process water, can be significant.

4.17. Pollution is generally measured in terms of the quantity of a measured determinand (see, for example, the list of pollutants shown in box IV.1) released during a certain period. It can be expressed either directly in terms of the quantity of a determinand (for example, in kilograms of dissolved oxygen) or in an arbitrary unit that represents one or more determinands, such as the population equivalent,[37] which includes biochemical oxygen demand (BOD), nitrogen, phosphorus and suspended solids.

4.18. Information on emissions into water is organized in the accounts according to table IV.2. In order to avoid double counting the emissions by ISIC division 37, sewerage, emission accounts comprise two tables: the first, part A, starts with a description of the gross emissions by industry. In this table, only the pollutant content of the urban run-off collected and discharged by ISIC division 37 is recorded under the ISIC division 37 column, which is the economic activity responsible for its collection and discharge.

4.19. The second part of the table of the emission accounts, part B, records the emissions into water by ISIC division 37. It allows for the reallocation of emissions of ISIC division 37 to the industries generating them in the first place, thus enabling the calculation of net emissions. Table IV.2, part A (gross and net emissions), reports the following items:

(*a*) The total amount of a pollutant generated by an economic unit (gross emissions) measured at the point of discharge (row 1). This information is disaggregated into the following categories:

(i) The quantity of pollutant that is released directly into water, that is, the pollutant is contained in the direct discharge of wastewater into the environment (row 1.a);

(ii) The quantity of pollutant that is released into the sewer system (row 1.b). It should be noted that the pollutant content of the urban run-off collected by ISIC division 37 is recorded in this row;

37 According to the *OECD Glossary of Statistical Terms*, one population equivalent refers to the amount of oxygen-demanding substances whose oxygen consumption during biodegradation equals the average oxygen demand of the wastewater produced by one person. Here, it refers to an organic biodegradable load (having a BOD5) of 60 grams of oxygen per day.

(*b*) The indirect emissions into the environment made by each industry through ISIC division 37 (row 2). These emissions can be calculated once the emissions into water by ISIC division 37 are identified in part B of table IV.2;

(*c*) The net emissions by industry (row 3) are obtained by summing the direct and indirect emissions.

4.20. The direct emissions into water are further disaggregated according to whether wastewater has undergone on-site treatment (rows 1.a.1 and 1.a.2 of table IV.2)[38] and/or according to the receiving media (rows 1.a.i and 1.a.ii), that is, water resources and the sea. Additional information can be presented in supplementary tables to further disaggregate emissions according to the type of receiving media, such as surface water or groundwater.

4.21. Part B (emissions by ISIC division 37) of table IV.2 presents detailed information on the emissions into water by ISIC division 37, sewerage, and enables the calculation of net emissions by various industries. In particular, the second part of table IV.2 presents the following information:

(*a*) The total amount of pollutant released by ISIC division 37, sewerage (row 4), which is disaggregated as follows:

(i) The volume of pollutants that is released directly into water after having undergone treatment (row 4.a);

(ii) The volume of pollutants that is released directly into water without treatment (row 4.b), for example, in discharges of raw sewage through a sewage-collecting system.

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

4.23. In order to calculate net emissions by industry, the emissions into water by ISIC division 37 (row 4 of table IV.2) have to be reallocated to the industry responsible for the discharge in the first place. Row 2 of table IV.2 shows explicitly the reallocation of emissions from ISIC division 37 to the various industries. In this example, the emissions by ISIC division 37 have been reallocated applying a global abatement rate of 67 per cent[39] to the pollutant release of each industry into the sewage network (row 1.b of table IV.2). It should be noted that, in this numerical example, it is assumed that urban run-off is discharged without treatment (see also table III.3); hence, for ISIC division 37, the figures in rows 2 and 4.b are the same. Net emissions (row 3 of table IV.2) are calculated by adding the direct emissions by industry (row 1.a) and the reallocation of emissions by ISIC division 37 (row 2).

4.24. When information is available, emissions from wastewater treatment plants could be further disaggregated in table IV.2 according to the type of treatment process. Three types of treatment processes are identified by the UNSD/UNEP questionnaire, namely, mechanical, biological and advanced, and by the OECD/Eurostat joint questionnaires: namely, primary, secondary and tertiary.

38 Note that it would be useful to have data on the amount of pollutant before the on-site treatment and after treatment in order to compute the “depollution” efficiency of an industry. However, since it is not mandatory to report emissions to an on-site facility in the emission registers for national policies, they are not included in the tables. (See European Commission, *Guidance Document for EPER Implementation* (Luxembourg, Office for Official Publications of the European Communities, 2000), annex 2, p. 77.)

39 In this example, the global abatement rate is obtained by dividing the pollutants removed by ISIC division 37 (row 1.b-row 4) by the pollutant received by ISIC division 37 (row 1.b). This corresponds to the equation: (16 878.0 – 5 594.8)/16 878.0 = 0.67.

Table IV.2
**Emission accounts**

**A. Gross and net emissions** (*tons*)

| Pollutant chemical oxygen demand | Industries (by ISIC category) 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) | **3 150.2** | **5 047.4** | **7 405.1** | **1 851.0** | **498.5**[a] | **1 973.8** | **19 925.9** | **11 663.6** | | **31 589.5** |
| 1.a. Direct emissions to water (= 1.a.1 + 1.a.2 = 1.a.i + 1.a.ii) | 2 470.0 | 390.1 | 7 313.2 | 1 797.8 | 0.0 | 27.7 | **11 998.7** | 2 712.7 | | **14 711.5** |
| *1.a.1. Without treatment* | *2 470.0* | *257.4* | *7 313.2* | *1 797.8* | | *7.9* | ***11 846.2*** | *1 865.0* | | ***13 711.3*** |
| *1.a.2. After on-site treatment* | | *132.7* | *0.0* | *0.0* | | *19.8* | ***152.5*** | *847.7* | | ***1 000.2*** |
| *1.a.i. To inland water resources* | *2 470.0* | *311.8* | *5 484.9* | *1 797.8* | | *27.7* | ***10 092.2*** | *2 599.7* | | ***12 691.9*** |
| *1.a.ii. To the sea* | *0.0* | *78.3* | *1 828.3* | *0.0* | | *0.0* | ***1 906.6*** | *113.0* | | ***2 019.6*** |
| 1.b. To sewerage (ISIC 37) | 680.2 | 4 657.3 | 92.0 | 53.2 | 498.5 | 1 946.0 | **7 927.2** | 8 950.9 | | **16 878.0** |
| **2. Reallocation of emissions by ISIC 37** | **213.6** | **1 403.3** | **66.8** | **16.7** | **498.5** | **585.9** | **2 784.7** | **2 810.1** | | **5 594.8** |
| **3. Net emissions** (= 1.a + 2) | **2 683.6** | **1 793.3** | **7 380.0** | **1 814.5** | **498.5** | **613.6** | **14 783.5** | **5 522.8** | | **20 306.3** |

**a** Corresponds to the pollutant content of the urban run-off collected by sewerage. In this numerical example, urban run-off is collected and discharged without treatment; thus, gross and net emissions coincide for ISIC division 37.

**B. Emissions by ISIC division 37** (*tons*)

| Pollutant chemical oxygen demand | ISIC division 37 |
|---|---|
| **4. Emissions into water** (= 4.a + 4.b) | **5 594.8** |
| 4.a. After treatment | 5 096.3 |
| *Into water resources* | *2 396.4* |
| *Into the sea* | *2 699.9* |
| 4.b. Without treatment | 498.5 |
| *Into water resources* | *234.4* |
| *Into the sea* | *264.1* |

**Source:** SEEA-Water-land database.

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 division 37 and the number of people with access to improved sanitation. Annex II furnishes an example of a supplementary table to the emission accounts.

4.26. In some countries, legislation regulates the generation and disposal of sewage sludge. Such legislation requires the collection of information on sludge production, usually its dry weight, depending on the method of water treatment and sludge treatment, such as digestion or filter-pressing, because the concentration of dry solids can vary considerably, as can the pollutant content of the sludge. For European countries, for example, the "sewage sludge directive"[40] regulates the generation and use of sewage sludge in order to prevent harmful effects on soil, vegetation, animals and people. The directive also encourages the use of sludge.

4.27. During wastewater treatment, solids are separated from water and they are accumulated as sewage sludge. Owing to the physical-chemical processes involved in the treatment, the

40 European Parliament and Council Directive 86/278/EEC of 18 June 1986 on the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture, *Official Journal L 181, 04/07/1986 P. 0006-0012*. Available from http://europa.eu.int/eur-lex/lex/LexUriServ/LexUriServ.do?uri=CELEX:31986L0278:EN:HTML.

sludge tends to concentrate heavy metals and poorly biodegradable trace organic compounds as well as potentially pathogenic organisms (viruses and bacteria), if they are present, in the wastewater. Yet sludge can be rich in nutrients, such as nitrogen and phosphorous, and it may contain valuable organic matter that is useful for replenishing depleted soils or those subject to erosion.

4.28. The previously mentioned target of the Millennium Development Goals reporting the number of people with access to improved sanitation (target 7.C) is an indicator of a country's ability to prevent damage to human and environmental health originating from wastewater discharge by avoiding, for example, the spread of excreta-related diseases and by reducing the pollution of water resources. The indicator is based on the distinction between improved and unimproved sanitation. Improved sanitation technologies consist of connection to a public sewer, connection to a septic system, pour-flush latrines and ventilated improved pit latrines. Unimproved sanitation technologies consist of service or bucket latrines, where excrement is removed manually, public latrines and latrines with an open pit.[41] Presentation of information on this indicator together with the accounts facilitates integrated analyses of emissions into water.

## 1. Urban run-off

4.29. The collection and discharge of urban run-off is recorded in terms of both volume (in the physical supply and use tables) and pollutant load (in the emission accounts). This is because urban run-off is highly polluted and there is increasing awareness of the potential danger of discharging it into the environment without treatment. Urban run-off usually contains a great deal of litter and organic and bacterial wastes as well as chemicals, such as oil, antifreeze, detergent, pesticide and other pollutants, that wash down 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 roads).

4.30. Even though the pollution content of urban run-off is the result of "diffuse" pollution and the run-off can often have natural origins (for example, leaves washed into gutters can create an organic form of pollution), its emissions into water are allocated to ISIC division 37, sewerage, since this is the economic unit responsible for its collection and discharge.

4.31. It should be noted that, when urban run-off 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 run-off.

## 2. ISIC division 36, water collection, treatment and supply

4.32. Emission accounts report (through ISIC division 37) the direct and indirect release of wastewater pollutants into the environment. Thus, the removal of pollutants during purification processes by the industry concerned (ISIC division 36, water collection, treatment and supply) does not appear in table IV.2. In addition, water supplied by ISIC division 36 can, in most cases, be considered almost free of pollutants, such as those described in section B of this chapter, because purification of water generally involves the removal of other pollutants, such as microbiological pollutants.

4.33. Supplementary tables can be constructed to analyse the pollutant load of the water abstracted and supplied by ISIC division 36 to study the efficiency of purification processes, that is, the removal of pollutants from abstracted water before its distribution.

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41 World Health Organization and United Nations Children's Fund Water Supply and Sanitation Collaborative Council, *Global Water Supply and Sanitation Assessment, 2000 Report* (Geneva, WHO, and New York, UNICEF), pp. 77-78.

Chapter V

# 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 aimed at achieving efficient allocation of water 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 supply and use 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 that infrastructure; and (*d*) the fees paid by the users for water-related services, as well as the subsidies received. The economic instruments for managing 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 for studying the economy of water involves presenting the conventional national accounts together with physical information on water abstraction, namely, its supply and use within the economy, and the discharge of wastewater and pollutants into the environment. These accounts are referred to as "hybrid accounts", where the term "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 enables the derivation of consistent indicators for evaluating the impact on water resources of changes in the economy, such as changes in economic structure and in interest rates. Using the hybrid accounts in economic models makes possible the analysis of potential 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 for (*a*) water-related activities carried out for own use, that is, when industries and households abstract water for their own use, or treat the wastewater they generate; and (*b*) government expenditures for water-related services, such as the formulation and administration of government policy and the setting and enforcing of public standards. Even though the value of these activities is likely to be small compared with 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 expenditures on water-related services are discussed in section C.

5.4. Even though they are not explicitly discussed in SEEA-Water, complete stock accounts, in physical and monetary units, for water-related infrastructure can be compiled by disaggregating the relevant information from the standard 2008 SNA accounts for produced assets. The standard tables furnish information only 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 2008 SNA, often require additional data sources and the undertaking of data-collection activities to identify separately those assets in monetary terms in the standard national accounts, as well as to obtain information on the physical characteristics of these structures, such as their number, capacity, lifetime and depreciation. Stock accounts for water-related infrastructure can assist in formulating and evaluating policies that are aimed at improving access to water and sanitation. The ability to improve access to these services is highly dependent on investments in infrastructure or on infrastructure which is 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 because users of water and water-related products do not always pay for the entire costs associated with their use. They benefit from transfers from other economic units (generally governmental) which bear part of the costs. Similarly, investments in infrastructure are also often partly financed by units other than the one that benefits from its use. Analysis of the financing of the use of water and water-related products, as well as investments in water-related infrastructure, produces information on how the expenditures are financed: by which agent and by means of what instrument, such as the sale of services or environmental taxes. Such information is relevant, for example, for assessing the implementation of the polluter/user-pays principle, as the accounts for financing show the portion of the total cost paid by the polluter or user.

## B. Hybrid supply and use tables

5.7. Hybrid supply and use tables juxtapose the standard SNA supply and use table with the corresponding physical tables described in chapters III and IV. In so doing, the physical and monetary data share the same structure, classifications and concepts. Physical information is juxtaposed with the monetary supply and use tables in respect of (*a*) water abstraction, supply and use within the economy, and returns into the environment; and (*b*) the emission 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.[42]

5.8. Hybrid accounts can be presented in two ways: one is based on the supply and use tables; the other, on input-output tables. For a more general and extensive description of hybrid accounts and input-output tables, reference is made to chapter 4 of SEEA-2003 and chapters 14 and 18 of the 2008 SNA. Here, the focus is on the supply and use table presentation of hybrid accounts.

5.9. The starting point for the hybrid supply and use tables is the 2008 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 previously described CPC Version 2. The industries are classified, by column, according to ISIC Rev. 4.

42 Ibid., para. 4.6.

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

(*a*) Natural water (CPC 1800), which is associated primarily with the output of ISIC division 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 division 36 and other economic units, such as other industries, households and the rest of the world). It should be noted that this division is very broad, covering very different types of water exchanged in the economy, including reused water;

(*b*) Sewerage, sewage treatment and septic tank cleaning services (CPC 941). This group includes 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 division 37, sewerage.

5.11. Depending on data availability, other products related to water could also be explicitly identified in the tables. These include the following: operation of irrigation systems for agricultural purposes, which is part of CPC 86110 and is primarily (and uniquely) associated with the output of ISIC class 0161, support activities for crop production; water-related administrative services, which are part of CPC 91123 and primarily associated with the output of ISIC class 8412; and site remediation and clean-up services (for surface water and groundwater) (CPC 94412 and part of CPC 94413), associated primarily with the output of ISIC class 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 the availability of data. The simplified standard tables identify a limited number of groups of industries for ease of compilation. These include the following:

(*a*) ISIC divisions 1-3: agriculture, forestry and fishing;

(*b*) ISIC divisions 5-33 and 41-43, which include mining and quarrying, manufacturing, and construction;

(*c*) ISIC division 35: electricity, gas, steam and air-conditioning supply, in particular; and hydroelectric power generation, transmission and distribution (part of ISIC division 3510);

(*d*) ISIC division 36: water collection, treatment and supply;

(*e*) ISIC division 37: sewerage;

(*f*) ISIC divisions 38, 39 and 45-99, which correspond to the service industries.

5.13. It is highly recommended for analytical purposes when compiling water accounts to further disaggregate the activities related to water other than ISIC classes 3600 and 3700, namely, the operation of agricultural equipment (part of ISIC class 0161), remediation activities and other waste management services related to water (part of ISIC class 3900) and administration of water-related programmes (part of ISIC class 8412).

5.14. It should be noted that in some countries the activities of water supply (ISIC division 36) and sewerage (ISIC division 37) are carried out by the same establishment and no separate accounts are kept by that establishment. This makes it difficult to separate information on the costs related to the two separate ISIC divisions. To the extent possible, therefore, information should be disaggregated in order to show explicitly the costs and the output of each of these activities. Additional information and estimation may be needed to separate these activities. As recommended in the 2008 SNA, in cases where water and wastewater are produced in an integrated production process, the cost structure of the firm which is treating the wastewater may be used only to estimate the portion of the cost for treating the wastewater.

## 1. Hybrid supply table

5.15. Table V.1 shows the form of the standard hybrid supply table, which consists of three parts:

(*a*) **Monetary supply table.** This table describes in monetary units the origin of products. It organizes information according to the 2008 SNA supply table where products are shown in rows and the producers are presented in columns;

(*b*) **Physical supply table of water.** This table contains information on the volumes of water supplied to other economic units (which corresponds to row 4 of table III.3) and discharged (returns) into the environment (which corresponds to row 5 of table III.3). This information corresponds to the physical supply table described in chapter III;

(*c*) **Total emission of pollutants in physical units.** Gross emissions are shown in this table by industry for the sake of simplicity (entries correspond to row 1 of table IV.2). Information on net emissions can also be shown in the same table. This information corresponds to the emission accounts described in chapter IV.

5.16. The monetary supply table presented in table V.1 shows, by column, the following information:

(*a*) Output at basic prices by industries classified according to ISIC Rev. 4;

(*b*) Imports;

(*c*) Other items to derive the total supply at purchasers' prices, namely: (i) taxes and subsidies on products; and (ii) trade and transport margins. Trade and transport margins include trade margins plus any transport charges paid separately by the purchasers in taking delivery at the required time and place.[43] In the case of water, transport margins are generally not invoiced separately and trade margins are often insignificant. For these reasons, table V.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 divisions 36 and 37 because they group together establishments having as their principal activities the distribution of water and wastewater services, respectively. Since an establishment may engage in other activities, SNA makes a distinction between principal and secondary activity. The "principal activity" of a producer unit is the activity with a value added exceeding 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.[44] The "secondary activity" is an activity carried out within a single producer unit in addition to the principal activity; its output, as in the case of the principal activity, must be suitable for delivery outside the producer unit.[45]

5.18. In the numerical example in table V.1, an industry (or group of industries) in ISIC divisions 5-33 and 41-43 supplies water as a secondary activity for a total of 40 million currency units. In addition, ISIC division 37 supplies water as a secondary activity. This corresponds to reused water from ISIC division 37 for further use in other industries.

43 Ibid., para. 15.40.

44 Ibid., para. 5.7.

45 Ibid., para. 5.8.

Table V.1
**Hybrid supply table**

| | Output of industries (by ISIC category) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 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 of currency units*) | 137.6 | 749.00 | 22.1 | 3.3 | 1.7 | 9.0 | 367.0 | **1 286.4** | 363.0 | 70.0 | 0.0 | **1 719.4** |
| *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 | 0.0 | **1.8** |
| 1.b. Sewerage services (CPC 941) | 0.0 | 0.00 | 0.0 | 0.0 | 0.0 | 8.8 | 0 | **8.8** | 0.0 | | 0 | **8.8** |
| **2. Total supply of water** (*millions of cubic metres*) | 82.9 | 157.00 | 405.6 | 300.0 | 426.9 | 526.5 | 49.8 | **1 648.7** | 0.0 | | | **1 648.7** |
| 2.a. Supply of water to other economic units | 17.9 | 127.60 | 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 | 117.60 | 5.6 | 0.0 | 1.4 | 0.0 | 49.1 | **191.6** | 0.0 | | | **191.6** |
| 2.b. Total returns | 65.0 | 29.40 | 400.0 | 300.0 | 47.3 | 483.8 | 0.7 | **1 026.2** | | | | **1 026.2** |
| **3. Total (gross) emissions of chemical oxygen demand** (*thousands of tons*) | 3 150.2 | 5 047.40 | 7 405.1 | 0.0 | 1 851.0 | 498.5 | 1 973.8 | **19 925.9** | | | | **19 925.9** |

**Source:** SEEA-Water-land database.
**Note:** Dark grey cells indicate zero entries by definition.

## 2. Hybrid use table

5.19. Table V.2 shows the format of the standard hybrid use table. It consists of two parts:

(*a*) **Monetary use table.** This table 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 in the conventional 2008 SNA use table;

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

5.20. The uses of products in table V.2 are described, by column, in terms of intermediate consumption, final consumption, exports and gross capital formation. Each of these uses is described below.

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 purchasers' prices.

5.22. In SEEA-Water, **final consumption** is measured in table V.2 in terms of actual final consumption rather than in terms of expenditures, which is the common practice in the 2008 SNA. This is done in order to monitor the link between the physical quantities of water and the monetary values of the goods and services delivered to households: water-related services often are not purchased directly by households, but are provided to them

Table V.2
**Hybrid use table**

| | Intermediate consumption of industries (by ISIC category) | | | | | | | | Actual final consumption | | | | | Capital formation | Exports | Total uses at purchaser's price |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 35 | | | | | | Households | | | Govern-ment | 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 non-profit institutions serving households | Total | | | | | |
| **1. Total intermediate consumption and use** (*billions of currency units*) | 72.9 | 419.4 | 9.9 | 1.1 | 1.10 | 1.7 | 157.8 | **664.0** | 321.4 | 131.4 | **452.8** | 53.6 | **506.4** | 146.0 | 403.0 | **1 719.4** |
| *of which:* | | | | | | | | | | | | | | | | |
| 1.a. Natural water (CPC 1800) | 0.2 | 0.3 | 0.02 | 0.0 | 0.00 | | 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 of cubic metres*) | 159.1 | 200.2 | 408.1 | 300.0 | 428.70 | 527.2 | 53.4 | **1 776.7** | | | **250.3** | | **250.3** | | 0.0 | **2 027.0** |
| 3.a. Total abstraction (U1) | 108.4 | 114.5 | 404.2 | 300.0 | 428.70 | 100.1 | 2.3 | **1 158.2** | | | **10.8** | | **10.8** | | | **1 169.0** |
| *of which:* | | | | | | | | | | | | | | | | |
| 3.a.1. Abstraction for own use | 108.4 | 114.6 | 404.2 | 300.0 | 23.00 | 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 | - | 0.00 | 427.1 | 51.1 | **618.5** | | | **239.5** | | **239.5** | | 0.0 | **858.0** |

**Source:** SEEA-Water-land database.
**Note:** Dark grey cells indicate zero entries by definition.

by governmental and non-profit institutions serving households (NPISHs) free, or almost free, of cost. Actual final consumption measures the value of the goods or services delivered to households, regardless of whether they are paid by the households concerned or by governmental units and NPISHs through social transfers in kind. Box V.1 shows how the actual final consumption is computed from final consumption expenditures.

5.23. Actual final consumption comprises the following two categories:

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

(*b*) **Actual final consumption of the Government**, which corresponds to its collective (as opposed to individual) consumption expenditures (2008 SNA, para. 9.114).

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 subsectors of the household sector. It is therefore attributed to the same governmental units that incur the corresponding expenditures.[46] In the case of water, administrative services of water control and water quality monitoring are examples of services furnished to the community as a whole, and their use is attributed to the Government as a collective consumer. Box V.2 presents the conditions of the 2008 SNA that distinguish between individual and collective goods and services.

5.25. Gross capital formation (GCF) is the total value of gross fixed capital formation and changes in inventories and acquisitions less the disposal of valuables. It is included in table V.2 at the aggregated level for consistency of presentation with the 2008 SNA tables in order to show the basic identity that supply equals use. In table V.2, 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 the sale of products from residents to non-resident units. In the numerical example in table V.2, there are no exports of water and wastewater services.

## 3. Hybrid account for supply and use of water

5.27. Tables V.1 and V.2 can be presented together to form the hybrid account for the supply and use of water as presented in table V.3. Table V.3 furnishes information by industry on the output produced, as well as the water-related output, the intermediate consumption, including the cost 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 into 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 division 36) and sewerage (ISIC division 37)

46 Ibid., para. 9.91.

## Box V.1
### From final consumption expenditure to actual final consumption

Total final consumption in the economy may be viewed from two perspectives. 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 non-profit institutions serving households (NPISHs) and general governmental 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.

The relevant paragraphs of the 1993 System of National Accounts (SNA) describing the concepts of final consumption expenditure and actual final consumption are presented below.

**Final consumption expenditure includes paras. 9.113, 9.114 and 9.115 of the 2008 SNA:**

(*a*) Household final consumption expenditure consists of the expenditure, including expenditure whose value must be estimated indirectly, incurred by resident households on individual consumption goods and services, including those sold at prices that are not economically significant and including consumption of goods and services acquired abroad;

(*b*) General government final consumption expenditure consists of expenditure, including expenditure whose value must be estimated indirectly, incurred by general government on both individual consumption goods and services and collective consumption services;

(*c*) Final consumption expenditure of NPISHs consists of the expenditure, including expenditure whose value must be estimated indirectly, incurred by resident NPISHs on individual consumption goods and services and possibly on collective consumption services.

**Actual final consumption includes paras. 9.116, 9.117 and 9.118 of the 2008 SNA:**

(*a*) Actual final consumption of households 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, above)
- Those acquired as social transfers in kind from general government and NPISHs that are the output of these institutions as non-market producers
- Those acquired as social transfers in kind from general government and NPISHs that have been purchased by these institutions from market producers for onward transmission to households free or at prices that are not economically significant

(*b*) Actual final consumption of general government is measured by the value of the collective consumption services provided to the community, or large sections of the community, by general government;

(*c*) Actual final consumption of NPISHs is measured by the value of the collective consumption services provided to the community, or large sections of the community, by NPISHs.

The table below shows how to obtain information on actual final consumption from the 2008 SNA use table. Total final consumption may be presented by reorganizing the columns as follows: the table on the left shows the 2008 SNA presentation of the use table, that is, table 14.7 of the 2008 SNA, using the expenditure side. The table on the right shows the SEEA-Water presentation of the use table using the acquisition side.

| | Total final consumption recorded in the 2008 SNA use table | | | | | Total final consumption recorded in the SEEA-Water use table | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Final consumption expenditure | | | | | Actual consumption | | | |
| | | | Government (c) = ($c_i$) + ($c_{ii}$) | | | Households | | | |
| | Households (a) | NPISHs (individual) (b) | Collective ($c_i$) | Individual ($c_{ii}$) | Total = (a) + (b) + (c) | Final consumption expenditures (a) | Social transfers in kind from Government and NPISHs (b) + ($c_{ii}$) | Government ($c_i$) | Total = (a) + (b) + ($c_i$) + ($c_{ii}$) |
| **Total use of products** | | | | | | | | | |

Box V.2

**Individual and collective goods and services of government and non-profit institutions serving households**

The consumption expenditures incurred by government units and non-profit institutions serving households (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" goods, 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 supplied 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 concerned only 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 if 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.

**Source:** United Nations, *SNA Handbook on Integrated Environmental and Economic Accounting* (United Nations publication, Sales No. F.93.XVII.12); and Commission of the European Communities, International Monetary Fund, Organization for Economic Cooperation and Development, United Nations and World Bank, *System of National Accounts, 2008* (United Nations publication, Sales No. E.08.XVII.29).

are carried out by the Government (as may be the case in some countries), they should be classified to the extent possible in the specific divisions (ISIC 36 and 37) and not in ISIC division 84, public administration.

5.29. Where information is available, the producing units could be further disaggregated according to the type of institutional sector that owns them (Government, corporation or household). Such information can be useful for assessing, for example, the degree of involvement of the Government in water supply or wastewater sanitation.

5.30. Table V.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 it relates to water supply or wastewater services.

5.31. In order to enhance their analytical capacity, the accounts can be augmented with supplementary information on specific aspects related to water. Such information 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 also indicators in target 7.C of the Millennium Development Goals, are notable examples of social indicators that could be linked to the SEEA-Water accounting tables. Information on labour input may be important for analysing the impact of water allocation policies on employment. Similarly, information on access to water and sanitation may be used to evaluate policy reforms and structural changes aimed 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 account presented in table V.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 identified explicitly in the national accounts. Their costs are incorporated into those of the principal activity of the establishment. In SEEA-Water, these costs are identified explicitly in order to obtain a more complete picture of the total water-related expenditures by the economy and to assess how much is spent by each economic activity 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 tables V.2 and V.3. Consumption expenditure of the Government, that is, intermediate consumption, compensation of employees and consumption of fixed capital, is identified separately by purpose: In the case of SEEA-Water, this is done according to whether these are related to collective services involving 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 identify explicitly the intermediate costs and outputs 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 identified separately.

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

(*a*) Water collection, treatment and supply (ISIC division 36);

(*b*) Sewerage (ISIC division 37).

Remediation activities related to water (part of ISIC division 39) can also be carried out for own use. However, they 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. Such units include, for example, farmers who abstract water directly from the environment for irrigation purposes, power plants or other industrial establishments that directly abstract water for their own use, such as for cooling purposes. By the same token, enterprises and households

Table V.3

**Hybrid account for supply and use of water**

| | Industries (by ISIC category) | | | | | | | | Rest of the world | Taxes less subsidies on products, trade and transport margins | Actual final consumption | | Capital formation | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-3 | 5-33, 41-43 | 35 | | 36 | 37 | 38, 39, 45-99 | Total industry | | | Households | Government | | |
| | | | Total | (*of which*) Hydro | | | | | | | | | | |
| **1. Total output and supply** (*billions of currency units*) | 137.6 | 749.0 | 22.1 | 3.3 | 1.7 | 9.0 | 367.0 | **1 286.4** | 363.0 | 70.0 | | | | **1 719.4** |
| *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 of 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 | **1 719.4** |
| *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 of 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 of 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 of currency units*) | | 5.2 | | | 197.1 | 22.2 | | **224.4** | | | | | | **224.4** |
| **6. Closing stocks of fixed assets for sanitation** (*billions of currency units*) | | 2.4 | | | | 115.7 | 0.1 | **118.2** | | | | | | **118.2** |
| **7. Total use of water** (*millions of cubic metres*) | 159.1 | 200.2 | 408.1 | 300.0 | 428.7 | 527.2 | 53.4 | **1 776.7** | 0.0 | | 250.3 | | | **2 027.0** |
| 7.a. Total abstraction | 108.4 | 114.5 | 404.2 | 300.0 | 428.7 | 100.1 | 2.3 | **1 158.2** | | | 10.8 | | | **1 169.0** |
| *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 of cubic metres*) | 82.9 | 157.0 | 405.6 | 300.0 | 426.9 | 526.5 | 49.8 | **1 648.7** | 0.0 | | 240.3 | | | **1 889.0** |
| 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 | **1 026.2** | | | 4.8 | | | **1 031.0** |
| **9. Total (gross) emissions of chemical oxygen demand** (*thousands of tons*) | 3 150.2 | 5 047.4 | 7 405.1 | | 1 851.0 | 498.5 | 1 973.8 | **19 925.9** | | | 11 663.6 | | | **31 589.5** |

**Source:** SEEA-Water-land database.

**Note:** Dark grey cells indicate zero entries by definition.

may operate their own wastewater treatment facilities, such as industrial wastewater treatment plants and septic tanks. The costs associated with these activities do not appear explicitly in the accounts described in the previous section because they are incorporated within those of the principal activity.

5.38. In the 2008 SNA, goods and services produced for own use should be valued at the basic prices of the same goods or services sold on the market, provided they are sold in sufficient quantities to enable reliable estimates to be made of those average prices.[47] However, since reliable market prices do not generally exist for water-related activities, in SEEA-Water, the value of the output of these activities is deemed, by convention, to be 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 V.4 presents the hybrid account for activities of "water abstraction" and "sewerage" carried out for own use. In SEEA-Water, these activities are recorded under the ISIC division of the principal activity. For example, if a manufacturing industry (ISIC division 17) treats wastewater on site before discharging it into the environment, the activity of treating the wastewater is recorded under ISIC division 17. This presentation is consistent with the way in which information is organized in physical terms (as presented in chaps. III and IV) where wastewater discharged into the environment (with or without treatment) by an industry is recorded under the ISIC division of the industry discharging the 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 are linked with the volume of wastewater discharged after on-site treatment.

5.40. For other purposes, it may be relevant to reorganize and allocate activities for own use to the relevant ISIC categories, such as ISIC divisions 36 or 37. The separate identification of water-related activities for own use, as reflected in SEEA-Water, enables this reorganization to be done easily if so desired.

5.41. It should be noted that table V.4 also includes households as they may abstract water directly from the environment and often carry out activities of wastewater treatment through the use of septic tanks, for example.

5.42. The information required for table V.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 the average costs could be used to populate the table as a first step in its compilation.

## 2. Government accounts for 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 governmental expenditures on water-related services. These are classified according to the Classification of the Functions of Government (COFOG).[48] COFOG is a classification of expenditures by the Government according to

47 Ibid., para. 6.93.

48 United Nations, *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),* Statistical Papers, Series M, No. 84 (United Nations publication, Sales No. E.00.XVII.6).

Table V.4
**Hybrid account for water supply and sewerage for own use**

| | | Industries (by ISIC category) | | | | | | | | House-holds | 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 cubic metres*) (from table III.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*) | | 3 354.1 | | | | | 30.5 | **3 384.6** | 480.2 | **3 864.9** |
| | **4. Return of treated water** (*millions of cubic metres*) (from table III.3) | | 10.0 | | | | | 0.5 | **10.5** | 1.5 | **12.0** |

**Source:** SEEA-Water-land database.

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:

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

(*b*) **Soil and groundwater protection:** part of COFOG 05.3. This category covers activities relating to soil and groundwater protection. Such activities include the construction, maintenance and operation of monitoring systems and stations (other than weather stations); measures to remove pollution from bodies of water; and the construction, maintenance and operation of installations for the decontamination of polluted soil and for the storage of pollutant products;

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

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

5.45. It should be noted that the above-mentioned COFOG categories refer to collective services of the Government. The categories COFOG 05.2 and 06.3 should not be confused with activities of “sewerage” and “water collection, treatment and supply”, classified under ISIC divisions 37 and 36, respectively, which are considered individual services in SEEA-Water. Expenditures incurred by Governments at the 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.[49]

5.46. In cases where the activities of water supply and sewerage are carried out by the Government and are classified under ISIC division 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 identified separately, 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 and the setting and enforcement of public standards (see also box V.2), and they should be classified under the relevant ISIC category.

49 Based on *System of National Accounts, 2008*, op. cit., para. 9.98.

5.47. Table V.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 governments. This table serves as input in the compilation of the table on financing covered in section D.

## D. Taxes, fees and water rights

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 governments include decisions and actions that affect the behaviour of consumers and producers by impacting the prices to be paid. As mentioned in the previous sections, the intermediate and final uses of water are valued at the purchaser's price. A more detailed description of the recording of the policy instruments related to water is provided below.

### 1. Payment for water supply and sanitation services

5.49. The costs associated with providing the services of supplying water and collecting and treating wastewater (industries classified as ISIC 36 and ISIC 37) may be recovered in different ways, mainly through the sale of the services, and through subsidies and transfers from government to the utilities.

5.50. Different terminology is used to refer to payments for services, such as tariffs, fees or taxes. These payments for services may not cover the total cost of the services provided.

### 2. Water rights

5.51. One way in which governments control the use of water resources is by issuing water rights. With the issuance of water rights for exploiting water resources in a particular water

Table V.5
**Government accounts for water-related collective consumption services**

| | Government (by Classification of the Functions of the Government category) | | | |
|---|---|---|---|---|
| | 05.2 Wastewater management | 05.3 (part) Soil and groundwater protection | 05.6 Environmental protection not elsewhere classified | 06.3 Water supply |
| 1. **Costs of production** (= 1.a + 1.b) (*millions of currency units*) | 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:** SEEA-Water-land database.

body, the government recognizes those water resources or part of them as economic assets. These rights are granted through water licences—for a fee or free of charge—which entitle the licence holder to use the water resources as an input into the economy or as a sink to absorb pollutants. The terms of the agreements regarding the water licences may vary considerably, within and between countries, with respect to their duration, payment schedule, transferability and other arrangements.

5.52. The payments for water rights are treated differently depending on the terms of agreements of the rights to use the water resources. Permits to use water resources can be basically characterized according to three different sets of conditions. The owner may permit the resource to be used in perpetuity. The owner may allow the resource to be used for an extended period of time in such a way that, in effect, the user controls the use of the resource during this time with little, if any, intervention from the legal owner. The third option is that the owner can extend or withhold permission for continued use of the water resources from one year to the next.

5.53. The first option, where the owner of the water rights is permitted to use the resources in perpetuity, results in the sale of the resource, and the transaction is recorded in the capital account. In the second option, in which the holder of the water rights (the user) controls the use of the water resource over the contract period, an asset (non-produced assets called contracts, leases and licences) for the user is created. This asset is distinct from the water resource itself, but its value and that of the water resources are linked. The payment for the water rights in this case is either recorded as payment of rent or purchase of water resources, depending upon the terms of the water rights. In the third option, payments for the water rights are recorded as rent for the use of the water resources.

5.54. As mentioned earlier, in situ use of water resources for transportation or recreation purposes involves the use of space of land, the payment for which should be recorded as rent on land, if it is recognized as an economic asset. Otherwise, the payments are considered other taxes on production.

5.55. There is no single, universal or clear-cut criterion to distinguish between rent and sale of an asset. The 2008 SNA (2008 SNA, para. 17.318) lists the following range of criteria:

(*a*) **Costs and benefits assumed by licensee:** The more the risks and benefits associated with the right to use an asset are incurred by the licensee, the more likely it is that the transaction will be classified as the sale of an asset (as opposed to rent);

(*b*) **Upfront payment or instalment:** Generally, the means of paying for a licence is a financial issue and, as such, not a relevant factor in determining whether or not it is an asset. However, business practice shows that upfront payments of rent for long periods are highly unusual and this favours interpretation as sale of an asset;

(*c*) **Length of the licence:** Licences granted for long periods suggest treatment as the sale of an asset; shorter periods suggest treatment as payments for rent;

(*d*) **Actual or de facto transferability:** The possibility of selling the licence is a strong indication of ownership and if transferability exists, this is considered a strong condition for characterizing the licensing act as the sale of third-party property rights.

(*e*) **Possibility of cancellation:** The stronger the restrictions on the issuer's capacity to cancel the licence at its discretion, the stronger the case for treatment as a sale of an asset.

5.56. Not all of these considerations have to be satisfied in order to characterize the licence as a sale of an asset, nor do even a simple majority of them. However, in order to qualify as a payment of rent on water resources, at least some conditions of the following kind should hold (2008 SNA, para. 17.319):

(*a*) The contract should be of short-term duration, or renegotiable at short-term intervals;

(*b*) The contract should be non-transferable;

(*c*) The contract should contain detailed stipulations on how the holder of the water right should make use of the water resource;

(*d*) The contract should include conditions that give the lessor the unilateral right to terminate the lease without compensation;

(*e*) The contract would require payments over the duration of the contract, rather than a large upfront payment.

### 3. Permits to use water resources as a sink

5.57. Governments are increasingly using emission permits as a means of controlling water pollution. If the permits are tradable, they constitute assets and should be valued at the market price for which they can be sold. The payments for discharging pollutants into the water resources may be recorded differently as described below.

5.58. The payment by a polluting entity without a permit to discharge pollutants into the water is treated as a penalty intended to inhibit discharge and should be recorded as a fine, that is, a current transfer.

5.59. If the permits are issued with the intent to restrict discharges of pollutants, the payments are recorded as rent or sale of the asset, depending on the range of criteria (see paras. 5.53 to 5.56), if the water resources are recognized as economic assets. Otherwise, the payments are recorded as other taxes (on production).

5.60. If the payments for the discharge of pollutants into the water resources are linked to remedial action, this should be recorded as payment for a service.

## 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 greater detail below.

5.62. The accounts presented in this section are based on environmental protection expenditure accounts.[50] Information from the hybrid and economic accounts presented in the previous sections furnish inputs to the tables on national expenditure and financing that are presented in this section.

50 Ibid.; Eurostat, *The European System for the Collection of Information on the Environment: SERIEE 1994 Version* (Luxembourg, Office for Official Publications of the European Communities, 2002); Eurostat, *SERIEE Environmental Protection Expenditure Accounts: Compilation Guide* (Luxembourg, Office for Official Publications of the European Communities, 2002); and Eurostat, *SERIEE Environmental Protection Expenditure Accounts: Results of Pilot Compilations* (Luxembourg, Office for Official Publications of the European Communities, 2002).

## 1. Environmental protection and resource management related to water

### (a) Environmental protection

5.63. This section describes environmental protection activities as well as products, actual outlays (expenditure) and other transactions related to water. They are classified according to the Classification of Environmental Protection Activities and Expenditure (CEPA), which is a generic, multi-purpose, functional classification system for environmental protection that was developed by Eurostat in cooperation with the United Nations. Called CEPA 2000, this system can be used to classify **environmental protection activities, environmental protection products** and e**xpenditures for environmental protection**.

5.64. **Environmental protection activities** are those for which 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, the activities, or parts thereof, must satisfy the primary purpose criterion (causa finalis): environmental protection must be the prime objective of the activities. Actions and activities which have a favourable impact on the environment but which serve other goals are not classified as environmental protection activities.

5.65. Environmental protection activities are production activities in the sense of national accounts,[51] that is, they combine resources, such as equipment, labour, manufacturing techniques and information networks or products, in order to create an output of goods or services. An activity may be one that is principal, secondary or for own use.

5.66. **Environmental protection products** are (*a*) environmental protection services produced by environmental protection activities; and (*b*) adapted products and connected products. Adapted (or "cleaner") products are defined as those that meet the following criteria: (i) on the one hand, they are less polluting when consumed and/or disposed of than equivalent normal products (equivalent normal products are products that provide similar utility, except for their impact on the environment); (ii) on the other, the adapted products are more costly than equivalent normal products.[52] 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. The expenditures recorded are the prices that purchasers pay for environmental protection services and connected products and the extra costs they incur over and above a viable but less clean alternative for cleaner products.

5.67. **Expenditures for environmental protection** include outlays and other transactions related to:

(*a*) Inputs for environmental protection activities (energy, raw materials and other intermediate inputs, wages and salaries, taxes linked to the production and the consumption of fixed capital);

(*b*) Capital formation and the purchase of land (investment) for environmental protection activities;

(*c*) Outlays of users for the purchase of environmental protection products;

(*d*) Transfers for environmental protection, such as subsidies, investment grants, international aid, donations and taxes earmarked for environmental protection.

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51 See, for example, *System of National Accounts, 2008*, op. cit., para. 6.24.

52 Eurostat, *SERIEE Environmental Protection Expenditure Accounts: Compilation Guide*, op. cit.

5.68. In the case of water, "wastewater management" and "protection and remediation of soil, groundwater and surface water" are considered to be activities for the protection of the environment and are part of CEPA 2000.

5.69. Wastewater management (CEPA 2) comprises activities and measures aimed at preventing the pollution of surface water through reductions in the release of wastewater into inland surface water and seawater. This category includes the collection and treatment of wastewater, including monitoring and regulation activities. Septic tanks are also included (see explanatory notes of CEPA 2000 and 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, and administration activities in the wastewater domain (these activities correspond to sewerage under ISIC division 37 and part of the public administration activities under ISIC division 84); (*b*) the use of specific products relevant to 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, the cleaning up of soils and bodies of water and the protection of soil from erosion and other forms of physical degradation, as well as from salinization; monitoring and control of soil and groundwater pollution are included (see explanatory notes of CEPA 2000 and SEEA-2003). Protection and remediation of soil, groundwater and surface water mainly include (*a*) activities for the protection of soil and groundwater (which correspond to part of ISIC division 39, remediation activities and other waste management services, and to part of the public administration activities of ISIC division 84); and (*b*) specific transfers.

#### *(b) Management and exploitation*

5.71. **Natural resources management** covers activities and measures for research into the management of natural resources; monitoring, control and surveillance; data collection and statistics; and the costs of the natural resource management authorities at various levels, as well as temporary costs for facilitating structural adjustments of the 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.[53]

5.72. The management of natural resources, such as water supply, are not included under the CEPA system. Even though there is no agreed classification for natural resources management and exploitation, the framework of environmental protection expenditure accounts can be extended to cover the management and exploitation of natural resources.

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

### 2. National expenditure accounts

5.74. National expenditure accounts are aimed at recording the expenditure of resident units and are financed by resident units in order to obtain a total that corresponds to the effort that a country is making to use its own resources. They are compiled for environmental protection activities related to water, namely, wastewater management; protec-

53 *Handbook of National Accounting*, paras. 5.39-5.41.

tion and remediation of soil, groundwater and surface water; and 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". For their compilation, the tables on protection and remediation of soil, groundwater and surface water require additional disaggregation of the data included in the standard tables and are thus included as part of the supplementary tables.

5.75. This subsection describes the component of the national expenditures for environmental protection and illustrates the national expenditure accounts for wastewater management (table V.6). These accounts can also be compiled for water management and exploitation and for 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 V.6, consist of the following:

(*a*) Use of environmental protection services by resident units (except "specialized producers" to avoid double counting (see para. 5.78 for a detailed explanation)). This is the sum of intermediate and final consumption and capital formation. Intermediate consumption includes the use of environmental protection services for own use and for services purchased by "other producers". Only in the case of soil remediation can the use of such services for capital formation (row 1.c of table V.6) be non-zero for "other producers". This entry consists of improvement of land as a result of decontamination of soil. It is not included in row 2 of table V.6 because it is a use of the output of ISIC division 39 by other producers and not an investment for the production of environmental protection services or land acquisition, which are recorded in row 2 of table V.6. In the case of wastewater management, the use of environmental protection services corresponds to the use of wastewater services (CPC 941 and CPC 91123) for intermediate and final consumption by resident units (except by "specialized producers"—in this case, ISIC division 37). Capital formation is not relevant for water and wastewater services; thus, it is not recorded under this category;

(*b*) Use of "adapted" and "connected products" for intermediate and final consumption. In the case of wastewater management, adapted products include, for example, phosphate-free washing products and highly biodegradable products. Connected products include, for example, septic tanks, biological activators of septic tanks and services for collecting septic tank sludge;

(*c*) Gross capital formation for producing environmental protection services. This item corresponds to the investments made by environmental protection producers for producing environmental protection 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: the installation of sewage networks and treatment plants, for example. This corresponds to the investments made by the producers of wastewater services for collecting, treating and discharging wastewater;

(*d*) Specific transfers received for environmental protection. Specific transfers are unrequited payments received by residents or non-resident units which contribute to the financing of characteristic activities and uses of specific products or constitute a compensation for income or losses related to environmental protection (SERIEE, section 2039[54]). This item includes current and capital transfers for environmental protection. The transfers are not counterparts of the previous

54 See Eurostat, *SERIEE 1994 Version*, op. cit.

Table V.6
**National expenditure accounts for wastewater management** (*billions of currency units*)

| | Users/beneficiaries | | | | | |
|---|---|---|---|---|---|---|
| | Producers | | Final consumers | | | |
| | Specialized producers (ISIC 37) | Other producers | House-holds | Govern-ment | Rest of the world | Total |
| **1. Use of wastewater services** (CPC 941 and CPC 91123) | | 4.090 | 4.85 | 3.79 | | **12.730** |
| 1.a. Final consumption | | | 4.85 | 3.79 | | **8.640** |
| 1.b. Intermediate consumption | | 4.090 | | | | **4.090** |
| 1.c. Capital formation | n/r | n/a | | | | **n/a** |
| **2. Gross capital formation** | 9.18 | 0.510 | | | | **9.690** |
| **3. Use of connected and adapted products** | | | | | | |
| **4. Specific transfers** | | 0.001 | 0.00 | | | **0.001** |
| **5. Total domestic uses** (= 1 + 2 + 3 + 4) | 9.18 | 4.600 | 4.85 | 3.79 | 0.00 | **22.420** |
| 6. Financed by the rest of the world | 1.00 | | | | | **1.000** |
| **7. National expenditures** (= 5 - 6) | 8.18 | 4.600 | 4.85 | 3.79 | 0.00 | **21.420** |

**Note:** Dark grey cells indicate non-relevant or zero entries by definition.
**Abbreviations:** n/r = not recorded in order to avoid double counting; n/a = not applicable in the case of wastewater management.

items in the table created, in order to avoid double counting. In the case of wastewater management, specific transfers consist, for example, of subsidies to specialized producers of sewerage and treatment services, and of transfers to the rest of the world in order to finance programmes of collective sewerage and treatment in other countries (international public or private aid for development) (SERIEE, section 4071).

5.77. The sum of the above-mentioned categories corresponds to the total domestic use of environmental protection services. Since the national expenditure is aimed at recording the expenditure of resident units and is financed by resident units in order to get a total that corresponds to the effort that a country is making using its own resources, the financing of the "rest of the world" (row 6 of table V.6) for environmental protection has to be subtracted from total domestic use. In the case of wastewater management, such financing consists of international aid for wastewater management.

5.78. National expenditure for environmental protection is allocated by column to the following categories of beneficiary: "producers", "final consumers" and "rest of the world". Producers are further disaggregated into "specialized producers" and "other producers". Specialized producers are defined as those that carry out an environmental protection activity as their principal activity. In the case of wastewater management, the specialized producers correspond mainly to those classified in ISIC division 37. "Other producers" are those that use environmental protection services (including the use of such services for own use) and connected and adapted products for their intermediate consumption, invest in the production of environmental protection services for own use and receive specific transfers for environmental protection.

5.79. Final consumers identified in national expenditure accounts are "households" as actual consumers of environmental protection 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 classification rest of the world is included by column as part of the users/beneficiaries because it may receive specific transfers for environmental protection. In the case of wastewater management, transfers to the rest of the world include transfers to finance programmes of collective sewerage and treatment in other countries (SERIEE, section 4071).

5.81. Expenditure by specialized producers (ISIC division 37) consists of gross capital formation for the production of wastewater services (row 2 of table V.6) and specific transfers (row 4). The entries in the other cells of the column for specialized 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 specialized producers is part of the output of the specialized 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 environmental protection services for capital formation (row 1.c) likewise should not be recorded for specialized producers, as it represents the use of capital goods for the production of environmental protection services and thus should be included under gross capital formation in row 2.

5.82. The expenditures of other producers include 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 a 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 rows 1 and 2 of table V.6 is derived from the hybrid account for supply and use of water in table V.3, the hybrid account for water-related activities for own use in table V.4 and government accounts for water-related collective services in table V.5. For example, the use of wastewater services by other producers is the sum of the use of sewerage services from table V.3 and the value of the output of sewerage service for own use from table V.4.

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 V.3. The use of wastewater services by the Government is derived from the government accounts for water-related collective services. It corresponds to row 1 of table V.5 (3.79 million currency units).

5.85. Information additional to that contained in the tables in sections B and C of this chapter is required in order 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 for 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 expenditures by identifying the financing sector (the sector providing the financing) and the beneficiaries (the units benefiting from the financing), as well as the amount being financed.

5.87. Table V.7 presents the financing accounts for wastewater management in order to show how the national expenditure for wastewater management is financed. The columns of table V.7 show the same categories of users/beneficiaries identified in table V.6. The rows of table V.7 show the different financing units (those actually bearing the cost), which are

Table V.7
**Financing accounts for wastewater management** (*millions of currency units*)

| Financing sectors: | Users/beneficiaries: Producers: Specialized producers (ISIC 37) | Producers: Other producers | Final consumers: Households | Final consumers: Government | Rest of the world | Total |
|---|---|---|---|---|---|---|
| **1. General Government** | 1.64 | 0.00 | 2.43 | 3.79 | | **7.86** |
| **2. Non-profit institutions serving households** | | | | | | |
| **3. Corporations** | 6.55 | 4.40 | | | | **10.95** |
| 3.a. Specialized producers | 6.55 | | | | | **6.55** |
| 3.b. Other producers | 0.00 | 4.40 | | | | **4.40** |
| **4. Households** | | 0.20 | 2.43 | | | **2.63** |
| **5. National expenditure** | 8.19 | 4.60 | 4.86 | 3.79 | 0.00 | **21.44** |
| **6. Rest of the world** | 1.00 | | | | | **1.00** |
| **7. Domestic uses** | 9.19 | 4.60 | 4.86 | 3.79 | 0.00 | **22.44** |

**Source:** SEEA-Water-land database.
**Note:** Dark grey cells indicate non-relevant or zero entries by definition.

classified according to the institutional sectors of the national accounts: general Government, which can be further disaggregated under central and local government, non-profit institutions serving households, corporations and households.

5.88. The expenditures recorded in the column of "specialized producers" correspond to their gross capital formation and net acquisition of land. The table entries describe how capital formation is financed: partly by the specialized producers themselves (row 3.a) and partly by the Government through investment grants (row 1). However, if the investment grants are funded from earmarked taxes, it is assumed that the taxpayers (in general households and other producers) are the financing units (rows 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), 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 specialized 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 non-profit institutions serving households (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 the 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 the sale of non-market services (partial payments) are not accounted in the column of Government, because the part of non-market output that is covered by partial payments does not come under collective services to begin with.

5.92. The expenditure recorded in the column "rest of the world" corresponds to the transfers paid for international cooperation for environmental protection. These transfers can be financed either by the Government or by households, through non-profit institutions serving households

Chapter VI

# 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, thus enabling an assessment of how current levels of abstraction and discharge affect the stocks of water.

6.2. The chapter begins 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 forests or mineral resources which are subject to slow natural changes, water is in continuous movement through the processes of evaporation and precipitation, etc. It is important to understand the natural cycle of water in order to reflect it correctly in the accounting tables and to determine, for analytical purposes, how to meet the demand for water in dry seasons, for example.

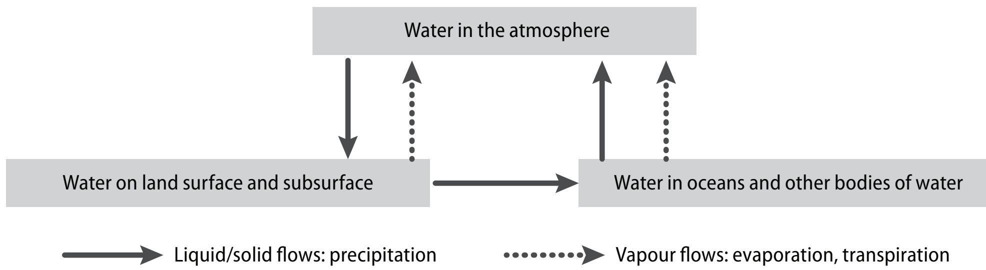
6.3. Section C describes how the 2008 SNA asset boundary has been expanded. It presents the SEEA-Water asset classification and describes the SEEA-Water standard tables for asset accounts. In cases where water resources are shared among several countries, the asset accounts can identify explicitly information on the part of the water resources belonging to each country and the origin and destination of the water flows between countries. Water asset accounts can be used for the management of shared water as they facilitate the formulation and monitoring of policies for the allocation of water among countries with connected water resources. Section D describes how information on transboundary waters is included 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 VII. The monetary description of the assets of water resources is not considered in this chapter: as yet, no standard techniques exist 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 for valuing water is presented in chapter VIII.

## B. The hydrological cycle

6.5. Water is in continuous movement. Owing to solar radiation and gravity, water keeps moving from land and oceans into the atmosphere in the form of vapour and, in turn, falls back onto land and into oceans and other bodies of water in the form of precipitation. The succession of these stages is called the hydrological cycle. Understanding the hydrological cycle helps in defining the water asset boundary and explaining spatial and temporal differences in water distribution. Figure VI.1 shows the various stages of the natural water cycle, depicting land, atmosphere and sea as repositories of water. If focus is given to water on the surface

Figure VI.1
**Natural water cycle**




**Source:** United Nations Educational, Scientific and Cultural Organization and World Meteorological Organization, *Comparative Hydrology: An Ecological Approach to Land and Water Resources* (Paris, UNESCO, 1989).

and subsurface of land, the natural input of water is precipitation. Part of this precipitation evaporates back into the atmosphere, some infiltrates into the ground to recharge groundwater, and the remainder drains into rivers, lakes and reservoirs and eventually may reach the sea. This cycle continues as water evaporates from land, oceans and seas into the atmosphere and falls back onto land and into oceans and other bodies of water in the form of precipitation.

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

Precipitation = evapotranspiration + run-off +/- changes in storage

This means that precipitation evaporates or transpires through vegetation (evapotranspiration) or flows within rivers or streams (run-off), or is stored in natural or constructed bodies of water (changes in storage).

6.7. Within this natural water balance, adjustments should be made to reflect modifications in 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 storage 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 the 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 2008 SNA and its expansion in SEEA-2003.

### 1. Extension of the 2008 SNA asset boundary

6.9. The 2008 SNA defines economic assets as entities:

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

(*b*) From which economic benefits may be derived by their owners, by holding them or using them, over a period of time.[55]

6.10. In particular, in the case of water, the 2008 SNA defines water resources within its asset boundary as “surface and groundwater resources used for extraction to the extent that their scarcity leads to the enforcement of ownership and/or use of rights, market valuation and

55 *System of National Accounts, 2008*, op. cit., para. 10.2.

some measure of economic control". Thus, only a small portion of the total water resources in a country is included in the 2008 SNA.

6.11. As indicated in para 2.23(a), the extension of the 2008 SNA asset boundary with respect to water resources relates only to recording such assets in physical units (quantity). Valuation of water resources in monetary terms is not recommended except for those recognized as assets in the 2008 SNA, namely those surface and groundwater resources used for exploitation to the extent that their scarcity leads to the enforcement of ownership or use of water rights, market valuation and some measures of economic control (2008 SNA, para. 10.184)

## 2. Asset classification

6.12. Water resource assets are defined as water found in freshwater, brackish surface water and groundwater bodies within the national territory that provide direct use benefits, currently or in the future (option benefits), through the provision of raw material, and may be subject to quantitative depletion through human use. The SEEA-Water 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 SEEA-Water asset classification expands the SEEA-2003 classification by including the categories EA.1314, glaciers, snow and ice, and EA.133, soil water. While 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 the temporary storage of water. The explicit inclusion of glaciers, snow, ice and soil water in the SEEA-Water asset classification reflects the increasing importance of these resources in terms of stocks, in particular soil water; it also allows for a clearer representation of water exchanges among 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 rain-fed agriculture, pasture, forestry, etc. Water management tends to focus on water in rivers, lakes, etc., and to neglect soil water management, even though the management of soil water holds significant potential for saving water, increasing water use efficiency and protecting 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 flows in dry months and it contributes 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.[56] Surface water includes **artificial reservoirs**, which are constructed reservoirs used for the storage, regulation and control of water resources; lakes, which are generally large bodies of standing water occupying depressions in the Earth's surface; **rivers and streams**, which are

56 For details of this definition, see *International Glossary of Hydrology*, 2nd ed. (UNESCO/WMO, 1992).

bodies of water flowing continuously or periodically in channels; **snow and ice**, which include seasonal layers of these forms of frozen water 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 equivalents.

6.16. **Groundwater** comprises 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 supply significant quantities of water to wells and springs. An aquifer may be unconfined, that is, have a water table and an unsaturated zone, or it may be confined 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 during the human lifespan. It should be noted that the concerns about non-renewable water apply not only to groundwater, but also to other bodies of water: for example, lakes may be considered non-renewable when their replenishment rate is very slow compared with their 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 into 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, such as for human, agricultural, hydroelectric power generation or mixed use. Rivers could be further classified on the basis of the regularity of the run-off: as perennial rivers, where water flows continuously throughout the year, or ephemeral rivers, where water flows only as a result of precipitation or the flow of an intermittent spring.

6.19. It should be noted 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. However, this is mostly a hydrological problem; it 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 in the table for ease of compilation.

### *(a) Fresh and non-fresh water resources*

6.20. Water resources comprise all inland water bodies regardless of their salinity level; thus, they include fresh and brackish inland water. Freshwater is naturally occurring water having a low concentration of salt. Brackish water has a salt concentration between that of fresh and marine water. The definition of brackish and freshwater is not clear cut: the salinity levels used in defining brackish water vary among countries. Brackish water is included in the asset boundary on the basis that this type of water can be and often is used, with or without treatment, for some industrial purposes, for example, as cooling water or even for the irrigation of some crops.

6.21. The asset classification of water resources can be further disaggregated to distinguish between fresh and brackish water. Such a step would enable a more detailed analysis of the stocks of water and their uses according to salinity level. Chapter VII presents quality accounts for water, which can be based on salinity levels.

### *(b) Water in oceans, seas and the atmosphere*

6.22. The asset classification of water resources excludes water in oceans, seas and the atmosphere because the stocks of these resources are enormous compared with the abstraction.

These assets, in general, do not incur depletion. Water in oceans, seas and the atmosphere is recorded in the accounts only in terms of abstracted water as described below:

(i) The physical supply and use tables (see chap. III) record (*a*) water abstracted from and returned into the sea (for example, in the case of the abstraction of sea water for cooling purposes or for desalination); (*b*) precipitation used directly by the economy (for example, in the case of water harvest); and (*c*) evaporation and evapotranspiration, which occur within the economic sphere (part of water consumption);

(ii) The asset accounts record (*a*) water flowing into oceans and seas (outflows from rivers); (*b*) water vaporized and evapotranspired from water resources; and (*c*) precipitation into water resources (dropping from the atmosphere into inland water resources).

### *(c) Produced versus non-produced assets*

6.23. All water resource assets described in the previous paragraphs are considered in SEEA-Water as non-produced assets, that is, they are "non-financial assets that come into existence other than through processes of production".[57] However, it could be argued 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 about whether to consider water in a reservoir as a produced asset has not yet concluded. For this reason, SEEA-Water retains the classification of SEEA-2003.

## 3. Asset accounts

6.24. Water asset accounts describe the stocks of water resources and their changes during an accounting period. Figure VI.2 presents an asset account, in schematic form, in particular:

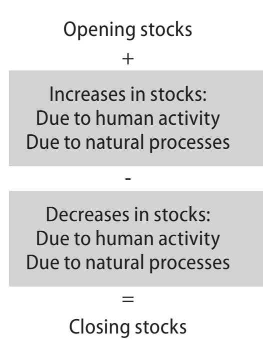
(*a*) Opening and closing stocks, which are the stock levels at the beginning and the end of the period;

(*b*) Increases in stocks, which include those due to human activity (returns) and natural causes, such as inflows and precipitation;

(*c*) Decreases in stocks, which include those due to human activity (abstraction) and natural causes, such as evaporation/evapotranspiration and outflows.

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 VI.2
**Schematic representation of an asset account**




57 *System of National Accounts, 2008*, op. cit., para. 10.9.

6.25. The standard table for asset accounts for water resources is presented in table VI.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 detail below.

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 III.

6.27. **Precipitation** consists of the volume of atmospheric wet precipitation (rain, snow, hail, etc.) on the territory of reference during the accounting period before evapotranspiration takes place. Most of the precipitation would fall on the soil and would thus be recorded in the column under soil water in the asset accounts. Some precipitation would also fall into other water resources, such as surface water. It is assumed that water would reach aquifers after having passed through either the soil or surface water, such as rivers and lakes; thus, no precipitation would be shown in the asset accounts for groundwater. The infiltration of precipitation into 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, that is, (*a*) inflows from other territories/countries; and (*b*) from other water resources within the territory. Inflows from other territories occur in the case of shared water resources. For example, when a river 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 as attributable to its 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 artificial, among the resources within the territory. They include, for example, flows of infiltration and seepage, as well as channels built for water diversion.

6.29. **Abstraction** 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 generating hydroelectric power, it is advisable to identify separately the abstraction by, and returns from, the power plant. Abstraction also includes the use of precipitation for rain-fed agriculture as this is considered removal of water from the soil as a result of a human activity, such as agriculture. Water used in rain-fed agriculture is thus recorded as 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. It should be noted that evaporation refers to the amount of water evaporated from bodies of water, such as rivers, lakes and artificial reservoirs. 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 conditions of the soil and vegetation: 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 entire area of ground that is well supplied with water. Actual evapotranspiration, which is reported in the accounts, refers to the amount of water that evaporates from the land surface and is transpired by the existing vegetation/plants when the moisture content of the ground is at its natural level, which is determined by precipi-

Table VI.1
**Asset accounts** (*millions of 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** |

**Source:** SEEA-Water-land database.
**Note:** Dark grey cells indicate zero entries by definition.

tation. It should be noted that actual evapotranspiration can be estimated only through modelling, and it 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 water flowing out of a body of water 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 an upstream country to a downstream country. Outflows to the sea/ocean represent the volume of water that flows into such bodies of water.

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, and the disappearance or appearance of water due to natural disasters, etc. Other changes in volume can be calculated directly or as a residual.

6.33. Exchanges of water between water resources are also described in more detail in a separate table, table VI.2. This table, which expands the information contained in rows 4.b and 7.c of table VI.1, furnishes information on the origin and destination of the flows between the water resources of the territory of reference, enabling 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 separately assessing this indicator for surface and groundwater due to the water exchanges between these resources.[58] Table VI.2 assists in identifying the contribution of groundwater to the surface flow, as well as the recharge of aquifers by surface run-off.

6.34. In table VI.1, sustainable water abstraction, which broadly is the level of abstraction that meets the needs of the current generations 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; 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 the territory of reference that is measured at specific points in time (the beginning and the end of the accounting period). Whereas the concept of a stock of water is straightforward for lakes, reservoirs and groundwater (even though for groundwater it may be difficult to measure the total volume of water), it is not always easy to define for rivers. Water in a river is in constant motion and moving at a much faster rate than that of other bodies of water: the estimated residence time of the world's water resources is about two weeks for rivers and about 10 years for lakes and reservoirs.[59]

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 with the total stocks of water resources and the annual flows of rivers. However, the river profile and the depth of water are important indicators for environmental and economic considerations. There might be cases, however, in which the stocks of river water may not be meaningful either because the rate of flow is very high or because the profile of riverbeds change constantly due to topographic conditions. In these circumstances, computing the stock of rivers is not a realistic task; therefore, such stocks can be omitted from the accounts.

## 5. 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 II.3). The abstraction that appears in the asset accounts in table VI.1 corresponds to the abstraction from water resources by the economy in the physical use table, row 1.i of table III.1 or table III.3. Similarly, the returns that appear in table VI.1 correspond to the total returns to water resources in the physical supply table, row 5.a of table III.1 or table III.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,

58 Food and Agriculture Organization of the United Nations, "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, 1-4 October 2001.

59 Igor A. Shiklomanov, "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 International Hydrological Programme of UNESCO) (St. Petersburg, Russian Federation, Federal Service of Russia for Hydrometeorology and Environment Monitoring, State Hydrological Institute, 1999). Available from http://www.unep.org/vitalwater/05.htm.

Table VI.2
**Matrix of flows between water resources** (*millions of cubic metres*)

| | 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 | | | 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:** SEEA-Water-land database.

as well as the destination of water discharges by the economy. It enables 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 and the European Union 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 VI.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 of 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 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 the country, the opening and closing stocks of water resources could be disaggregated according to the country to which the water resources belong. Similarly, information on abstraction and returns could be disaggregated according to the country responsible for those flows. Table VI.4 presents an example of an asset account for a river basin shared by two countries. It should be noted that the same structure can be used in cases where there are more riparian countries sharing waters.

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 when a country abstracts more than its share of the stock that is assigned by a treaty. In such cases, there is a transfer of water from one country to the other.

Table VI.3
**Asset account at the 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 | | n/a |
| 4. Inflows: | | |
| 4.a. From upstream territories[a] | | |
| 4.a.1. Country 1[a] | | |
| … | | |
| 4.b. From other water resources in the territory | | n/a |
| Decreases in stocks | | |
| 5. Abstraction[a] | | |
| 6. Evaporation/actual evapotranspiration | | n/a |
| 7. Outflows: | | |
| 7.a. To other water resources in the territory | | n/a |
| 7.b. To the sea | | n/a |
| 7.c. To downstream territories[a] | | |
| 7.c.1. Country 2[a] | | |
| … | | |
| 8. Other changes in volume | | **n/a** |
| **9. Closing stocks** | | |

**Abbreviation:** n/a = not applicable.
**a** Each of these flows may be subject to quotas established in treaties and agreements between riparian countries.

6.43. Established quotas for abstractions and returns (merely in physical terms) as well as for other flows can be included in the tables in a separate column in order to monitor compliance with the treaties, as in table VI.3; however, for the sake of simplicity of presentation, this information is not included in table VI.4.

Table VI.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. From country 1[a] | | | |
| 4.b. From country 2[a] | | | |

| | Water resources (classified according to the asset classification) | | |
|---|---|---|---|
| | Country 1 | Country 2 | Total |
| 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** | | | |

**a** Each of these flows may be subject to quotas established in treaties and agreements between riparian countries. Information on such quotas, when available, should be reported in a separate column.

# PART TWO

Chapter VII

# Water quality accounts

## A. Introduction

7.1. Water quality determines the uses that can be made of water. Pollution creates health hazards, detrimentally affects biodiversity, raises the cost of treating water and increases water stress. The 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.[60] International targets have been established with regard to the quality of water. For example, the previously mentioned European Union Water Framework Directive requires European Union countries to establish water policies aimed at ensuring that all water would meet "good status" requirements by 2015 (see box VII.1).

7.3. Whereas the previous chapters focused on water in terms of input into the production process and water availability regardless of its quality, this chapter focuses on the quality of water and its link to various uses, which could be seen as being the 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 VI. However, SEEA-Water covers the quality accounts since quality is an important characteristic of water and can limit its use. Further, SEEA-Water covers driving forces in terms of the structure of the economy and the population, pressures in terms of the abstraction of water and emissions into it, and responses in terms of environmental expenditures and the taxes and fees charged for water and sanitation services. The state of water quality and related impacts are represented in the 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, appear to be 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 regard to implementation: the definition and the measurement of water quality classes. Water quality is generally defined for a specific concern; there is little standardization of concepts and definitions or aggregation methods. Aggrega-

60 See, for example, World Meteorological Organization, *Dublin Statement and Report of the Conference: International Conference on Water and the Environment: Development Issues for the 21st Century* (Geneva, WMO, 1992); and General Assembly resolution 55/2 of 8 September 2000.

tion can be over (*a*) different pollutants, in order to construct one index which measures the combined impact of pollutants on water resources; (*b*) time, in order to address seasonal variations; and (*c*) space, in order to reach a single quality measure for measurements at different locations.

7.7. Because of the issues outlined above and the insufficient number of country experiences, this chapter is presented in terms of the issues and lessons learned from trial implementations rather than ready-made solutions. Section B describes the 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 assessment and choice of "determinands", that is, those characteristics that help in determining quality. 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 that is aimed at constructing quality accounts for rivers.

## B. Basic concepts of water quality assessment

7.8. Natural waters exhibit a wide variety of characteristics: chemical (containing nitrates, dissolved oxygen, etc.), physical (temperature, conductivity, etc.), hydromorphological (water flow, river continuity, substrate, etc.) and biological (bacteria, flora, fish, etc.). These result from natural processes and anthropogenic activities, and water quality is characterized by all of them.

7.9. Quality applies to bodies of water, to waterbeds which contain or transport the water, and to the riparian zone concerned. The quality of water running through a river could be very good, even though the riverbed may be severely polluted with heavy metals that have sunk into its sediment. This chapter is restricted to consideration of the quality of bodies of water.

Box VII.1

**European Union Water Framework Directive**

The European Union Water Framework Directive, which came into force on 22 December 2000, has the following key elements:

- It expands the scope of water protection to all waters. Distinctions are made between surface waters (rivers, lakes, transitional and coastal waters), groundwater and protected areas, that is, areas that are designated for water abstraction, protection of aquatic species or recreational purposes. "Water bodies" are the units 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 key to 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". Good ecological status is defined in annex V of the Directive in terms of the biological community, hydrological characteristics and physicochemical characteristics. Member States are to report the ecological status for each surface water category in five classes, ranging from "high" to "bad". The boundary values are established through an intercalibration exercise. Chemical status is reported as "good" or "failing to achieve good". For groundwater, because 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 that all existing source-based controls be implemented. At the same time, a list of priority substances, annex X of the Directive, are defined and prioritized according to risk, the load of which should be reduced based on an assessment of cost-effectiveness.

**Source:** European Parliament and Council, Directive 2000/60/EC, *Official Journal of the European Communities* (22 December 2000). Available from http://ec.europa.eu/environment/water/water-framework/index_en.html.

7.10. Quality describes the current state of a particular body of water in terms of certain characteristics, called determinands. The term determinand is used rather than pollutant, parameter or variable[61] in order to underscore the fact that a determinand describes a feature constitutive of the quality of a body of water; it is not exclusively associated with either human activities or natural processes. Examples of determinands, as used in Le système d'évaluation de la qualité des cours d'eau (the System for the Evaluation of the Quality of Water) or SEQ-eau as it is widely known (see below), are depicted in the second column of table VII.1.

7.11. For policy purposes, such as for setting objectives and checking compliance, it is necessary to define the quality of water by specifying the series of normative values for its determinands, which represent the requirements for certain uses[62] or the allowable deviations from reference conditions, as in the previously mentioned European Union Water Framework Directive, for example. For reasons of practicality and ease of reporting, as well as the inherent uncertainty involved, water quality is eventually reported in the form of discrete classes. The description of quality accounts in SEEA-2003 supposes that quality classes have been defined (see section C).

7.12. The quality of a body of water may be approached in terms of its uses/functions, although there is no standard classification of water uses/functions. Nonetheless, the uses/functions most commonly used are drinking water, leisure, irrigation and industry; by contrast, France uses aquatic life, drinking water, leisure, irrigation, livestock and aquaculture.[63]

Table VII.1
**Indicators and their determinands included in the System for the Evaluation of the Quality of Water**

| Indicators | Determinands[a] |
|---|---|
| **Organic and oxidizable matter** | Dissolved oxygen ($O_2$), percentage of oxygen (%$O_2$), chemical oxygen demand (COD), biochemical oxygen demand (BOD), dissolved organic carbon (DOC), ammonium minus nitrogen ($N_{Kj}$), ammonium ($NH_4$) |
| **Nitrogen (except nitrates)** | $NH_4^+$, $N_{Kj}$, nitrogen dioxide ($NO_2$) |
| **Nitrates** | Nitrate radical ($NO_3$) |
| **Phosphorus** | Phosphate ($PO_4^{3-}$), total phosphorus |
| **Suspended matter** | Suspended solids, turbidity, transparency |
| **Colour** | Colour |
| **Temperature** | Temperature |
| **Salinity** | Conductivity, chlorine ($Cl^-$), sulphate ($SO_4^{2-}$), calcium ($Ca^{2+}$), magnesium ($Mg^{2+}$), potassium ($K^+$), toxic air contaminant (TAC), hardness (mineral content) |
| **Acidity** | Acidity or alkalinity (pH), dissolved aluminium (Al) |
| **Phytoplankton** | %$O_2$, and pH, zero pigments (chlorophyll a + pheopigments), algae, $\Delta O_2$ (24 hours) |
| **Micro-organisms** | Total coliforms, faecal coliforms, faecal streptococci |
| **Mineral micropollutants 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 of concern |
| **Organic pollutants (except pesticides) in water** | 59 substances are of concern |

**Source:** Louis-Charles Oudin, "River quality assessment system in France", paper presented at the International Workshop Monitoring Tailor-Made III—Information for Sustainable Water Management, Nunspeet, Netherlands, 2001. Available from http://www.mtm-conference.nl/mtm3/docs/Oudin2001.pdf.

**a** The original list does not use the term determinand, but parameter.

61 Peter Kristensen and Jens Bøgestrand, *Surface Water Quality Monitoring. Topic Report, Inland Waters No. 2/96* (Copenhagen, European Environment Agency, 1996).

62 Russell E. Train, *Quality Criteria for Water* (London, Castle House Publications, 1979).

63 Louis-Charles Oudin and Danièle Maupas, *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, 1999).

Australia and New Zealand mention aquatic ecosystems, primary industries, recreation and aesthetics, drinking water and industrial use, as well as cultural and spiritual values, although for the latter two categories no quality guidelines are provided.[64] The Millennium Ecosystem Assessment investigates functions such as services supplied by aquatic ecosystems: flood mitigation, groundwater recharge, food provision and pollution control.[65]

7.13. Some researchers[66] assess water quality in terms of hydrological power. That power is defined based on topographic position, which gives indications of the potential for hydroelectric power generation, and osmotic power due to salt concentrations, which limit water availability for animal and plant nutrition.

7.14. Countries assign water uses/functions to bodies of water in different ways. France has adopted an approach that uses 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 body of water.

7.15. Since 1999, France has used SEQ-eau[67] as an assessment framework, which 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, leisure, irrigation, livestock watering and aquaculture, and one function, aquatic life, which together are called "uses". The evaluation system is based on 15 suitability indicators (see table VII.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 4 indicators apply, namely, salinity, micro-organisms, micropollutants and pesticides, but for drinking water, 13 out of 15 apply. Each indicator has a set of determinands (a group of parameters having similar impacts) selected from a list of 135 monitored parameters, as specified in table VII.1. For example, the "nitrogen (except nitrates)" indicator is computed from the concentration values for $NH_4^+$, $N_{Kj}$, $NO_2^-$. 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 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 "90th percentile" rule is applied.

7.16. In the French approach, it is possible to derive a global quality index and a global quality class for a body of water. This is not done by taking the worst of the worst scores obtained for the different uses of water, but by defining "quality" threshold values for each indicator determinand and selecting the "suitability" threshold values associated with 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 being for aquatic life and 50 mg/l for drinking water. The global quality index is the worst score obtained for any indicator.

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64 Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ), *Australian and New Zealand Guidelines for Fresh and Marine Water Quality,* vol. 1, Guidelines (chaps. 1-7), Paper No. 4, vol. 1, 2000. Available from http://www.mincos.gov.au/publications/australian_and_new_zealand_guidelines_for_fresh_and_marine_water_quality.

65 Millennium Ecosystem Assessment, *Ecosystems and Human Well-being: Wetlands and Water Synthesis* (Washington, D.C., World Resources Institute, 2005).

66 G. Gascó and others, "Influence of salt concentration and topographical position on water resource quality: the Spanish case study", *Water SA*, vol. 31, No. 2, pp. 199-208 (2005). Available from http://www.wrc.org.za.

67 Louis-Charles Oudin, "River quality assessment system in France", paper presented at the International Workshop Monitoring Tailor-Made III: Information for Sustainable Water Management, Nunspeet, Netherlands, 2001. Available from http://www.mtm-conference.nl/mtm3/docs/Oudin2001.pdf.

7.17. Other countries, such as Australia and the United States of America, define water uses/functions specific to the actual uses/functions of the body of water. For each such body, a specific use or uses are identified and the quality criteria are set accordingly. The standards are specific for the body of water. In the case of multiple uses, water quality could be defined in terms of its most sensitive or stringent use. In Australia, for example, "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".[68]

7.18. The quality assessment for ecological status used in the European Union Water Framework Directive (see box VII.1) is not based on a specific classification for different uses, but evaluates quality as the deviation from the reference conditions observed for each "type" of body of water. The directive classifies surface water bodies into five ecological status classes: high, good, moderate, poor and bad. This classification is the result of observations of quality elements: biological, physicochemical (as illustrated in table VII.2) and hydromorphological.

7.19. The observation of a quality element depends on the monitoring of its determinands. For example, three determinands are considered for the "oxygenation" quality element: chemical oxygen demand, biochemical oxygen demand and dissolved oxygen. Each determinand is valued using a "ratio" between 0 and 1, with values close to 1 representing reference conditions for the type of body of water. The [0, 1] interval is divided into 5 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 intercalibration exercise. In order to determine the quality class for a quality element, the values of a group of determinands may be combined (by taking the average, median, etc.) when they show

Table VII.2
**Physicochemical quality elements used for the ecological status classification of rivers in the European Union Water Framework Directive**

| Element | High status | Good status | Moderate status |
|---|---|---|---|
| **General conditions** | The values of the physicochemical elements correspond totally or nearly totally with undisturbed conditions.<br>Nutrient concentrations remain within the range normally associated with undisturbed conditions.<br>Levels of salinity, pH (acidity or basicity), oxygen balance, acid neutralizing capacity and temperature do not show signs of anthropogenic disturbance and remain within the range normally associated with undisturbed conditions. | Temperature, oxygen balance, acidity or basicity, acid-neutralizing capacity and salinity do not reach levels outside the range established in order to ensure the functioning of the type-specific ecosystem and the achievement of the values specified for the biological quality elements.<br>Nutrient concentrations do not exceed the levels established in order to ensure the functioning of the ecosystem and the achievement of the values specified for the biological quality elements. | Conditions consistent with the achievement of the values specified 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 of the Directive without prejudice to Directive 91/414/EC and Directive 98/8/EC. | Conditions consistent with the achievement of the values specified for the biological quality elements. |
| **Specific non-synthetic pollutants** | Concentrations remain within the range normally associated with undisturbed conditions. | Concentrations not in excess of the standards set in accordance with the procedure detailed in section 1.2.6 of the Directive without prejudice to Directive 91/414/EC and Directive 98/8/EC. | Conditions consistent with the achievement of the values specified for the biological quality elements. |

**Source:** European Parliament and Council, Directive 2000/60/EC—Official Journal of the European Communities (22 December 2000). Available from http://ec.europa.eu/environment/water/water-framework/index_en.html.

**Note:** Waters achieving a status below moderate shall be classified as poor or bad. Waters showing evidence of major alterations in 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 in 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.

68 ANZECC and ARMCANZ, *Australian and New Zealand Guidelines*.

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 the relevant quality elements determines the status class of the body of water.

## C. 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 VI. The only difference is the addition of the quality dimension, which describes the volume of water. Table VII.3 shows the general structure for quality accounts as presented in 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.

7.21. Each column shows the volume of water of a certain quality class at the beginning and at the end of the accounting period. The column "total" represents the stock of the body of water at the beginning and the end of the accounting period as defined in chapter VI. The row "changes in stocks" is derived as the difference between the closing and the opening stocks.

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

7.23. Table VII.3 can be compiled for costal waters also in view of 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 pollution).

7.24. Each entry in table VII.3 represents the amount of water of a certain quality measured in the volume of the water. However, for rivers this is not a convenient unit owing to the flowing nature of the water. A specific unit of account has been introduced for river quality, that is, the "standardized river-kilometre",[69] which later was changed to the "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 SRUs, of a stretch of river of length $L$ and of flow $q$ is the product of $L$ multiplied by $q$. Quality accounts for rivers can be compiled by assessing the quality class for each stretch, by computing the SRU value for each stretch, and by summing the corresponding SRU per quality class to populate the quality accounts in table VII.3. The different quality classes can be aggregated without double counting.[70]

Table VII.3
**Quality accounts** (*physical units*)

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

**Source:** *Handbook of National Accounting: Integrated Environmental Economic Accounting: An Operational Manual*, Series F, No. 78, Rev.1 (United Nations publication, Sales No. E.00.XVII.17).

69 Johan Heldal and Torbjørn Østdahl, "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.

70 *System of National Accounts, 2008*, op. cit., para. 8.128.

7.25. The total quantity of SRUs should appear in the total column of table VII.3, even though the quantity cannot be related to the total column in the asset accounts for rivers, which is expressed in volume, not in SRUs. This quantity strongly depends on the minimum size of rivers to be considered in a river basin. Because of the lack of adequate data, the marginal contribution of the smallest rivers is generally unknown.

7.26. In the case of France, the national river system is composed of about 10.8 million SRUs for its approximately 85 000 km of main courses; the river system is disaggregated into 55 catchments. Estimates from the Institut Français de l'Environnement suggest that considering all rivers mapped at a scale of 1:50000 would increase by a factor of 2.5 the total SRUs mapped at a scale of 1:1400000.[71] Therefore, it was concluded that the total quantity of SRUs should not be aimed at covering the entire river system, but only that part of it which is actually being monitored and is subject to quality assessment. The ratio between the quantity of SRUs for the monitored rivers and an estimate of the quantity of SRUs for the entire system produces an estimate of the monitoring coverage of the river system.

7.27. Table VII.4 shows the quality accounts for rivers in France as compiled 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 because they were obtained from comparable assessment methods. The quality accounts show that there has been an improvement between the two years: there are more SRUs in good quality classes (1A and 1B) and fewer in poor quality classes (3 and NC).

7.28. In the case of groundwater, since the flow is very low, quality accounts can be constructed directly in volumetric units, such as cubic metres. Table VII.5 provides an example of quality accounts for groundwater in Australia, using salinity levels for defining quality classes: fresh (salinity < 500 mg of sodium chloride per litre), marginal (500 < salinity < 1 500), brackish (1 500 < salinity < 5 000) and saline (salinity > 5 000). These categories correspond to potential limitations for economic uses: fresh quality is recommended for human consumption, 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).

Table VII.4
**Quality accounts of French watercourses by size class** (*organic matter indicator: in 1 000 standard river units*)

| | 1992 status | | | | | *Changes by quality class* | | | | | 1994 status | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1A | 1B | 2 | 3 | NC | *1A* | *1B* | *2* | *3* | *NC* | 1A | 1B | 2 | 3 | NC |
| Main rivers | 5 | 1 253 | 891 | 510 | 177 | *3* | *336* | *9* | *-183* | *-165* | 8 | 1 583 | 893 | 358 | 12 |
| Main tributaries | 309 | 1 228 | 1 194 | 336 | 50 | *16* | *464* | *-275* | *-182* | *-22* | 325 | 1 691 | 919 | 154 | 288 |
| Small rivers | 260 | 615 | 451 | 128 | 47 | *44* | *130* | *-129* | *-17* | *-28* | 306 | 749 | 322 | 110 | 188 |
| Brooks | 860 | 1 464 | 690 | 243 | 95 | *-44* | *176* | *228* | *15* | *-23* | 810 | 1 295 | 917 | 258 | 72 |

**Source:** Institut Français de l'Environnement, *The Accounts of the Quality of the Watercourses: Implementation of a Simplified Method, On-going Development* (Paris, IFEN, 1999).

**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, biochemical oxygen demand at five days, chemical oxygen demand and ammonium. It also considers eutrophication and the presence of nitrates.

71 Institut Français de l'Environnement, *The Accounts of the Quality of the Watercourses—Implementation of a Simplified Method, On-going Development* (Paris, IFEN, 1999).

Table VII.5
**Accounts of groundwater quality in Victorian provinces, Australia, 1985 and 1998** (*gigalitres*)

| | Fresh | Marginal | Brackish | Saline | Total |
|---|---|---|---|---|---|
| 1985 | 477.5 | 339.2 | 123.3 | 32.3 | **972.3** |
| 1998 (incomplete)[a] | (39.1) | (566.6) | (141.1) | (n/a) | **(746.8)** |

**Source:** Australian Bureau of Statistics, *Water Account for Australia 1993-94 to 1996-97* (Canberra, ABS, 2000).

**Abbreviation:** n/a = not applicable.

**a** The 1998 assessments are based on permissible annual volume (PAV), which is equivalent to sustainable yield.

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.

7.30. Quality accounting is useful for following the evolution of the water quality and it furnishes an indication of the efficiency of the measures taken to protect or improve the state of bodies of water. The comparison of changes in "stocks of quality" is expected to provide an assessment of the effectiveness of protective and restorative measures.

7.31. There is a complication, however, as changes in water quality may have different causes. The changes could result from the emission of pollutants, self-purification, changes in dilution factors owing to the increased abstraction of water and increased run-off due to uncontrolled events or new regulations restricting emissions, among other such events. 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 interactions):

Water quality $t_1 = f$(water quality $t_0$, Δ(uncontrolled events), Δ(abstractions), Δ(emissions), Δ(expenditure))

where Δ(uncontrolled events) signifies the change that occurred between $t_0$ and $t_1$ which cannot be related to any event in the economic sphere; and Δ(abstractions), Δ(emissions) and Δ(expenditure) represent causes related to the economic sphere. Thus, 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 analyses of cost-effectiveness may be carried out with the help of these accounts. An example is supplied in the following situation: the global quality of water 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 of river. 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). However, this does not imply that the quality increase would have been 0.8 if the expenditures had been doubled in value.

# D. Issues

## 1. The choice of determinands

7.33. Different countries use different determinands, as illustrated by table VII.6. Large differences exist in both the number and choice of the determinands used; also, 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 so for pesticides, of which only a few dozen can be accurately quantified among the several hundred active substances in use. The same problem occurs when considering biological toxins, especially cyanotoxins, and endocrine disruptors. Large numbers of chemicals, such as toxic hydrocarbon derivatives, are virtually insoluble in water; they pose considerable problems when attempts are made to obtain reliable samples.

7.35. There has been little or no standardization of determinands or the methods to measure them, or of threshold values to define quality classes. The main consequence of this lack of standardization has been the inability to compare accounts across countries. In the context of the previously mentioned Directive, attempts are under way to standardize both the choice of determinands and the threshold values for assessing quality classes.

## 2. The choice of assessment method

7.36. As mentioned in section B, most water quality assessments evoke a form of the "rule of the worst" (or "one out, all out"), that is, the rule always requires the choice of the lowest quality 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 (choosing the quality class of the worst-performing indicator); at the level of classifications (choosing the worst class obtained in any classification, whether biological or chemical, as recommended by the European Union Directive); or a combination of the above. This rule has different justifications. When applied to one determinand or indicator computed from multiple samples, this rule reflects the fact that a peak in pollution has more detrimental effects than average pollution. When applied

Table VII.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 matter | 7 | | 4 | 1 | |
| Others | 1 | | | 1 | |
| Pathogenic germs | 8 | 1 | | 3 | 2 |
| Pesticides | 68 | 22 | 23 | 6 | 4 |
| Radioactivity | 26 | 26 | | | |
| Salinity | 14 | | 1 | 3 | 4 |
| Toxins (n-metal, n-pesticides) | 104 | 36 | 38 | 3 | 2 |

**Source:** Philippe Crouzet (based on Canadian Council of Ministers of the Environment, "Canadian water quality guidelines for the protection of aquatic life: CCME Water Quality Index 1.0, technical report", in *Canadian Environmental Quality Guidelines, 1999*, Canadian Council of Ministers of the Environment, eds. (Winnipeg, Canada, 2001)); Louis-Charles Oudin and Danièle Maupas, *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, 1999); and Department of Water Affairs and Forestry, *South African Water Quality Guidelines,* vol. 1-8, 2nd ed. (Pretoria, South Africa, 1996). Available from http://www.dwaf.gov.za/iwqs/wq_guide.

**Note:** The total number of determinands reflects the number of determinands used by at least one country. Common determinands refer to the number of determinands used by the three countries in their guidelines. Country-specific determinands refer to the number of determinands used only by that country in its guidelines (and not by the other countries in the table).

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 VII.1 for arbitrary values.

7.37. Figure VII.1 represents a hypothetical situation in which 12 measurements are obtained from 2 locations (A and B) in years 1 and 2. Each point represents the quality index resulting for each sample; each of them is plotted in the figure, in which the 5 quality classes are represented on the y axis. Location B shows a significant improvement in 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 the worst in year 1 and as bad in year 2, despite the fact that the results suggest a significant improvement in quality.

7.38. Several issues arise with regard to the rule of the worst. Extreme values, as illustrated in figure VII.1, can have a significant impact on the eventual classification of a body of water. A body of water is classified as bad regardless of whether it has only a single trespassing value, or has a permanently bad quality status. Furthermore, the improvement in monitoring often results in the apparent worsening of the quality index (a larger number of measurements of a larger number of determinands increases the probability of monitoring extreme values). Finally, the rule of the worst tends to hide seasonal variations.

7.39. One possible solution in dealing 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 per cent of the samples analysed during the monitoring period.[72]

7.40. An alternative to the rule of the worst is exemplified by the Canadian federal system.[73] 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 (variables, the objectives of which have not been met/total number of determinands monitored); the frequency with which the objectives have not been met during the assessment period (frequency (F) = number of failed tests/total number of tests); and the distance (or amplitude) between the threshold and the observed value (excursion (E) = [observed value/target value] – 1. All factors are normalized so that they fall within the range of 0 to 100.

7.41. The final CCME Water Quality Index (CCME WQI) is equal to 100 minus the length of the three-dimensional vector [S,F,E] normalized to 0-100.

$$CCMEWQI = 100 - \sqrt{\frac{S^2 + F^2 + E^2}{3}}$$

This means that CCME WQI 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 four 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).

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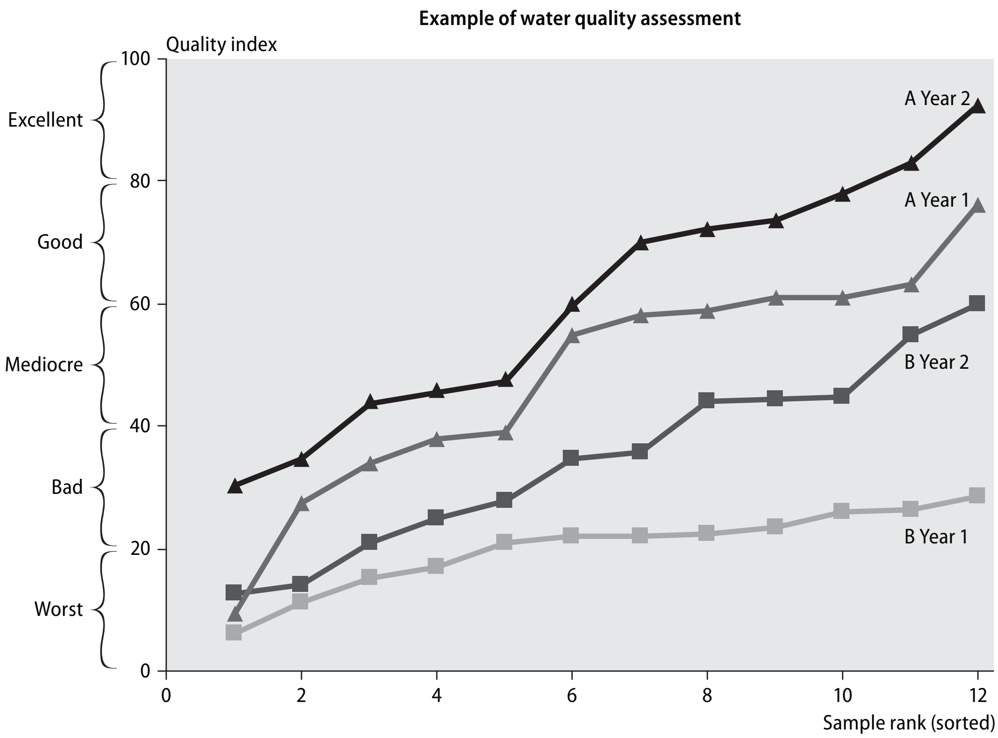
72 Oudin, "River quality assessment system in France", op. cit.

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

Figure VII.1
**Comparison of assessment rules for two different sets of data**




**Source:** Elaborated by Philippe Crouzet.

# E. Water quality indices

7.42. Owing 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 Generalized 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 in water quality. Therefore, it is important to be able to aggregate water quality over river basins.

7.44. The pattern index measures variance in the quality classes of the stretches that underlie a particular RQGI score for a river basin. It enables differentiating between basins where water is of a uniform quality and basins where the quality results pertain to certain "hotspots" or occasional exceeding of the quality standard. 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. 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. The formula for calculating the index is shown below:

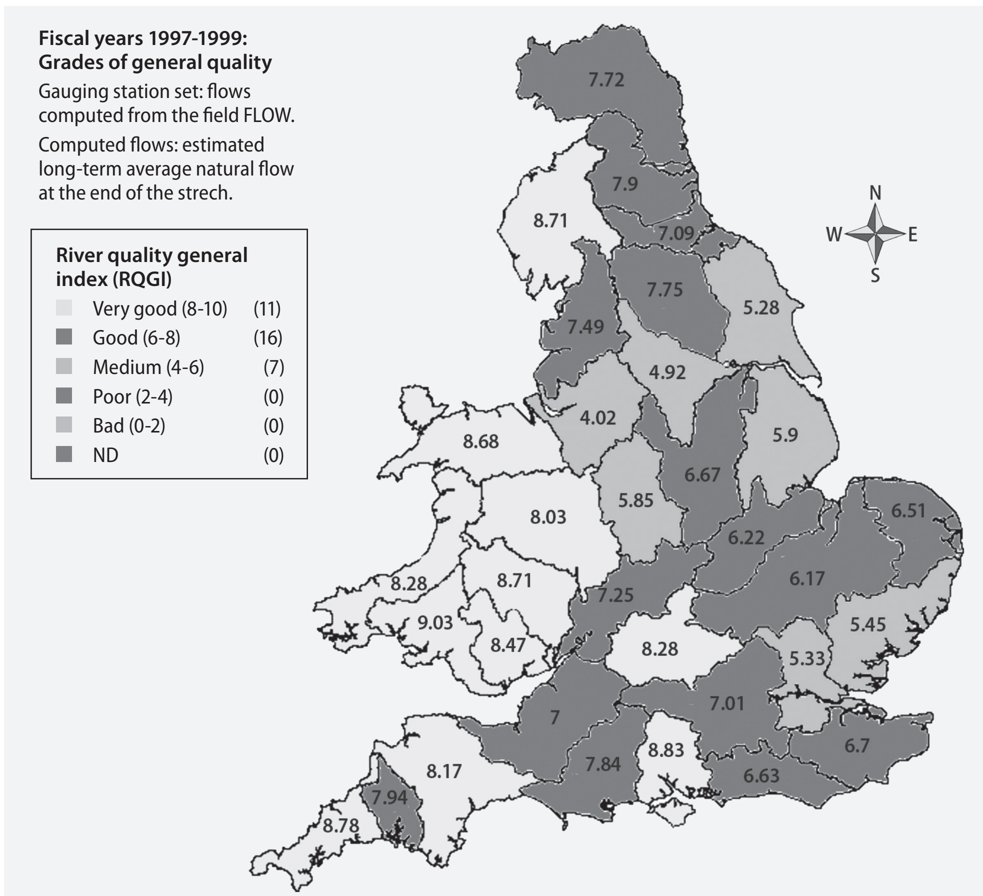
$$RQGI = \frac{10}{n} \times \frac{\sum_j S_j \times G_j}{\sum_j S_j}$$

where $n$ is the number of quality classes.

7.46. As an application, figure VII.2 shows the RQGI score for each river basin in England and Wales in the period 1997-1999.[74] The overall index for all reviewed catchments improved from 6.50 in 1990 to 7.47 in that period.

7.47. As an application of the pattern index, figure VII.3 shows the aggregated map of river basins in the Republic of Ireland and Northern Ireland having potentially mediocre-quality waters. These basins, although not showing a high proportion of bad quality waters, record a low proportion of good quality waters. Owing to their low variance in quality per stretch, severe water quality problems could be an issue.

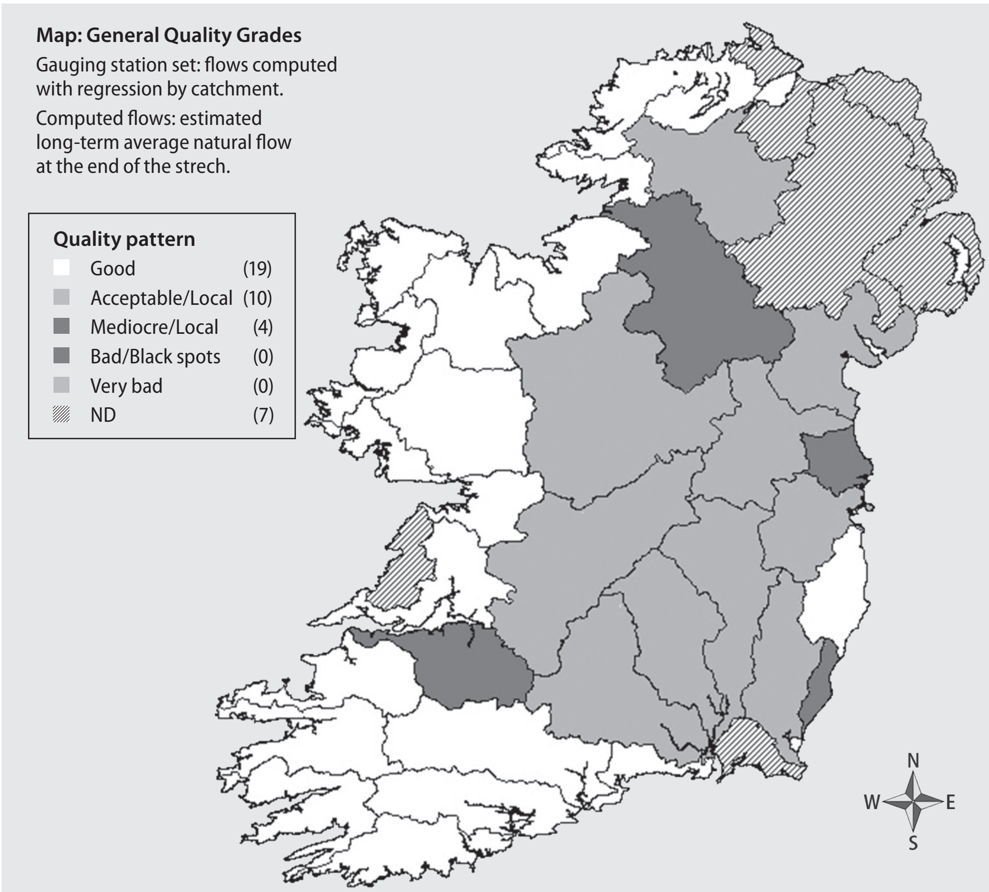
Figure VII.2
**Global river quality in England and Wales, United Kingdom of Great Britain and Northern Ireland, 1997-1999**




**Source:** Data collected by the Environment Agency of England and Wales and published in the European Environment Agency report entitled, "Test application of quality water accounts in England and Wales", prepared by Beture-Cerec (Copenhagen, 2001). Original data published in European Environment Agency, *The State of the Environment of England and Wales: Fresh Waters* (London, The Stationery Office, 1998).

74 Environment Agency of England and Wales and published in European Environment Agency report entitled, *Test Application of Quality Water Accounts in England and Wales*, prepared by Beture-Cerec (Copenhagen, EEA, 2001).

Figure VII.3
**Pattern index for the Republic of Ireland and Northern Ireland, 1990**




**Source:** Data provided by the Environmental Protection Agency of Ireland; processing reported in the European Environment Agency report entitled, "Test application of quality water accounts in the Republic of Ireland", prepared by Beture-Cerec (Copenhagen, 2001).

Chapter VIII

# Valuation of water resources

## A. Introduction

8.1. National accounts value water in the same way that they value all other products: at the price of water transactions. Unlike many other products, however, the prices charged for water often furnish only a poor and inadequate indicator of water's economic value, a situation arising from the following unique characteristics of water:

(*a*) 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 supplied 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;[75]

(*b*) Water supply often has the characteristics of a natural monopoly because water storage and distribution are subject to economies of scale;

(*c*) Property rights, essential for competitive markets, are often absent and not always easy to define when the 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;

(*d*) Water is a "bulky" commodity, that is, its weight-to-value ratio is very low, inhibiting the development of markets beyond those in the local area;

(*e*) Large amounts of water are abstracted for own use by industries other than those under ISIC division 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. IWRM, the previously described concept for water management, identifies maximizing the economic value obtained from the use of water and from investments in the water sector as two of its key objectives, along with equity and environmental sustainability.[76] This principle has been reaffirmed at international meetings and

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75 For a more detailed exploration of this topic, see William K. Easter, Nir Becker and Yacov Tsur, "Economic mechanisms for managing water resources: Pricing, permits and markets", in *Water Resources: Environmental Planning, Management and Development*, Asit K. Biswas, ed. (New York, McGraw-Hill, 1997); and Robert A. Young, *Measuring Economic Benefits for Water Investments and Policies*, *World Bank Technical Paper*, No. 338 (Washington, D.C., World Bank, 1996).

76 Global Water Partnership, "Integrated water resources management", TAC Background Paper 4 (Stockholm, GWP, 2000).

in major publications.[77] Nevertheless, the prices charged for water recorded in the national accounts often do not reflect its full economic value.

8.3. The economic valuation of water can be useful in 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 current generation, the allocation of resources between current and future generations and the degree to which wastes discharged into water are treated among 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 comprise 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 2008 SNA valuation. It does not make recommendations on which valuation technique should be used; the chapter should be seen as an overview of existing practices. Further, because there is no consensus on the valuation techniques to use or on the inclusion of these techniques in SEEA-Water (because of their lack of consistency with the 2008 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 currently 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 the national levels. Section C describes some background concepts in the economic valuation of water and the valuation principle of the 2008 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 in the valuation of water goods and services: namely, the scaling and aggregation of water values, the risk of double counting (as some of the value of water is already captured in the accounts), and the types of measures of value and their implications.

### 1. 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 levels. Projects and policies are often implemented for a designated water management area, such

77 The World Summit on Sustainable Development, which was held in Johannesburg, South Africa, from 26 August to 4 September 2002; the Third World Water Forum, held in Kyoto, Japan, 16-23 March 2003; and the Millennium Project Report to the United Nations Secretary-General: *Investing in Development: A Practical Plan to Achieve the Millennium Development Goals* (New York, UNDP, 2005).

as a river basin. There has been little experience in aggregating these localized values at the national level.

8.10. Because water is a bulky commodity and the costs of transporting and storing it are often high, the value of water is determined by local and regional site-specific characteristics and options for its 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, the quality of water and the reliability of its supply are also important determinants of the value of water. 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 those estimated for one area of a country cannot be assumed to apply 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 applied as readily. 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 the national level in order to obtain national water accounts. River basin accounts may also be more useful for policymakers because many water management decisions are taken at the level of the river basin, 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. Interbasin transfers are often valued according to the use made of the water in the receiving river basin.

## 2. 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 2008 SNA, although it is rarely identified explicitly; for example:

(*a*) For industries purchasing water from ISIC classes 0161 (support activities for crop production-operation of agricultural irrigation equipment) and 36 (water collection, treatment and supply), the water value in the 2008 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 the treatment, storage or transport of water, and industry value added where any residual water value accrues;

(*b*) For industries abstracting water for own use, the value of water is split between the costs incurred for the abstraction, transport, treatment or storage of water, and the industry's value added;

(*c*) For households, water value in the 2008 SNA includes the portion paid to water utilities or incurred by self-providers for abstraction.

8.13. The value of wastewater treatment may be reflected partly in the cost of services provided under ISIC division 37, sewerage, and the costs of self-treatment by industry and households. Damage to industrial productive capacity as a result of changes in water quality and the cost to industry of averting behaviour are already included in the 2008 SNA as part of the affected industries' costs of production. Some averting behaviour by consumers and health costs may be included in the 2008 SNA as part of consumer expenditures, but others may not be, or they may not be easy to identify. The value of recreational or aesthetic water services to consumers may also be reflected, at least partly, in the market prices of land, housing or tourism facilities.

8.14. In summary, most values for water are already included in the 2008 SNA, but they are not explicitly attributed to water. The role of water valuation is to make those values explicit; however, they should not be interpreted as additional values not included in the 2008 SNA. The value of water when extracted directly from the water resources is part of the SNA production boundary. As such its value should be imputed even if no transaction takes place.

## 3. Valuation techniques: marginal versus average value

8.15. Many valuation techniques exist for various water uses, and they can produce three conceptually different measures of "value" because of their foundation in cost-benefit analysis and its emphasis on economic welfare:

(*a*) **Marginal value** is 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 2008 SNA valuation;

(*b*) **Average value** is the average price that all buyers would be willing to pay, including a portion of consumer or producer surplus, which is the maximum amount that each buyer would be willing to pay, even though the consumer is not actually charged that price. Average value can be quite different (higher or lower) from that of the marginal value. For example, the "average" damage from a heavy load of pollution emitted into a lake may be substantially lower than the "marginal" damage that would result from a small increase in the pollution load;

(*c*) **Total economic value** is a measure of total economic welfare, which includes consumer surplus and producer surplus, and can be used to estimate the 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 2008 SNA, it would certainly be preferable to use techniques that measure marginal value, but often it is not possible to do so (see sections C and D). Nevertheless, water valuation is useful in its own right, but attention should be paid to comparing water values with national account aggregates because 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 advanced with great certainty. Valuation studies often produce a range of values because of the uncertainty and considerable amount of judgement 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.[78]

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 can be made aware of how this may distort policy analysis.

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

## C. Economic approach to the valuation of water

8.19. In economic terms, water is an essential commodity; thus, 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 it. 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 VIII.1).

8.20. Economists have many techniques for estimating shadow prices and have accumulated a great deal of practical experience in applying these techniques. Most techniques were developed typically for cost-benefit analysis of projects and policies, and other applications, whose requirements and purposes differ considerably from those of the national accounts. Consequently, the application of these techniques for the valuation of water in the water accounts, which, as satellite accounts of the 2008 SNA, should be based on the same valuation principles as the 2008 SNA, is not entirely straightforward.

8.21. Water valuation can be quite complex: data are often not available and those that are may be expensive to collect; water values are usually very site-specific; and benefits transfer, a method of applying the 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 contained in the 2008 SNA, raising major challenges to monetizing water accounts in a manner that is consistent with the 2008 SNA.

Box VIII.1
**Shadow prices**

In economic analysis, such as an evaluation of alternative allocations of water among competing users, it is necessary to express the costs and benefits 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, such as water and energy; taxes or subsidies that distort market prices of agricultural commodities; minimum wages that are 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 to accommodate these distortions. In other cases, there may be no market price at all, and the price must be estimated. The resulting adjusted or estimated price is called a "shadow price".

8.22. The 2008 SNA records actual market (and near market) transactions; the 2008 SNA value of a product is its market price. In competitive markets, prices represent the marginal values of goods and services. However, there are many instances in which observed prices may differ from marginal values, sometimes significantly, owing to factors such as market failure, administered prices, taxes and subsidies, and trade protection. Sometimes these distortions may be large; other times they may be small.

8.23. Non-market valuation techniques estimate marginal value, average value or total economic value, 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 all consumers are charged the same price in a given market regardless of what the consumer is willing to pay. Prices in the 2008 SNA may be quite different from marginal values, but the 2008 SNA does not include measures of consumer surplus. The relationships among these three concepts of economic value are illustrated in figure VIII.1 and described below:

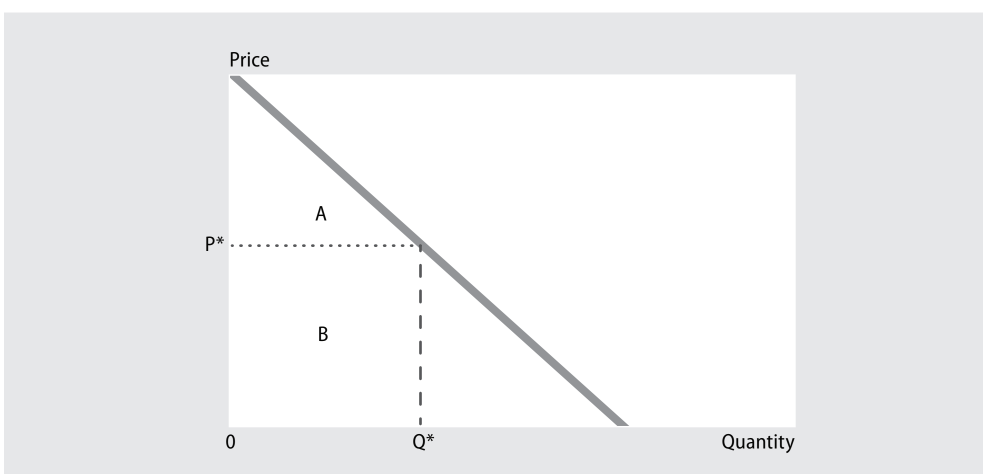
(*a*) The total economic value of water is measured as the sum of the total willingness to pay of all consumers, and is typically displayed as the area under the demand curve. For quantity Q*, *total economic value* is the area A + B. This measure is appropriate in applications such as cost-benefit analysis when the purpose is to measure the total change in economic welfare;

(*b*) 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 the marginal value (by the amount A/Q*) because it includes a portion of consumer surplus, the difference between the consumers' willingness to pay (the demand curve) and the market price;

(*c*) 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 damage resulting from water pollution, then divide that estimate by the tons of pollutant emitted in order to obtain the average damage per ton of pollutant. This average value is likely to differ significantly from the marginal values if the dose/concentration-response function is non-linear. 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 previously, water services are often provided and acquired without trade or through trade in imperfect markets; hence, information is not available for the specification of proper demand functions and the calculation

Figure VIII.1
**Demand curve for water**




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

of marginal or total economic values. In such cases, cost rather than benefit-based measures are commonly used to value water.

## D. Overview of valuation methodologies

8.25. People value an environmental good, such as water, for many purposes, which economists classify into use values and non-use values (see box VIII.2). It should be noted 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. The values include (*a*) the direct use of water as a resource, (*b*) the indirect support provided by water ecosystem services, and (*c*) the value of maintaining the option to enjoy the direct or indirect use of water in the future (option values). Non-use values include the value of knowing the intrinsic value of water ecosystems (existence value) and that water and water ecosystems will be available to future generations (bequest value).

8.26. An estimate of the total value of water should include all the 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, such as waste assimilation services, is also fairly well developed. However, the valuation of other indirect services, such as habitat protection and associated cultural values, and the non-use values are more controversial and not as well developed. Since such services are not yet included in the water accounts, they will not be discussed further.

8.27. Table VIII.1 lists the valuation techniques that have been applied most often to the water uses included in water accounts. All of them, except contingent valuation, are based on what economists call "revealed preference" methods, that is, water value is derived from observed market (revealed) behaviour towards a marketed good related to water. Contingent valuation is a "stated preference" technique based on surveys that ask people to state their values (stated preferences). Economists are often more comfortable with estimates derived from actual market behaviour, but for some water services, even indirect market information

Box VIII.2
**Categories of economic values for water**

**Use values**

- **Direct use values:** the direct use of water resources for consumptive uses, such as input to agriculture, manufacturing and domestic use; and non-consumptive uses, such as generating 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 and 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 the benefit of future generations
- **Existence value:** the intrinsic value of water and water ecosystems, including biodiversity; for example, the value people place simply on knowing that a wild river exists, even if they never visit it

may not be available, such as for protecting wetlands or endangered species. In the next section, each technique is described in greater detail.[79]

Table VIII.1
**Valuation techniques for water**

| Valuation techniques | Comments |
|---|---|
| **1. Water as an intermediate input to production: agriculture and manufacturing** | |
| Residual value<br>Change in net income<br>Production function approach<br>Mathematical programming models<br>Sales and rentals of water rights<br>Hedonic pricing<br>Demand functions from water utility sales | Techniques furnish average or marginal value of water based on observed market behaviour. |
| **2. Water as a final consumer good** | |
| Sale and rental of water rights<br>Demand functions from water utility sales<br>Mathematical programming models<br>Alternative cost<br>Contingent valuation | All techniques except contingent valuation furnish average or marginal value of water based on observed market behaviour.<br>Contingent valuation measures the total economic value based on hypothetical purchases. |
| **3. Environmental services of water: waste assimilation** | |
| Cost of actions to prevent damage<br>Benefits from the 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 the environmental services of water for waste assimilation.

8.29. Examples are also presented in order to illustrate some of the problems that arise when applying these techniques and to show how different practitioners have solved them. The majority of water valuation studies have addressed the value of water for irrigation, waste disposal and recreation.[80] It should be kept 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 season (irrigation water has a low value outside the growing season). The value of water for a particular use is also affected by the quality of the water and the reliability of supply.

79 A more detailed discussion of valuation methodologies for water, with references to many studies in the literature, can be found in Diana C. Gibbons, *The Economic Value of Water* (Washington, D.C., Resources for the Future, 1986); Kerry Turner and others, "Economic valuation of water resources in agriculture: from the sectoral to a functional perspective of natural resource management", *FAO Water Reports 27* (Rome, Food and Agriculture Organization of the United Nations, 2004); and Robert A. Young, *Measuring Economic Benefits for Water Investments and Policies*, op. cit. An exhaustive review of water valuation studies in the United States can be found in the work by Kenneth D. Frederick, Tim Vandenburg and Jean Hanson, "Economic values of freshwater in the United States", *Resources for the Future,* Discussion Paper 97-03 (Washington, D.C., RFF, 1997).

80 Frederick, Vandenburg and Hanson, "Economic values of freshwater", ibid.; Gibbons, *The Economic Value of Water*, op. cit.; and Young, *Measuring Economic Benefits*, op cit.

## 1. Valuing water as an intermediate input into agriculture and manufacturing

8.30. The most commonly used valuation techniques for water as an intermediate input into agriculture and manufacturing are residual value and its variants, mathematical programming and hedonic pricing applications.

8.31. Irrigation constitutes the single largest use of water in the world,[81] but it is also among the lowest-valued uses of water.[82] Production decisions in agriculture are highly complex and filled with uncertainties. In a review of irrigation water valuation studies,[83] it was found that most of the studies were 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 and paper, and chemicals) accounted for 43 per cent of total freshwater water use in 1995.[84] It is often assumed that the industrial value of water is relatively high compared with agriculture, but the industrial use of water has received much less attention than its other uses.[85] In a review of studies on the valuation of water in the United States,[86] 177 estimates for irrigation water and 211 estimates for the recreational value of water were found, but only 7 estimates for the value of water for industry.

### *(a) Residual value, change in net income and production function approaches*

8.33. Residual value and its related techniques of change in net income and the production function approach are techniques applied to water used as an intermediate input into 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 when their shadow prices can be estimated), then the shadow price of water is equal to the difference (the residual) between the value of the output and the costs of all non-water inputs to production, using the following formulas:

$$TVP = \sum p_i q_i + VMP_w q_w$$

$$VMP_w = \frac{TVP - \sum p_i q_i}{q_w}$$

where

81 Peter H. Gleick, ed., *Water in Crisis: A Guide to the World's Fresh Water Resources* (New York, Oxford University Press, 1993).

82 Gibbons, *The Economic Value of Water*, op. cit.

83 Young, *Measuring Economic Benefits*, op. cit.

84 Gunnar Brånvall and others, *Water Accounts: Physical and Monetary Data Connected to Abstraction, Use and Discharge of Water in the Swedish NAMEA* (Stockholm, Statistics Sweden, 1999).

85 Hua Wang and Somik Lall, "Valuing water for Chinese industries: a marginal productivity approach", paper prepared for the World Bank Development Research Group, World Bank, Washington, D.C., 1999.

86 Frederick, Vandenburg and Hanson, "Economic values of freshwater", op. cit.

$TVP$ = total value of the commodity produced;

$p_i q_i$ = the opportunity costs of non-water inputs into production;

$VMP_w$ = the value of the marginal product of water;

$q_w$ = the cubic metres 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 the 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 the water, as well as water tariffs. These costs are already included in the national accounts and should not be double counted.

8.36. The residual value method has been widely used for irrigation because it is relatively easy to apply, but it is quite sensitive to small variations in the specification of the production function and assumptions about the market and the policy environment. If an input into production is omitted or underestimated, its value would be 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 VIII.3 demonstrates this method by using a case study from Namibia.

8.37. Assuming that 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 as a result of taxes, subsidies for energy, trade protection, etc. Water is a major input into 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; only estimates of its use are available, based on "rules of thumb" applied to the number of hectares under irrigation and the type of crop being cultivated.[87] In the Namibian case study described in box VIII.3, the farmers' own estimate of the water used was at least 50 per cent higher than that of the guidelines used by water management authorities.[88]

8.38. Labour is a significant input in agriculture; often at least some portion of this labour is unpaid. In the 2008 SNA, it is recorded as mixed income together with operating surplus in case of unincorporated enterprises. If a value is not estimated for this input, the value of water would be overestimated. Family labour is often unpaid in both developed and developing countries; in the 2008 SNA, it 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 is sometimes less easy to value unless there are comparable farms which hire a manager.

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87 Robert Johansson, "Pricing irrigation water: a literature survey", World Bank Policy Research Working Paper, No. 2449 (Washington, D.C., World Bank, 2000).

88 Glenn-Marie Lange, "Water accounts in Namibia", in Glenn-Marie Lange and Rashid M. Hassan, *The Economics of Water Management in Southern Africa: An Environmental Accounting Approach* (Cheltenham, Edward Edgar Publishing, 2006); and Glenn-Marie Lange, "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 2002, Souse, Tunisia.

Box VIII.3
**Calculating residual value: an example from Namibia**

The residual value technique was applied to agricultural production in the Stampriet region of Namibia, where farmers abstract groundwater to raise cattle and irrigate crops, including lucerne, for their livestock. 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 on some items are considered reasonably accurate, notably, farm income, inputs of most goods and services, and the 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; thus, 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 using the following formula:

> Gross farm income - inputs of goods and services - 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 in illustrating the sensitivity of the residual method to the assumptions made. The table below shows the costs of production and residual value of water under different assumptions about the cost of capital. Assuming a 5 per cent cost for capital investments, the residual value of water was 19 Namibian cents per cubic metre. However, if the real cost of capital rose to 7 per cent, farmers would not earn enough to cover even the capital costs and the value of the water would be negative.

| Farm revenue and costs (in 1999 Namibian dollars) | | Data source |
|---|---|---|
| Gross farm income | $601 543 | Output multiplied by market prices obtained from survey |
| Inputs of goods and services | $242 620 | Inputs multiplied by prices obtained from survey |
| Value added, *of which:* | $358 923 | |
| Compensation of employees | $71 964 | Wages paid + in kind payments obtained from survey |
| Gross operating surplus, *of which:* | $286 959 | |
| Imputed value of farmers' labour | $48 000 | Imputed value based on average salary of hired farm manager |
| Depreciation | $66 845 | Standard depreciation rates multiplied by farmers' estimated historical cost of capital in survey |
| Cost of working capital | $17 059 | Imputed as percentage of the value of fixed capital |
| Cost of fixed capital including land, 3-7 per cent | $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 (cubic metres) | 154 869 | Farmers' "best guess" (water is not metered) |
| Residual value (Namibian dollars/ cubic metre) | $0.51 to -$0.14 | |

**Source:** Adapted from Glenn-Marie Lange, "Water valuation case studies in Namibia", in Glenn-Marie Lange and Rashid M. Hassan, *The Economics of Water Management in Southern Africa: An Environmental Accounting Approach* (Cheltenham, United Kingdom, Edward Elgar Publishing, 2006); Glenn-Marie Lange, J. MacGregor and Simon Masirembu, "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; and Glenn-Marie Lange, "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 2002, Souse, Tunisia.

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 subsidized, 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 VIII.4 shows two examples of residual value adjusted for trade protection: the United Kingdom and Jordan. In the example of the United Kingdom, information was not available concerning the amount of water used for each crop, so the residual value is given as the value per hectare, that is, for the total amount of water required to cultivate a given crop on a hectare of land. After correcting for trade protection, only one crop, potatoes, would generate a positive return to water.

8.41. For irrigated 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.[89] This may be appropriate when there is a short-term disruption in the water supply, such as a drought, where the objective is to maximize profits by allocating water to higher-value crops under such unusual short-term conditions. However, these short-term values of water do not reflect the long-term values; they 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 as a result of a change in the input of water, rather than the value of all water used in production. The CNI approach is often used to compare the value of water under current allocation to the value that would be obtained under an alternative allocation of water. For example, this technique might be used to assess a farmer's response to a policy initiative intended to bring about a change in crop mix or production technology. In contrast to residual value, CNI measures the marginal value of water by measuring the impact of a change, rather than the average value obtained with the residual value approach.

8.43. It has been noted that the CNI approach is used more often than the single-crop residual value approach.[90] The use of CNI encounters the same problems in correctly specifying the production function and correcting for missing or distorted prices. Since CNI essentially compares 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 for 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 analyses 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 cost, 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 valuing water used in manufacturing. The residual value method is not used for water valuation in industry 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. A production function approach has also been used to measure the marginal value of water in manufacturing (see box VIII.5).[91] A similar study was undertaken in China in 1993, using data for about 2 000 firms, mostly medium-sized and large State-owned enterprises.[92]

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89 For example, Radwan A. Al-Weshah, "Optimal use of irrigation water in the Jordan Valley: a case study", *Water Resources Management*, vol. 14, No. 5, pp. 327-338.

90 Young, *Measuring Economic Benefits*, op. cit.

91 Steven Renzetti and Diane Dupont, "The value of water in manufacturing", *CSERGE Working Paper ECM 03-03* (Norwich, United Kingdom, University of East Anglia's Centre for Social and Economic Research on the Global Environment, 2003).

92 Wang and Lall, "Valuing water", op. cit.

Box VIII.4

**Adjusting the residual value of water for market distortions**

The case studies for the United Kingdom and Jordan show the importance of adjusting for market distortions occurring as a result of trade protection. In both cases, the residual value of water is calculated with and without the effective subsidies from trade protection. Substantial differences occur as a result.

**Case 1. United Kingdom.** Bate and Dubourg estimated the residual value of water used for irrigating five crops in East Anglia from 1987 to 1991, using data from farm budget surveys. However, because data about actual water use were not available, the residual value was calculated for the amount of water needed to cultivate a hectare of a given crop. When the effective subsidies from the European Union's Common Agricultural Programme are taken into account, the residual value is negative for all crops except potatoes.

| | British pounds sterling per hectare[a] | |
|---|---|---|
| | Not adjusted for Common Agricultural Programme subsidies | Adjusted for Common Agricultural Programme subsidies |
| Winter wheat | 101.12 | -176.48 |
| Barley | 13.45 | -164.70 |
| Oilseed (rape) | 220.04 | -146.48 |
| Potatoes | 1 428.84 | 880.04 |
| Sugar beet | 327.93 | -3 565.10 |

**Source:** Adapted from Roger N. Bate and W. Richard Dubourg, "A net-back analysis of irrigated water demand in East Anglia", *Journal of Environmental Management* (1997), vol. 49, No. 3, pp. 311-322.

**a** The actual amount of water used per hectare of a crop is unknown.

**Case 2. Jordan.** Schiffler 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 per cent) for fruit crops, but nearly 50 per cent for vegetables.

| | Jordanian dinars per cubic metre 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 Manuel Schiffler, *The Economics of Groundwater Management in Arid Countries* (London and Portland, Oregon, Frank Cass Publishers, 1998).

### *(b) Mathematical programming models*

8.46. Various forms of mathematical programming models have been developed to guide decisions on water allocation and infrastructure development. These models specify an objective function, such as maximizing the value of output, subject to production functions, water supply and institutional and behavioural constraints. These models may be applied to one sector, such as agriculture, in order to determine the optimum mix of crops; to a watershed in order to determine the optimum allocation of water among all users; or to a national economy. These may be linear programming models, 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. Optimization models, as the name implies, estimate marginal values for water that are based on an "optimum" allocation of water and the corresponding reconfiguration of economic activity and prices. Box VIII.6 contains an example of a linear programming approach to agriculture in Morocco. An economy-wide approach may use linear programming, simulation, or, more commonly, a CGE model. A CGE model of Morocco has been

Box VIII.5
**Marginal value of water in Canada, by industry, 1991**

Using a production function approach, the marginal value of raw water was estimated for 58 manufacturing industries in Canada in 1981, 1986 and 1991. Assuming that firms would minimize their costs, the researchers formulated a translog cost function based on the quantity of output; the quantity of water; the price of capital, labour, energy, materials, water recirculation and in-plant water treatment; as well as several dummy variables that took into consideration site-specific and industry-specific characteristics, such as the aridity of provinces and the share of raw water that was used for industrial processes. In the cost function approach, the shadow price of water was 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 per cubic metre 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 (Canadian dollars per cubic metre) | Industry | Shadow price of water (Canadian dollars per cubic metre) |
|---|---|---|---|
| Food | 17 | Paper and allied products | 31 |
| Beverages | 38 | Basic metals | 107 |
| Rubber | 6 | Fabricated metal | 48 |
| Plastic | 32 | Transport equipment | 25 |
| Primary textiles | 14 | Non-metallic minerals | 23 |
| Textile products | 5 | Refined petroleum/coal | 288 |
| Wood | 20 | Chemicals | 72 |

**Source:** Adapted from Steven Renzetti and Diane Dupont, "The value of water in manufacturing", CSERGE Working Paper ECM 03-03 (Norwich, United Kingdom, University of East Anglia's Centre for Social and Economic Research on the Global Environment, 2003).

used to determine the impact of trade reform on the shadow value of water in agriculture.[93] The long-term change in shadow prices (the shadow prices themselves are not reported) ranged from -22 per cent for wheat to +25 per cent for fruits and vegetables.

### *(c) Hedonic pricing*

8.48. Hedonic pricing is based on the notion that the purchase of land represents the acquisition of a bundle of attributes, including water services, which cannot be sold separately. For agriculture, the bundle includes soil quality, existing farm infrastructure and water resources, among other attributes. Regression analysis of land sales (or reasonably assessed values of land) on the attributes of the land, both positive and negative, reveals the contribution that water services make 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 the value of water for recreation purposes and to a lesser extent to estimate the value of water for agricultural uses. Box VIII.7 presents an interesting example of hedonic pricing that combines both water quantity and quality in Cyprus. Many similar studies have been conducted throughout the world in places where water quality is an issue.

93 Xinshen Diao and Terry Roe, "The win-win effect of joint water market and trade reform on interest groups in irrigated agriculture in Morocco", in *The Political Economy of Water Pricing Reforms*, Ariel Dinar, ed. (New York, Oxford University Press, 2000).

Box VIII.6

**Linear programming approach to valuing irrigation water**

**Shadow price of water in selected sectors in Morocco, 1995**

A linear programming model for Morocco was developed to assist in water management and water policy design. The economic part of the model was based on the Moroccan social accounting matrix, expanded to include 13 irrigated crops and 1 rain-fed agricultural sector. Four types of water were distinguished: water inputs from a network, groundwater, precipitation and return flows.

| | Dirhams per cubic metre | | Dirhams per cubic metre |
|---|---|---|---|
| Sugar cane | 2.364 | Legumes | 5.603 |
| Other cereals | 3.013 | Sunflower | 6.219 |
| Sugar beet | 3.042 | Wheat | 7.498 |
| Fodder | 3.047 | Vegetables | 12.718 |
| Barley | 3.291 | Livestock | 25.019 |
| Maize | 3.426 | Industrial crops | 48.846 |
| Citrus | 3.692 | Industry and services | 92.094 |

**Source:** Adapted from Hynd Bouhia, Water in the Macro Economy (Aldershot, United Kingdom, Ashgate Publishing Company, 2001).

Box VIII.7

**Hedonic valuation of the quantity and quality of irrigation water**

Hedonic pricing was used to estimate the value of water for irrigation use in Cyprus where saltwater intrusion is occurring in coastal areas. The researchers had to address an additional challenge to hedonic modelling: land could be used for either agriculture or tourism. Land that is closer to the sea is less productive for agriculture owing to saltwater intrusion, but it has a higher value for tourism. Therefore, they regressed land values (from a 1999 survey of 282 landowners) 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 the land would not be affected by the demand for land for tourism. The marginal amount farmers were willing to pay for avoiding saline groundwater was 10.7 pounds sterling per hectare.

**Source:** Phoebe Koundouri and Panos Pashardes, "Hedonic price analysis and selectivity bias", in *Economics of Water Resources, Theory and Policy*, Panos Pashardes, Timothy Swanson and Anastasios Xepapadeas, eds. (Dordrecht, Netherlands, Kluwer Academic Publishers, 2002), pp. 69-80.

## 2. Water as a final consumer good

### *(a) 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 a permanent basis, notably, Australia, Chile and Spain, as well as parts of the United States.[94] Trading in a competitive market could establish a price that represents the marginal value of water. In 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 transaction prices do not represent the marginal value because the conditions necessary for a competitive market are not present.[95]

8.50. A competitive market requires, among other things, a large number of buyers and sellers, and this results in frequent transactions. In Chile, water trades accounted for only

94 For an overview of these markets and how they function, see Alberto Garrido, "The economics of water allocation and the feasibility of water markets in agriculture", in *Sustainable Management of Water in Agriculture* (Paris, OECD, 2003).

95 Young, *Measuring Economic Benefits*, op. cit.

1 per cent of the total abstractions by the mid-1990s and prices ranged from US$ 250 to $4 500 a share (4 250 cubic metres).[96] The development of water markets was greatest in areas with effective water-use associations, well-defined property rights and good irrigation infrastructure (large reservoirs and adjustable gates with flow meters); in areas without these characteristics, high transaction costs limited the development of the water market. In a few countries, tradable water rights may furnish a basis for water valuation in the future, but this technique has not yet been applied.

### (b) 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 the domestic use of water, above a basic survival amount, involve estimation of the demand curve either from actual sales of water (revealed preference) or from the use of the contingent valuation approach (stated preference). Both approaches estimate the average value of water.

### (c) 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 often cannot be obtained, even in developed countries.[97] Water use must be metered in order to provide accurate data about the volume consumed and water charges must be based on that volume, because when consumers pay a lump sum, the marginal cost is zero and their consumption does not reveal the marginal value. Demand curves cannot be estimated where water is rationed or where all consumers are charged a single marginal price. Where a single price is charged, a less reliable alternative sometimes is used to trace the real tariff over time and the changes in the water consumed. It has also been pointed out that the water demand function of households with piped water differs substantially from those households relying on unpiped water supply, a common situation in most developing countries.[98] An accurate estimate of consumer demand must include both types of household. Appropriate sales data will furnish 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.

### (d) 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 that they place on something: it asks them how much they would be willing to pay for the item in question. This method is particularly useful for eliciting the value of environmental goods and

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96 Monica Rios Brehm and Jorge Quiroz, *The Market for Water Rights in Chile, World Bank Technical Paper*, No. 285 (Washington, D.C., World Bank, 1995); and Robert R. Hearne and K. William Easter, *Water Allocation and Water Markets: An Analysis of Gains from Trade in Chile, World Bank Technical Paper,* No. 315 (Washington, D.C., World Bank, 1995).

97 For a more detailed discussion, see Ian Walker and others, "Pricing, subsidies and the poor: demand for improved water services in Central America", World Bank Policy Research Working Paper, No.2468 (Washington, D.C., World Bank, 2000).

98 Ibid.

services for which there are no market prices, such as recreation, water quality and aquatic biodiversity. CVM was first used several decades ago; it gained in popularity 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.[99] 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 VIII.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 demand function approach is considered more reliable because it is based on actual market behaviour; in estimating consumer water demand, CVM is not a good substitute for revealed preference.[100] A comparison of values derived from CVM and revealed preference studies for a wider range of environmental services show a similar disparity.[101]

Box VIII.8

**Two approaches for measuring the value of domestic water in Central America**

A group of researchers 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 to 1998 in seven cities in Central America. The survey distinguished households with piped and unpiped water. The price paid for a cubic metre of water was different for households with piped and unpiped water; thus, a demand curve was derived from the two points. For households that relied 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 metre of water depending on the distance to the water source.

The other method, the contingent valuation survey, asked households how much they would be willing to pay for improved service with a monthly consumption of 30 cubic metres. Each household was given only one price to which it could respond; each could answer yes or no. Different households were given different prices; the distribution of yes and no answers for the different prices was used to derive a demand curve. In four cities, the revealed preference and contingent valuation methodology (CVM) estimates were fairly similar, but in the other three cities, the two approaches differed by 100 per cent. It was concluded that the variation was too great to use the CVM where good revealed preference data were available.

| | Price at which consumers would demand 30 cubic metres (United States dollars per cubic metre) | |
|---|---|---|
| | CVM | Revealed preference |
| San 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 City and Colón, Panama | 0.51 | 0.40 |

**Source:** Adapted from Ian Walker and others, “Pricing, subsidies and the poor: Demand for improved water services in Central America”, World Bank Policy Research Working Paper, No. 2468 (Washington, D.C., World Bank, 2000).

**Note:** Figures represent average values.

99 Kenneth Arrow and others, “Report of the NOAA Panel on Contingent Valuation”, *Federal Register*, vol. 58, No. 10, pp. 4601-4614.

100 Walker and others, “Pricing, subsidies and the poor”, op. cit.

101 Nick Hanley and Clive L. Spash, *Cost-Benefit Analysis and the Environment* (Cheltenham, United Kingdom, Edward Elgar Publishing, 1993).

## 3. Valuing the environmental services of water for waste assimilation

8.55. SEEA identifies two principles for the direct valuation of environmental degradation: one is cost-based and the other is damage-based. The cost-based principle stems from the cost of preventing environmental degradation; in the past it was referred to as the "maintenance cost" approach. The damage-based principle originates from the benefits of averting the damage that would be incurred as a result of environmental degradation.

### *(a) Benefits from averting damage from water degradation*

8.56. This damage-based approach measures the value of water's waste assimilation services in terms of the benefits that would be obtained from averting the damage that would be incurred from loss of this service. The damage includes such events as 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 body of water. Water standards have been established by international organizations, such as the World Health Organization (WHO), as well as by national agencies, in terms of the concentration of substances. Such concentrations are often grouped according to the maximum level acceptable for a particular use, with human consumption requiring the highest standard of quality. Recreational water usually does not have to meet such a high standard. Some industrial processes require extremely clean water while others may not, for example, water used for cooling; however, polluted water may damage or corrode equipment. Water for irrigation also does not have to meet the highest standards of water quality.

8.58. The next step is to determine the extent of the damage that would be caused by a change in water quality. For damage to human health, 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 furnish similar concentration-response functions for damage to land, buildings, structures, equipment and the environment. The potential damage must then be valued.

8.59. The value of clean drinking water can be measured, for example, as the value of the waterborne diseases and premature deaths averted. The value of the health risks averted usually includes the cost of medical treatment and the 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 the generation of 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: the damage 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 the damage may occur further downstream, even in another country. Even when damage can be measured, it is not easy to value, particularly environmental damage. In most instances, the total damage and an average damage cost per unit of pollutant are estimated. A great deal of effort goes into estimating marginal damage functions, although these estimates are more widely available for air pollution than for water pollution.

### *(b) Costs of averting damage from water degradation*

8.61. As is the case with the damage-based valuation approach, the maintenance-cost approach is also based on environmental degradation. However, rather than looking at the cost of the damage caused, the maintenance-cost approach is based on the cost of actions to prevent damage. This approach 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 environmental 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 wastewater, represent a social perception of relative costs and benefits. As in the damage-based approach, the information needs of the maintenance-cost approach 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 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 solutions, such as filters that remove pollutants from the wastewater stream, and change-in-process solutions, such as substitution with less polluting materials. At the consumer level, solutions include expenditures for substitute goods, such as buying bottled water instead of using tap water, or the cost of activities, such as boiling water to make it safe for drinking. The "restoration cost approach" measures the cost of restoring a damaged body of water to an acceptable state. The abatement cost approach is the most widely used of the cost-based approaches.

8.64. The cost of preventing the emission of pollutants was used to value the loss of water quality in some of the early water degradation accounts in developing countries, such as the Republic of Korea[102] and the Philippines.[103] Pollution abatement costs were estimated using the process of benefits transfer, which involved adjusting parameters, cost functions and damage function, 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, however, 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 the technologies used to reduce pollution emissions than to estimate the benefits that could be obtained 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 damage averted from changes in water quality, although much of the value of the damage is average rather than marginal.

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

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

8.65. The benefit obtained from the damage averted is a widely used approach in the cost-benefit literature and the preferred technique for SEEA. Often, the results are reported as the total benefit from costs averted or the average cost per statistical life saved or illness prevented. Marginal costs, which relate the potential damage averted to marginal changes in water quality (measured as the concentration of substances), are not often reported. One study does use marginal damage cost functions.[104] Box VIII.9 shows part of the results of that study.

Box VIII.9

**Marginal cost of water degradation**

In a report to the Australian National Land and Water Resources Audit, two researchers estimated the value of water under different uses, and the costs of water degradation countrywide, which included water degradation due to salinity, erosion, sedimentation and turbidity. The authors estimated marginal damage costs using cost functions derived from engineering studies. With regard to salinity, the major problem is corrosion of equipment. The marginal damage from a unit increase in salinity is shown below. Households use the most water (85 per cent) 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 form of damage is to cooling towers and the water feeders of boilers.

**Marginal damage costs from a unit increase in salinity for urban and industrial water users, Murray River** (*1999 Australian dollars per unit of electrical conductivity units*[a])

| | Marginal cost of salinity | Share of total water use (*percentage*) |
|---|---|---|
| Households | 111 270 | 85 |
| Industrial | 54 780 | 12 |
| Commercial | 7 400 | 4 |

**Source:** Adapted from Stefan A. Hajkowicz and Michael D. Young, eds., "Value of returns and costs of resource degradation", consultency report to the National Land and Water Resources Audit (Canberra, Land and Water Division of the Commonwealth Scientific and Industrial Research Organisation, 2002).

**a** A measurement of water salinity roughly equivalent to 1.6 x total dissolved solids in water (mg/l).

104 Stefan A. Hajkowicz and Michael D. Young, eds., "Value of Returns to Land and Water and Costs of Resource Degradation", consultency report to the National Land and Water Resources Audit (Canberra, Land and Water Division of the Commonwealth Scientific and Industrial Research Organisation, 2002).

Chapter IX

# Examples of applications of water accounts

## A. Introduction

9.1. Global freshwater resources are under pressure from the ever-increasing demand created by human activities, from the contamination caused by pollution, from the increasing incidence of water-related disease, from the loss and degradation of freshwater ecosystems and from global climatic change that affects water supply and demand. As the limits of domestic water resources are reached, countries are becoming increasingly dependent on shared international water resources, a situation that raises the potential for conflict. These concerns affect 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 not much attention has been paid to the economic and social aspects of water.[105] Some critical policy questions require the linking of data on water with economic data, such as the following:

(*a*) The consequences for water resources of economic growth and the patterns of household consumption and international trade;

(*b*) The social and economic impacts of water policy instruments, such as regulation, water pricing and property rights;

(*c*) The contribution of specific economic activities to the pressure on water resources and the options for reducing that pressure.

Water accounts comprise a unique tool for improving water management because they integrate data on 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 IWRM, a widely accepted approach to water management adopted by Agenda 21, the European Union Water Framework Directive and the Third World Water Forum.[106] IWRM has also been identified as one of the immediate approaches that countries should take for achieving the Millennium Development Goals; the approach has been widely adopted as the framework for development.[107]

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105 Michael Vardon and Stuart Peevor, "Water accounting in Australia: Use and policy relevance", paper presented to the London Group on Environmental Accounting, Copenhagen, 2004.

106 See works cited in notes 7, 8 and 76; and Millennium Project Task Force on Water and Sanitation, "Background paper on water and sanitation", UNDP, 2003.

107 Millennium Project Task Force on Water and Sanitation, "Background paper", ibid.

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, the quantity and the quality of which 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 supply and use in a framework that supports quantitative analysis. Water managers often have access to information about water use by broad groups of end-users, but such 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 (supply, use, resources, discharge of pollutants, assets, etc.) directly to economic accounts. They achieve this by sharing structures, definitions and classifications with the 2008 SNA; for example, water suppliers and end-users are classified by the same system used for the economic accounts, that is, ISIC.[108]

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. As is the case with other environmental accounts and economic accounts, water accounts furnish (*a*) indicators and descriptive statistics for the purposes of monitoring and evaluation; and (*b*) detailed statistics for policy analysis. Section B describes the most common indicators used to evaluate the current patterns of water supply and use, and of pollution. It begins with macrolevel indicators that serve as "warning" signs of trends 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 the sources of pressure on water resources, on the opportunities for reducing the pressure and on the contribution of economic incentives, such as pricing, to the problem and its possible solutions. These indicators can be compiled directly from the water accounts without requiring much technical expertise.

9.7. Annex III to the present report addresses more thoroughly the link between indicators that can be derived from the water accounts and the sets of indicators and index numbers developed by international organizations, such as the United Nations (Millennium Development Goals), the United Nations Commission on Sustainable Development (sustainable development indicators), the Organization for Economic Cooperation and Development (environmental indicators) and various other major publications of United Nations agencies and programmes.[109]

9.8. This information sets the stage for the analysis of more complex water policy issues, based mostly on economic models that incorporate the water accounts. Section C is aimed at demonstrating the use of water accounts for several critical policy issues, such as projecting future water demand or estimating the impact of water pricing reform, rather than attempting a comprehensive review. Generally, these applications require cooperation among statisticians, 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 the country's policy concerns more directly. Countries generally start with physical supply and use tables, emission accounts and asset accounts. They add monetary accounts at a later stage of implementation depending on the policy concerns and availability of data. Most examples of policy applications utilize accounts for the supply and use of water and the emission accounts described in chapters III and IV.

108 See work cited in note 23.

109 See work cited in note 2.

9.10. Although the water accounts are usually compiled at the national level for an accounting period of one year, doing so is often not very 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 type of "accounting catchment" defined in chapter II. Several countries now compile water accounts on a regional basis, for example, Australia, France, the 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 SEEA-2003 that would be useful for IWRM and a more comprehensive approach to sustainable development.

## B. Indicators for water management

9.12. The first step towards improved water management is usually to obtain a good understanding of current patterns of supply, use and pressure. Descriptive statistics and indicators from the accounts furnish information on the following:

(*a*) Sources of pressure on water resources: determining how much each sector contributes to particular environmental problems, such as overexploitation of groundwater or water pollution;

(*b*) Opportunities for improving water productivity: determining if water is being allocated to the highest value users; identifying what opportunities exist to increase water efficiency and productivity; assessing the extent of the losses;

(*c*) Water pricing policies: determining if water providers are achieving full cost recovery; finding out if pricing is equitable across different users; assessing whether pricing policies provide incentives for water conservation and pollution prevention, or whether they encourage excessive use of water resources;

(*d*) Sustainability of water use: comparing water resources and water use.

9.13. This section discusses how the water accounts contribute to each of these areas of information. All of the indicators presented have been introduced and defined in chapters III to V; notes to each table and figure identify the relevant chapter.

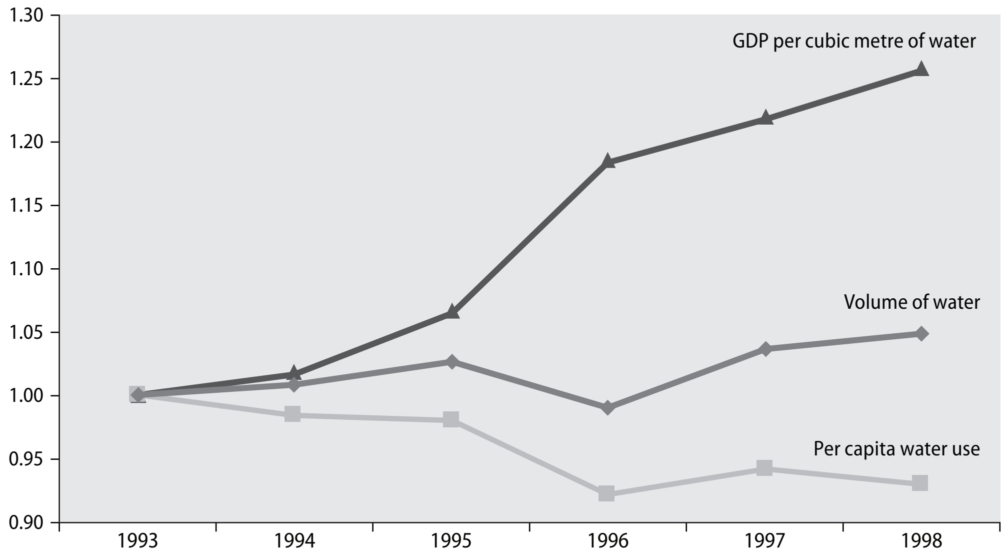
### 1. Sources of pressure on water resources

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, per capita water use in Botswana declined and water productivity, measured by GDP per cubic metre of water used, increased, so that the volume of total water use increased by only 5 per cent (see figure IX.1), even though GDP grew by more than 25 per cent. 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 1996-2001:[110] even though GDP of the Neth-

110 Rob Van der Veeren and others, "NAMWA: a new integrated river basin information system", *National Institute for Integrated Water Management and Wastewater Treatment Report 2004.032* (Voorburg, Netherlands, Central Bureau of Statistics, 2004), figure 25. Available from http://www.rws.nl/rws/riza/home/publicaties/riza_rapporten/rr_2004_032.html.

Figure IX.1
**Index of water use, population and GDP in Botswana, 1993-1998**




**Source:** Based on Glenn-Marie Lange, Rashid M. Hassan and Moortaza Jiwanji, "Water accounts: an economic perspective on managing water scarcity", in Glenn-Marie Lange, Rashid M. Hassan and Kirk Hamilton, *Environmental Accounting in Action: Case Studies from Southern Africa* (Cheltenham, United Kingdom, Edward Elgar Publishing, 2003).

**Note:** 1993 = 1.00. These indicators can be derived from the physical supply and use table described in chapter III.

erlands had grown considerably, the country managed to reduce the volume of water pollutants substantially (figure IX.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 within their water accounts, an issue taken up later in this chapter.

9.16. Even at the macroeconomic level, further distinctions are typically made in the water accounts based on the characteristics of water in order to provide a more thorough and useful assessment of trends. Some of the most common characteristics include the following:

(*a*) Volume of water used disaggregated by purpose, such as cooling, industrial process and cleaning. These data are useful for identifying the potential for water conservation and improvements in water efficiency. In Denmark, for example, 79 per cent of water was used for cooling (table IX.1);[111]

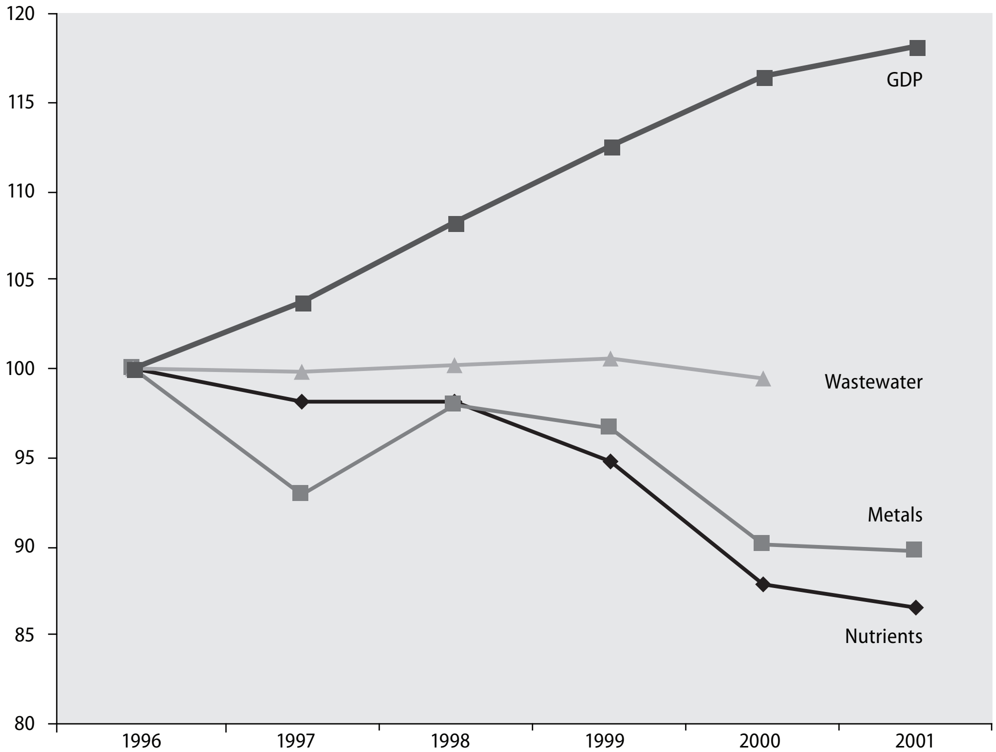
(*b*) Volume of water supplied by water utilities compared with the water abstracted for own use and the reuse of water. Nearly half of the water use in Australia in 2000/01 was abstracted directly by end-users, with the remaining supplied through water mains or the reuse of water (table IX.2). This distinction is important because in some countries there are significant differences among these sources in terms of water regulations; the capacity for monitoring may also differ and investment strategies for the future are affected by the source of water;

(*c*) Volume of water abstracted by natural source. Overexploitation of groundwater, for example, may be a critical issue in some countries. Therefore, water managers need accounts that would identify trends in groundwater abstraction and the users of groundwater. Similarly, it may be very helpful to identify the use of water from shared international water resources when allocations from such resources are restricted;

(*d*) Wastewater returned to inland water resources. For example, the proportion of wastewater collected that is treated and the amount of pollution discharged;

111 Gunner Brånvall and others, op. cit.

Figure IX.2
**Index of growth of GDP, wastewater and emissions of nutrients and metals in the Netherlands, 1996-2001**




**Source:** Rob Van der Veeren and others, "NAMWA: a new integrated river basin information system", *National Institute for Integrated Water Management and Wastewater Treatment Report 2004.032* (Voorburg, Netherlands, Central Bureau of Statistics, 2004), figure 25. Available from http://www.rws.nl/rws/riza/home/publicaties/riza_rapporten/rr_2004_032.html.

**Note:** 1996=1.00. These indicators can be derived from the physical supply and use table and the emissions table described in chapters III and IV.

Table IX.1
**Water use in Denmark, by purpose, 1994**

| | 1 000 m$^3$ | Percentage |
|---|---|---|
| Tap water[a] | 434 400 | 6 |
| Cooling | 5 356 157 | 79 |
| Production processes | 58 276 | 1 |
| Added to products | 3 996 | [b] |
| Other purposes | 885 896 | 13 |
| **Total** | **6 738 725** | **100** |

**Source:** Adapted from Thomas Bie and Bo Simonsen, "NAMEA with water extraction and use", *Environmental Accounting Project Report to European Community Project*, DG XVI ERDF file No. 97/01/57/009 (Copenhagen, Statistics Denmark, 2001).

**Note:** This table can be derived from the physical supply and use table described in chapter III.

**a** Refers to water distributed by the water supply industry, ISIC division 36, water collection, treatment and supply.

**b** Less than 1 per cent.

Table IX.2
**Water use in Australia, by source, 2000-2001**

| | GL (109 litres) | Percentage of total water use |
|---|---|---|
| Abstraction for own use | 11 608 | 47 |
| Water received from ISIC division 36, water collection, treatment and supply | 12 784 | 51 |
| Reuse | 527 | 2 |
| **Total** | **24 919** | **100** |

**Source:** Australian Bureau of Statistics, *Water Account, Australia 2000-01* (Canberra, ABS, 2004). Summary available from http://www.abs.gov.au/ausstats/ABS@nsf/mf/4610.0.

**Note:** This table can be derived from the physical supply and use table described in chapter III.

(*e*) The quality status of bodies of water, identified by catchment and size classes. Identifying the various sources of pollution, such as municipal point sources, industrial point sources and other non-point sources, as well as the contributions of the different sources, enables the identification of sound investments for corrective purposes.

### (a) *Comparing the 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 in order to understand trends and prioritize 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 with the economic contribution that it makes. For a simple water profile, an industry's environmental burden is represented by its share of water use and/or pollution generated; its economic contribution is represented by its share of value added. Water profiles may be used for "benchmarking" industrial performance in order to promote water efficiency and water conservation.

9.18. In Australia, for example, agriculture accounts for 67 per cent of total water use, but less than 2 per cent of the gross value added (table IX.3), indicating that agriculture's burden on water is greater than its economic contribution; but how much greater in comparison with other industries remains a question. Water productivity combines the two elements—economic contribution and environmental burden—into a single number by dividing industry value added by water use (from the hybrid supply and use tables in chap. V).

Table IX.3
**Water profile and water productivity in Australia, 2000-2001**

| | Water consumption (megalitres) | Percentage distribution of water consumption | Percentage of industry gross value added | Value added in Australian dollars per megalitre of 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 cane | 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 and 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 | n/a | n/a |
| Environment | 459 393 | 1.8 | n/a | n/a |
| **Total** | **24 908 659** | **100.0** | **100.0** | |

**Source:** Based on Australian Bureau of Statistics, *Water Account, Australia 2000-01* (Canberra, ABS, 2004). Summary available from http://www.abs.gov.au/ausstats/ABS@.nsf/mf/4610.0.

**Note:** This table can be derived from the hybrid supply and use table described in chapter V.

**Abbreviation:** n/a = not applicable.

9.19. Water productivity is the most widely used indicator from the water accounts for cross-sector comparisons. It furnishes 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; it is sometimes mistakenly confused with water value (see chap. VIII for a discussion of this distinction). As shown in table IX.3, the water accounts of Australia reveal that water productivity in agriculture (A$ 0.58 of value added per cubic metre of water) is orders of magnitude less than that in services (other industries, A$ 487.65 of value added).

9.20. It is quite useful to compile a time series of environmental-economic profiles over time, such as the water productivity time series for Namibia in table IX.4. Water profiles can also be much more extensive, as shown in the example of two industries in Sweden (figure IX.3), using 14 measures of performance: 3 measures of economic contribution (production, value added, hours worked), 1 non-water environmental factor (energy use) and 10 factors related to water use and wastewater treatment.

9.21. For effective water management, the reasons for large differences in water use and pollution emissions from different industries must be understood. A country's use of water or level of 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 the water intensity of each sector.

9.22. Table IX.5 shows the distribution of water use in Namibia by industry and the water intensity of each industry. In the period 2001-2002, commercial crop farming accounted for 43 per cent of total water use and a "water intensity" of 327 litres per dollar of output, that is, commercial crops required 327 litres of water to generate 1 dollar of output. Within the agricultural sector, water intensities vary a great deal. Commercial livestock farming has a water intensity of only 18 litres per dollar of output; for other activities the water intensity is much higher. 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 make 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 make a much smaller impact on water use.

9.23. Water productivity could be increased within an industry by introducing more water-efficient technology or changing the product mix from lower-value products to higher-value

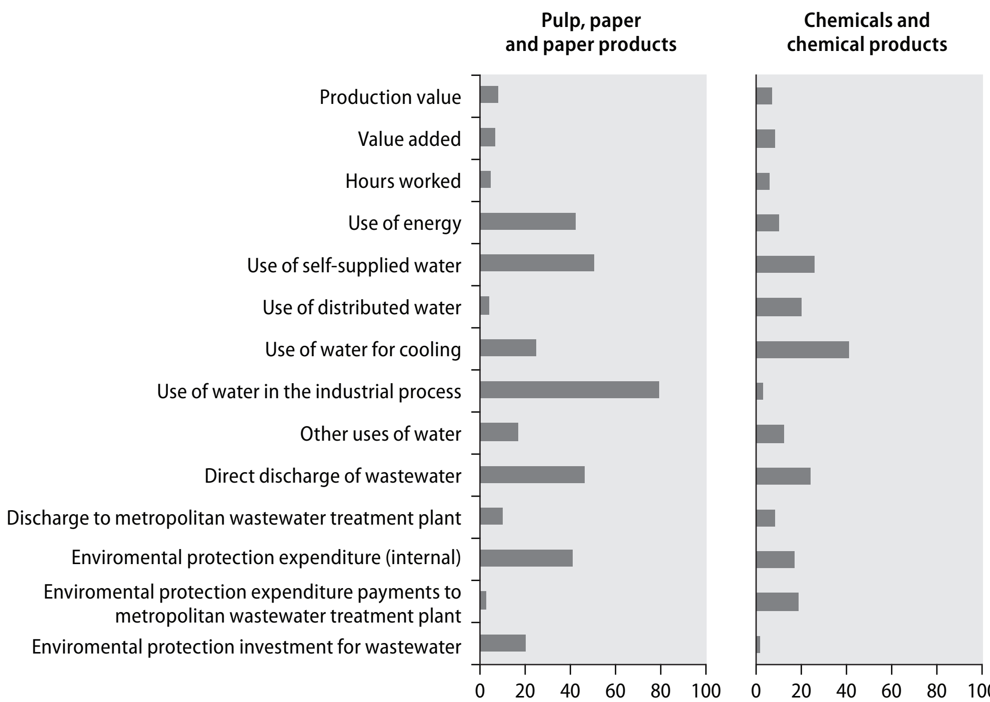
Table IX.4
**Water profile for Namibia, 1997-2001** (*Namibian dollars of value added per cubic metre of water use, at constant 1995 prices*)

| | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|
| 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 |

**Source:** Based on Namibian Department of Water Affairs, "Water accounts for Namibia: Technical report", draft, Windhoek, 2005; and Glenn-Marie Lange, "Water accounts in Namibia", in Glenn-Marie Lange and Rashid M. Hassan, *The Economics of Water Management in Southern Africa: An Environmental Accounting Approach* (Cheltenham, United Kingdom, Edward Elgar Publishing, 2006).

**Note:** This table can be derived from the physical supply and use table described in chapter III.

Figure IX.3
**Environmental-economic profiles for selected Swedish industries, 1995**




**Source:** Gunner Brånvall and others, *Water Accounts: Physical and Monetary Data Connected to Abstraction, Use and Discharge of Water in the Swedish NAMEA* (Stockholm, Statistics Sweden, Environment Statistics, 1999).

**Note:** The values are percentages of the total for manufacturing enterprises recorded against each variable. The indicators for this profile were obtained from the physical supply and use table (chap. III), the emission accounts (chap. IV) and the tables for environmental protection expenditures and investment (chap. V).

ones. Water productivity could also be increased by reallocating water from highly water-intensive industries to less (low) water-intensive ones. For a water-scarce country, the fundamental messages from such analysis are that:

(*a*) Sustainable economic growth may be limited if based on water-intensive sectors;

(*b*) Measures must be introduced to reduce water intensity if economic growth is to be based on water-intensive sectors, such as agriculture.

This does not mean that agriculture-led development is not feasible; rather, it indicates that consideration of the higher-value, less water-intensive agricultural subsectors, accompanied by incentives to increase water efficiency and conservation, should be taken into account when designing development policies.

9.24. The assessment of water intensity enables water managers to know why water use or pollution is so high, but it is also important for understanding the "driving forces", that is, the forces that determine the level and structure of industrial production. For example, Australian households used 1 800 gigalitres of water directly in the period 1994-1995, but they consumed many goods and services which also required water in their production. When taking into account all the water (direct and indirect) required to meet household demand, total water use rose almost ninefold, to 16 172 gigalitres.[112]

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 chap. V). Hybrid input-output tables can be used to calculate the total water requirement (direct and indirect) per unit of industrial output and compare it with the direct water requirement per unit of industrial output (water

112 Manfred Lenzen and Barney Foran, "An input-output analysis of Australian water usage", *Water Policy*, vol. 3, No. 4, pp. 321-340.

Table IX.5
**Water intensity and total domestic water requirements in Namibia, by industry, 2001-2002**

| | Percentage of water use | Water intensity (direct) in litres per Namibian dollar output | Total domestic water requirements in litres per Namibian dollar 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 | [a] | 0.17 | 16.3 |
| Water | [a] | 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 | n/a | n/a |
| **Total** | **100.0** | **n/a** | **n/a** |

**Source:** Based on Namibian Department of Water Affairs, "Water accounts for Namibia: Technical report", draft, Windhoek, 2005; and Glenn-Marie Lange, "Water accounts in Namibia", in Glenn-Marie Lange and Rashid M. Hassan, *The Economics of Water Management in Southern Africa: An Environmental Accounting Approach* (Cheltenham, United Kingdom, Edward Elgar Publishing, 2006).

**Note:** Total domestic requirements are calculated from the physical supply and use table (chap. III) coupled with an input-output table. They do not include water embodied in imports.

**Abbreviation:** n/a = not applicable.

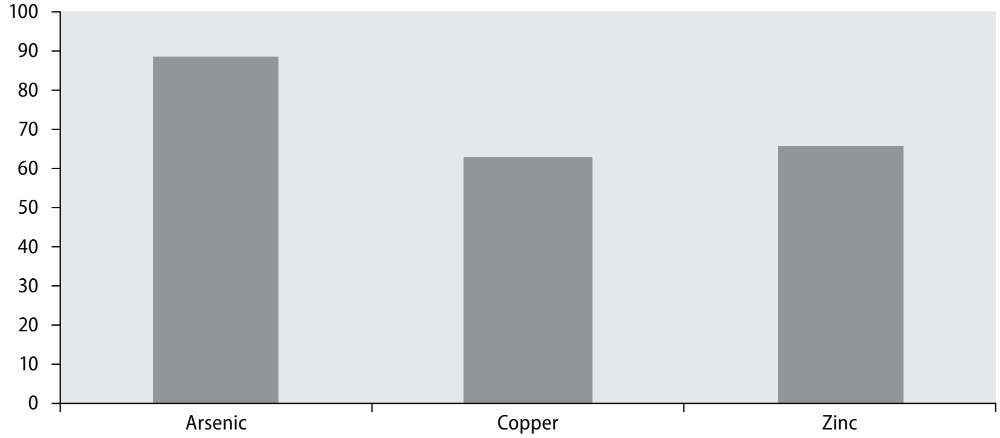
**a** Less than 0.1 per cent.

intensity). In the previous example for Namibia, total domestic water requirements (shown in the last column of table IX.5) are considerably higher than the direct water requirements in most instances. This important indicator is on the borderline of water statistics and more complex policy analysis; it will be taken up again in the next section in relation to trade.

### *(b) 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 to determine the volume and the 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. Figure IX.4 shows the significance of this problem for the Netherlands: most of the metal pollutants (arsenic (88 per cent), copper (62 per cent) and zinc (65 per cent)) originate abroad and are "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 IX.4
**Percentage of metal emissions originating abroad in 2000 polluting rivers in the Netherlands**




**Source:** Adapted from Rob Van der Veeren and others, "NAMWA" a new integrated river basin information system", *National Institute for Integrated Water Management and Wastewater Treatment Report 2004.032* (Voorburg, Netherlands, Central Bureau of Statistics, 2004). Available from http://www.rws.nl/rws/riza/home/publicaties/riza_rapporten/rr_2004_032.html.

**Note:** These indicators can be obtained from the supply and use table for emissions (chap. IV).

## 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 way of the following:

(*a*) Increasing the water efficiency of individual users. Domestic water requirements can be met with very different volumes depending on consumer behaviour and technology: shower versus 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 the level of pollution, as well as supply recyclable water. A simple and effective example is the dry recovery of animal droppings in the stall areas of slaughterhouses;

(*b*) Reducing system losses. Losses can result from leakage due to poor infrastructure maintenance and other causes, such as illegal connections and faulty water meters. In many industrialized countries, losses are fairly low. In Australia, for example, losses as a percentage of total supply range from a low of 3 per cent in the Australian Capital Territory to 17 per cent in Victoria.[113] In developing countries, losses can be much higher. Among the 29 municipalities in the water accounts of Namibia, 3 had losses ranging from 11 to 15 per cent of supply in 2001; 12 towns, accounting for 21 per cent of municipal water supply, had losses of 20 to 39 per cent; and the rest had losses of 40 per cent or more;[114]

(*c*) Increasing the reuse of water and the use of return flows by directing water to storage or other uses and minimizing the pollution and salinity of return flows: reuse of water has been identified as one of the most cost-effective ways to supply water. The reuse of water has been increasing steadily in water-scarce countries.[115]

113 Australian Bureau of Statistics, *Water Account, Australia 2000-01* (Canberra, ABS, 2004).

114 Glenn-Marie Lange, "Water valuation case studies in Namibia", op. cit.

115 Australian Bureau of Statistics, *Water Account, Australia 2000-01* (Canberra, ABS, 2004). Summary available from http://www.abs.gov.au/ausstats/ABS@.nsf/mf/4610.0.

## 3. Water pricing and incentives for water conservation

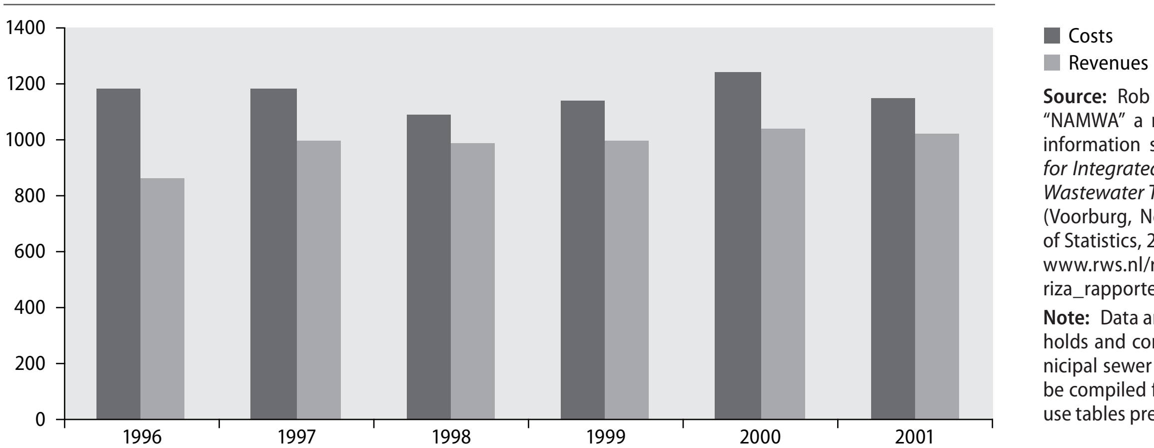
9.28. Water pricing is important for financial sustainability—a system must be able to recover its costs—and for environmental sustainability because incentive pricing enables efficient resource utilization. Except for the minimum amount of water necessary for human survival, people will generally use less water the higher the 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 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 are available on abstraction for own use.[116] 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 the averages are unlikely to match precisely in any given year. Sometimes researchers use this shorthand method to estimate the implicit unit price and supply cost (chap. V). However, many countries, especially developing countries, do not have full cost-recovery pricing, so their prices and supply costs will differ. Furthermore, even with full cost recovery, unit supply costs may vary significantly within a country owing to differences in the regional availability of water resources. For example, bulk water supply in Namibia is based on a system of nearly 200 water schemes; unit supply costs range from a low of N$ 0.27 per cubic metre to more than N$ 500.00 per cubic metre.[117] Prices vary by customer where water fees are a combination of fixed fees plus variable fees based on the volume and/or type of customer.

9.31. Once supply costs and prices have been calculated, the implicit subsidy by sector can be calculated. Similar calculations can be made for wastewater treatment supply costs and prices. Figure IX.5 shows an example for the Netherlands. In the case of the Netherlands, full cost-recovery has been achieved for drinking water, but not for wastewater.[118]

Figure IX.5
**Costs and revenues for wastewater treatment services in the Netherlands, 1996-2001**
(*millions of euros*)




**Source:** Rob Van der Veeren and others, "NAMWA" a new integrated river basin information system", *National Institute for Integrated Water Management and Wastewater Treatment Report 2004.032* (Voorburg, Netherlands, Central Bureau of Statistics, 2004). Available from http://www.rws.nl/rws/riza/home/publicaties/riza_rapporten/rr_2004_032.html.

**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 V.

116 See, for example, Statistics Sweden, *Water Accounts 2000 with Disaggregation to Sea Basins* (Stockholm, Statistics Sweden, 2003).

117 Glenn-Marie Lange, "Water valuation case studies in Namibia", op. cit.

118 Van der Veeren and others, "NAMWA", op. cit.

### 4. Sustainability: comparing water resources and water use

9.32. In assessing the sustainability of water use, the volume of water use must be compared with 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 supply and use tables. In some countries, water quality is a greater concern than water quantity (volume); thus, 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. Table IX.6 shows an example for Namibia. Water authorities acknowledge that the national-level figures for water availability shown in the table are useful mainly for building public awareness, but that national figures may hide relative surpluses and shortages among subnational regions; similarly, annual accounts may hide seasonal variability. Water management requires similar figures at a more spatially and temporally disaggregated level.

## 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 analyses the benefits of current allocations of water, anticipates future water demand and evaluates different policy options for meeting that demand. Options include increasing the effective supply of water from efficiency improvements, wastewater reuse, demand management and other measures. Policy analysis that uses the water accounts can address a very broad range of issues. Some of the most critical policy issues for water managers include the following:

(*a*) What are the likely future water demands under alternative economic development scenarios and are they sustainable?

(*b*) How do changes in agricultural, energy, forestry and other policies affect water supply and use?

(*c*) What would be the social and economic impacts of pricing reform for water and wastewater?

(*d*) What is the impact of trade on water use and pollution?

(*e*) What are the opportunities for water demand management and other water conservation measures?

(*f*) Can economic growth be "decoupled" from growth in water use?

(*g*) What are the costs and benefits of treating different sources of water pollution?

Table IX.6
**Water use in 2001 compared with estimated availability of water resources in Namibia**

| | Estimated long-term available water resources[a] (*millions of cubic metres per annum*) | Water use, 2001 (*millions of cubic metres*) |
|---|---|---|
| Dams on ephemeral rivers | 100 | 85 |
| Perennial rivers | 170 | 90 |
| Groundwater | 159 | 106 |
| Other (recycled) | 8 | 1 |
| **Total** | **437** | **282** |

**Source:** Namibian Department of Water Affairs, "Water accounts for Namibia: technical report", draft, Windhoek, 2005.

**Note:** These figures are obtained from water asset accounts (chap. VI) and physical supply and use tables (chap. III).

**a** Based on currently installed capacity.

(*h*) What is the highest value allocation of water among countries sharing an international river or lake?

(*i*) How will external phenomena, such as climate change, affect water resources and how can an economy best prepare for such impacts?

9.34. The water accounts provide detailed information that can be used to analyse the 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 III to V to economic models; integrating the input-output table with the water accounts is an essential step in building many of these models (see box IX.1). The consistency between national accounts and water accounts enables the easy incorporation of water accounts into many different kinds of economic models.

9.35. The number and range of potential policy applications of water accounts are vast. Because it is not possible to present a comprehensive review in this chapter, a selection of examples based on water accounts is given instead. These examples address issues such as projecting future water demand, listing the socio-economic benefits that can be realized from water policy reform, assessing the costs and benefits of water treatment and analysing the 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, such as water demand management and the reuse of water, and water policies, such as pricing and other incentives for water conservation. Scenario modelling designed to incorporate some of these factors, especially for influencing water demand and unconventional water supply, is a useful tool for water managers. Such models require sophisticated economic models, often built around water accounts that are integrated with input-output tables (see box IX.1).

Box IX.1
**Water accounts and input-output analysis**

There are many tools for economic analysis and those taking a multisectoral approach are often built around input-output tables. Multisectoral models include standard input-output analysis as well as other modelling approaches, notably, computable general equilibrium modelling (which uses a social accounting matrix, an input-output table expanded for institutions) and econometric models. Various partial equilibrium models, such as those developed for life-cycle analysis, also use input-output tables.

The water supply and use tables described in chapters III to IV are directly linked to the national accounts' supply and use tables; just as the input-output table is constructed from the supply and use table, water accounts can be derived from the water supply and use table. In modelling, water in physical units is included in the input-output table as a primary input of production. Input-output analysis of the water accounts provides very useful information regarding the structure of the economy, driving forces, and water use and pollution, as described in section B of this chapter. Input-output-based, multisectoral models are also widely used for projecting future water demand, or analysing different policy options and the economic instruments for achieving them. Statistics Denmark has noted that its water accounts are used most extensively for input-output analysis.

**Source:** Statistics Denmark, *The Danish Environmental Accounts 2002* (Copenhagen, Statistics Denmark, 2004).

9.37. In Australia, water accounts have been used extensively for water planning at the regional and national levels.[119] For example, on behalf of the Australian Productivity Commission, impacts on water demand have been projected under different scenarios for irrigated agriculture in the Murray-Darling Basin.[120] The Commonwealth Scientific and Industrial Research Organization (CSIRO) used water accounts, along with other data, to project water requirements for Australia in the year 2050 under a range of alternative scenarios of population growth, irrigated agricultural expansion, technological improvements in water efficiency and measures to improve or compensate for declining water quality (see box IX.2). Section D presents an example of projecting water use at the regional level for Sweden.

## 2. Social and economic gains from water policy reform

9.38. To evaluate the current distribution of water and the social and economic gains from policy changes, it is necessary to design criteria for evaluation and develop tools to measure the changes. Water policy concerns economic issues, such as property rights and water allocation, investment in infrastructure and pricing. Among the many possible types of analysis, two important applications of water accounts to water policy are described here: (*a*) the social and economic benefits of current water allocation and alternative allocations; and (*b*) the consequences of water pricing reform.

### *(a) Social and economic benefits of water reallocation*

9.39. Water consumption for production purposes, such as agriculture and industry, produces economic benefits, such as income, employment and foreign exchange earnings. Although such benefits do not measure the exclusive contribution of water to economic value (see discussion in chap. VIII), 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 B 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; instead, the water input supplies food processing industries, which in turn generate additional income and employment. An analysis of forward and backward linkages using the input-output approach furnishes a more comprehensive picture of the socio-economic benefits of water use in a particular activity, or a particular region. Box IX.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.[121]

9.41. In many countries, water is often not allocated efficiently from an economic perspective, that is, it is not allocated 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 making water allocations, water managers would benefit from an understanding of the potential economic gains that could be realized from improving the efficiency of water allocation.

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119 Vardon and Peevor, "Water accounting in Australia", op. cit.

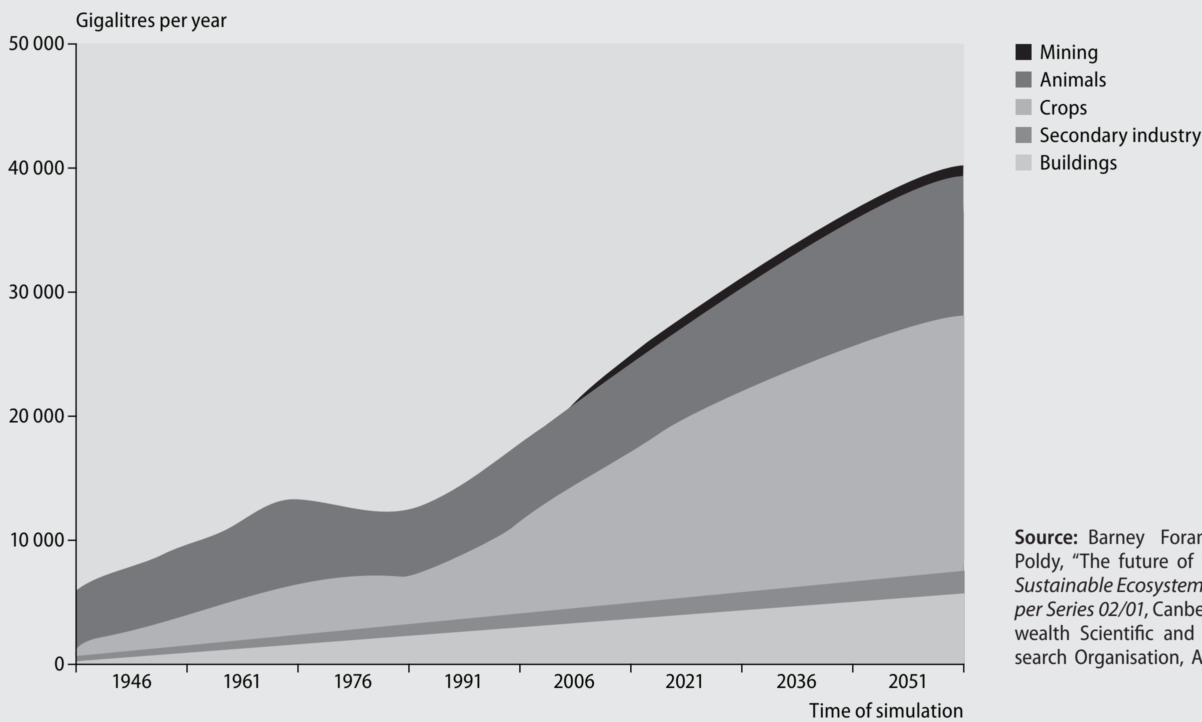
120 David Appels, Robert Douglas and Gavin Dwyer, "Responsiveness of demand for irrigation water: a focus on the southern Murray-Darling Basin", *Productivity Commission Staff Working Paper*, August 2004. Available from http://www.pc.gov.au/reserach/swp/watertrade/index.html.

121 Centre for International Economics, *Implications of Water Reforms for the National Economy: Report to the National Program for Sustainable Irrigation* (Canberra, CIE, 2004); and Lenzen and Foran, "An input-output analysis".

Box IX.2
**Projecting water use in Australia**

The Commonwealth Scientific and Industrial Research Organisation (CSIRO), a major Australian research centre, undertook a study of future water use to 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 24 000 gigalitres per year in 2000-2001 to more than 40 000 gigalitres per year by 2050. This would be due to a major expansion in irrigated agriculture in northern Australia as constraints on the availability and quality of water are experienced in the southern part of the country. 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 per cent of the total. Water use by animals reflects the growth of the dairy industry in particular, which is relatively water-intensive. The importance of international trade in driving water use should be noted: 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.

**Water use: main sectors, 1946-2051**




**Source:** Barney Foran and Franzi Poldy, "The future of water", *CSIRO Sustainable Ecosystems Working Paper Series 02/01*, Canberra, Commonwealth Scientific and Industrial Research Organisation, Australia, 2002.

9.42. The partial equilibrium approach of input-output may indicate the relationship between the current allocation of water and income and employment, but a different modelling approach is needed to determine what the optimum allocation of water would be in an economy. Optimization models for water (see chap. VIII for a discussion of different modelling 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 afforded by the water supply and use tables described in chapters III and V. The results include projected water demand by industry, the value of water and the resulting structure and level of economic activity, such as GDP growth. If pollution and pollution abatement costs or damage costs are included, the levels and costs of pollution would also be calculated.

Box IX.3

**Evaluating agricultural water use on a catchment basis in South Africa**

Water resources are under increasing pressure in post-apartheid South Africa for several reasons, notably, improved access to safe drinking water for millions of previously excluded households, and the emphasis on economic growth and job creation, often in water-intensive industries. An evaluation of the socio-economic benefits generated by each economic activity relative to its water use is essential to good water management. The researcher who was the source of this information 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 the employment generated per cubic metre of water used in each activity. He also extended the analysis to consider the "indirect" benefits by measuring the value added and the employment generated by upstream and downstream linkages to each agricultural activity.

Upstream linkages consist of inputs into agricultural activities, such as fertilizer and agricultural chemicals and fuels. Downstream linkages consist mainly of food processing industries and wood processing industries, including paper and pulp, wood products and furniture. 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.

In considering only the direct effects, both the income generated (value added) and employment were highest for mangoes, but when indirect effects were added, pinewood appears to be 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 cane moves to third place.

**Socio-economic benefits from water use for different agricultural activities in the Crocodile River catchment, South Africa, 1998**

| Value-added (rands/cubic metre of water input) | | | | Employment (1 000 person days/cubic metre of water) | | | |
|---|---|---|---|---|---|---|---|
| Direct | | Total (direct + indirect) | | Direct | | Total (direct + indirect) | |
| Mangoes | 2.8 | Pine | 21.3 | Mangoes | 20 | Pine | 114 |
| Oranges | 1.9 | Eucalyptus | 13.3 | Oranges | 18 | Eucalyptus | 78 |
| Avocados | 1.7 | Sugar cane | 9.9 | Grapefruit | 13 | Sugar cane | 44 |
| Eucalyptus | 1.5 | Mangoes | 8.9 | Eucalyptus | 12 | Oranges | 39 |
| Grapefruit | 1.5 | Oranges | 6.6 | Bananas | 7 | Mangoes | 37 |
| Bananas | 1.3 | Grapefruit | 4.9 | Pine | 6 | Grapefruit | 28 |
| Pine | 1.2 | Avocados | 3.4 | Avocados | 5 | Bananas | 12 |
| Sugar cane | 0.9 | Bananas | 3.2 | Sugar cane | 2 | Avocados | 7 |

**Source:** Adapted from Rashid M. Hassan, "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*, vol. 20, No. 2, pp. 171-195.

### *(b) 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 its full economic cost. Where the cost is subsidized, there is little incentive for resource conservation. Subsidies, if any, can be calculated for each industry from information in the water supply and use tables by subtracting the supply cost from the payment for water. The monitoring of subsidies is clearly important both for the sustainable management of resources as well as for reasons of equity, through identifying which groups in society receive the greatest subsidy. In addition to monitoring, however, policymakers 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 adversely affected?

9.44. Economic models, such as those used for assessing the optimum allocation of water, can introduce water price accounts for estimating the economy-wide impact of price reform. Similar analysis can be made for assessing the impact of pollution taxes and increased charges for wastewater treatment. Box IX.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 VIII. There are no water accounts currently that have fully monetized water pollution accounts. 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 IX.5 furnishes an example of valuing water quality and the use of this approach to assess the costs and benefits of wastewater treatment.

## 3. Trade and the environment: water use and pollution

9.46. Water use and the emission of pollution are affected by water policies, but they are 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 on the use of water. This section considers two aspects of trade and the use of water resources: trade in "virtual water" and the impact of trade barriers on water allocation.

Box IX.4

**Impact of water price increases on GDP in Australia**

Since the period 1996-1997, water charges across Australia have, on average, doubled. Water trading has been introduced in part of the Murray-Darling river basin, resulting in a significant improvement in water use efficiency. The Centre for International Economics has developed a model to simulate over a five-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 the reallocation of water among sectors. For irrigated agriculture, the Centre found that water use efficiency would have to increase by 1.5 per cent annually to counterbalance the impact of increased water charges.

The Centre then considered the impact of reducing current water diversions in order 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** (*millions of Australian dollars*)

| | Annual percentage increase in water use efficiency | |
|---|---|---|
| | 1 per cent annual increase | 2 per cent annual increase |
| Irrigated agriculture | -24 | 78 |
| Dryland agriculture | -51 | -112 |
| Food and fibre processing | 44 | 97 |
| Other industries | 262 | 410 |
| **Total impact on GDP** | **253** | **521** |

**Source:** Based on Centre for International Economics, *Implications of Water Reforms for the National Economy: Report to the National Program for Sustainable Irrigation* (Canberra, CIE, 2004).

Box IX.5

**Benefits of wastewater treatment in Wuxi, China**

The source of this information measured the costs and benefits of wastewater treatment in Wuxi, a rapidly industrializing city in the Yangtze river delta of China. 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 in the area. The cost of water treatment was measured as the current 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 the 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 almost US$ 3.5 million.

**Costs and benefits from wastewater treatment in Wuxi, China**
(*millions of United States dollars in 1992 prices*)

| | |
|---|---|
| Costs (investment + operating costs) | 22.43 |
| Benefits (damage 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 |
| Residents' recreational benefits | 1.73 |
| Tourism | 3.73 |
| **Subtotal, benefits** | **25.91** |
| **Net benefit** | **3.48** |

**Source:** Based on Fan Zhang, "Marginal opportunity cost pricing for wastewater disposal: a case study of Wuxi, China", *Research Report No. 1999071, Economic and Environmental Economics Program for Southeast Asia* (Ottawa, International Development Research Centre, 2003).

### *(a) 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 enables trade in virtual water, that is, the water used for the production of goods and services. Trade in virtual water enables 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".[122] Distorted water pricing, including heavy subsidies for agriculture and the omission of charges for ecosystem damage, means that international trade is unlikely to reflect the water "comparative advantage" of countries. The World Water Council recently identified virtual water as a critical issue for water management; it 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 the United Nations Educational, Scientific and Cultural Organization (UNESCO).[123]

122 Ashok K. Chapagain and Arjen Y. Hoekstra, "Water footprints of nations: water use by people as a function of their consumption pattern", *Water Resources Management*, vol. 21, No. 1, pp. 35-48.

123 United Nations and the World Water Assessment Programme, *United Nations World Water Development Report* 2, op. cit.

9.48. The measurement of virtual water should include the water used both directly and indirectly in production. "Direct water" is the amount used during the production process; this figure is obtained from the water supply and use table. Indirect water is the amount used to produce all the non-water inputs into the production of a given product. The difference between direct water use and total (direct + indirect) water use can be substantial: for example, very little water may be needed to produce a loaf of bread, but a great deal of water may be embodied in the grain used to make the bread. The methodology for measuring total water use, based on input-output models extended for direct water inputs (as described in box IX.1), is well established in the economics literature.[124] Box IX.6 shows an analysis of trade in virtual water among Botswana, Namibia and South Africa, and between these three countries and the rest of the world.

### *(b) 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

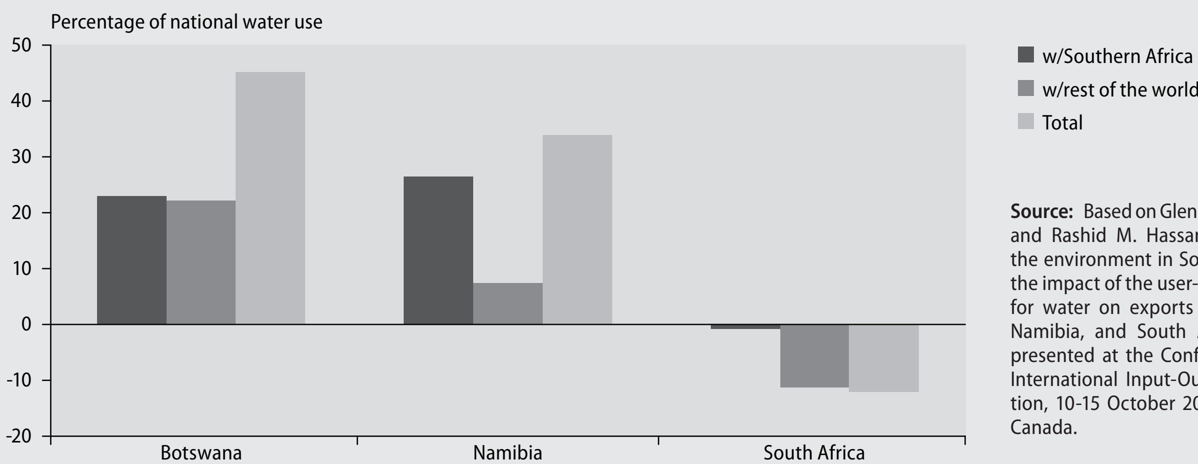
Box IX.6

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

Botswana, Namibia and South Africa have designed strategies for economic development based in part on economic growth, diversification and trade promotion. As in many developing countries, the structure of exports in these countries is heavily weighted towards primary commodities and the processing of these commodities, which is often water-intensive. These countries have identified the lack of water as a primary constraint to development; 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 three countries and with the rest of the world reveals that Botswana and Namibia are significant net water importers (45 and 33 per cent of their total national water use, respectively). South Africa, on the other hand, is a net water exporter (11 per cent of its national water use in 1998).

**Net water imports as a percentage of total national water use for Botswana, Namibia and South Africa, 1998**




**Source:** Based on Glenn-Marie Lange and Rashid M. Hassan, "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 2002, Montreal, Canada.

124 Finn R. Førsund, "Input-output models, national economic models, and the environment", in *Handbook for Natural Resource and Energy Economics*, vol. 1, Allen V. Kneese and James L. Sweeney, eds. (New York, Elsevier Publishing Company, 1985), pp. 325-341; Ronald Miller and Peter D. Blair, *Input-Output Analysis: Foundations and Extensions* (Englewood Cliffs, New Jersey, United States, Prentice-Hall, Inc., 1985); and P. J. G. Pearson, "Proactive energy-environment policy strategies: A role for input-output analysis?", in *Environment and Planning A*, vol. 21, No. 10, pp. 1329-1348.

irrigation, trade protection can inadvertently divert water to irrigation, thereby increasing the 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 VIII discussed the impact of trade protection on agriculture and the demand for irrigation water, using several examples. The example for Morocco[125] used a linear programming model (based on an input-output table with water use accounts) to assess the optimum allocation of water under several alternative scenarios. One of the alternative scenarios included a reduction in 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 its profitability. The model demonstrated the potential that the country had for realizing significant economic gains by reducing trade barriers and allowing water to be reallocated 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 the issue of sustainability on a national level when sustainability of water use is determined on a local or regional basis. Recognizing this, water managers have been adopting a regional approach to take into account temporal variations; this principle is endorsed under IWRM. However, this approach poses 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 has become increasingly common for countries to construct water accounts on a regional basis; Australia, the Netherlands, Sweden and Morocco have already done so. Seasonal water accounts have not yet been compiled.

### 1. Accounts at the level of the river basin or water management area

9.52. Water accounts must be national in coverage and compatible with the national economic accounts for the decisions to be made at the national/macroeconomic level. It should be noted, however, that 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 that water management should be approached 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 European Union 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 European Union Water Framework Directive, a suitable area

125 Hynd Bouhia, *Water in the Macro Economy* (Aldershot, United Kingdom, Ashgate Publishing Company, 2001).

is the “river basin district”, that is, the upper management unit that can extend over several provinces or States.

9.54. In most cases, the catchment area, or river basin, 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. Such cases require common management of the 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, owing to 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; the resulting region is called an “accounting catchment area”. In general, elaborating water accounts at the river basin level necessitates geographically referenced data on water flows and the discharge of pollutants, that is, spatial identification of establishments, wastewater treatment plants, etc.

9.56. All of the indicators and policy analyses discussed previously in this chapter can be applied at the catchment or regional level as well. Environmental economic profiles can be constructed for each water-accounting catchment. Box IX.7 shows the profiles for two sea basins in Sweden. The accounts can also be used for modelling at the regional level.

9.57. Regional accounts are necessary for the management of an individual river basin, but decision-making at the national level also needs an overview that brings together the different regions into a national accounting framework, as shown in figure IX.6. The overview helps

Box IX.7

**Forecasting water use at the district level in Sweden**

Under the European Union 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 classified 289 municipalities into 5 water districts. Built from relations at the municipality level, it has 5 submodels: (*a*) population, (*b*) labour market, (*c*) regional economy, (*d*) housing market and (*e*) 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, namely, pulp and paper, chemicals and basic metals, 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 and 2000.

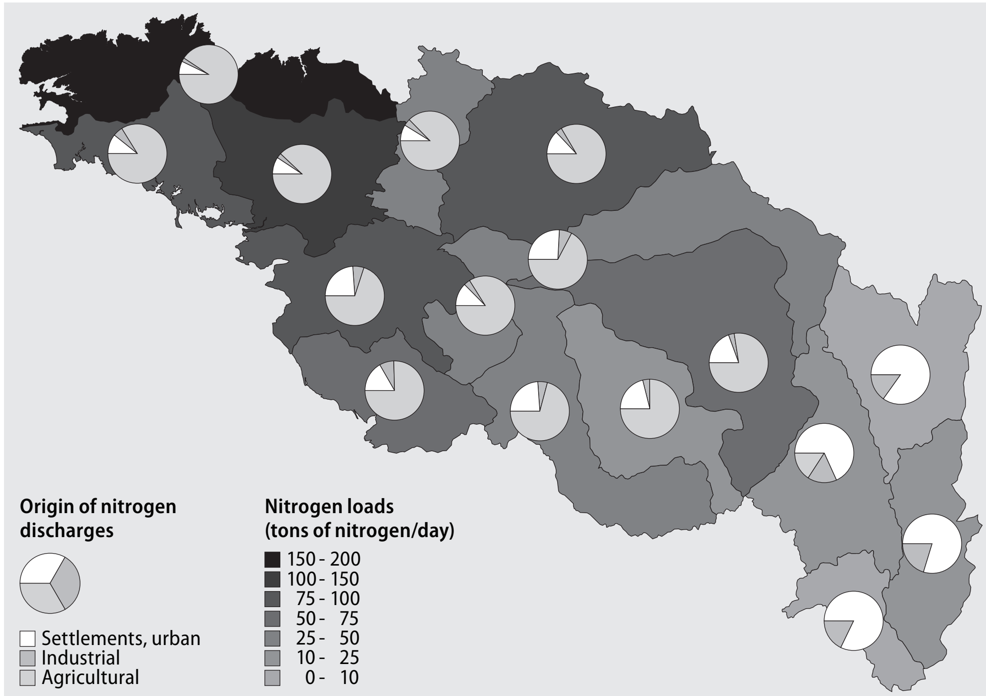
**Water use in 2015 by water district, Sweden** (*thousands of cubic metres*)

| District/sea basin | Water use in 2000 | Projected water use in 2015 | |
|---|---|---|---|
| | | Scenario 1 | Scenario 2[a] |
| 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** |

**Source:** Statistics Sweden, “Prognos över vattenuttag och vattenanvändning 2015—med redovisning på vattendistrikt” (Forecast of water abstraction and water use until 2015, by water district), Stockholm, Statistics, Sweden, 2004.

**a** This scenario assumes increased water efficiency in the most water-intensive industries.

Figure IX.6
**Location, level and origin of nitrogen discharges into the river basin of Loire-Bretagne, France**




**Source:** Presentation of the results of a meeting of the Institut Français de l'Environnement, 14 March 2001.

national decision makers in two ways: (*a*) in setting priorities for action among different river basins by demonstrating the relative severity of water problems in each basin; and (*b*) in providing national water managers with a tool for negotiating with decision makers in other sectors in order to coordinate policy.

9.58. Figure IX.6 shows an example of the daily discharge of nitrogen, indicating both the magnitude of nitrogen emissions in each part of the river basin and the source of the pollutant. Agriculture is the major source of pollution in all the heavily polluted parts of the river. Households are the second most important source of nitrogen, and the primary source in areas with little agriculture.

## 2. Temporal dimension

9.59. Water use is often concentrated in certain seasons; notably, irrigation water is in demand during the growing season. Because irrigation requires so much water—up to 80 per cent of total water use in developing countries[126]—it is extremely important to match seasonal supply with 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 that is flowing may be so reduced that dilution of the pollutants cannot occur. Abstractions and emissions usually cover an entire year, but this period does not provide an accurate picture of the stress on water resources because the seasonal variations may be hidden.

9.60. One possibility is to reduce the duration of the accounting period: in many countries, quarterly national accounts are already being 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 with winter. Abstraction of water and the level of emissions are higher in the summer as a result of tourism, while the volume of available water is smaller due

126 See work cited in note 107.

to the reasons described previously. While the quarters of the year used for national accounts may not coincide with seasonal variations in water availability and demand for all countries, the preparation of quarterly accounts for water would probably still be a useful step towards representing seasonal variations.

9.61. Accidents resulting in unusually high discharges of polluting substances at a certain point in time present another challenge for water accounts. An accidental discharge, when added to annual discharges, may not appear to be serious; the averaging of annual discharges 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 cognizance of factors such as the concentration of a pollutant, the threshold for water abstraction beyond which aquatic life would be impeded and the possible synergies among two or several pollutants.

9.62. The construction of such indicators implies a detailed knowledge of the absorption capacities of the different bodies of water vis-à-vis the pressures exerted against them. The location and the timeliness of the pressure are not independent in their effects, since the critical thresholds vary, notably, according to the volume and flow of the body of water. The severity of the pressure is also related to the current state of the water environment, that is, to the pressures accumulated over time. Thresholds should be estimated for each place, each period and each type of pressure. Possible indicators include, for example, the number of days (in the year, in a quarter) in which the thresholds have been exceeded. However, this type of information currently cannot be handled within the framework of water accounts.

## E. Links between water and other resource accounts (fisheries, forestry and 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 pollutants, and it supplies ecosystem services for many sectors.[127] 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. With regard to IWRM, the SEEA-Water framework has an advantage over other water frameworks because it is part of a more general environmental-economic accounting framework, that is, SEEA-2003,[128] which is designed for the 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 (*a*) the direct use of water as an intermediate input into production or as a final consumption good; and (*b*) the use of the 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.

127 Herbert Acquay, "Integrated land and water management: the Global Environment Facility's perspective", in *Freshwater Resources in Africa*, John Gash and others, eds. (Potsdam, Germany, BAHC International Project Office, 2001).

128 United Nations, *Handbook of National Accounting: Integrated Environmental and Economic Accounting: An Operational Manual,* op. cit.

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. Only the major issues are noted here. Future revisions of SEEA-Water for water accounting are likely to address these broader issues.

## 1. 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 the river basin. Groundwater recharge and quality can be affected by deforestation and land use conversion (affecting rates of infiltration) and the run-off of pollutants from agriculture and other economic activities. The water accounts do not usually address some important forms of degradation of water quality, such as increased turbidity from soil erosion, or increased salinity, although the framework can certainly accommodate such issues. The Australian water stock accounts do consider salinity, for example.

9.66. Furthermore, in many countries, accounts for the emission of pollutants into water may include only point-source emissions, although non-point source emissions are very important, especially those from agriculture. An exception 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 hydrogeological models are required to estimate the amount of fertilizer that leaves the farm field and the route and time that it takes to travel from the field to a body of water. It is not uncommon for the travel time to exceed one year, which is the typical accounting period for water accounts.

9.67. Water-based tourism and recreation have become important activities in many countries, both developed and developing. Some forms of water-based recreation may depend mainly on water flow, such as rafting and the observing of scenic beauty. However, the habitat protection service of water may be extremely important for other forms of tourism that depend on the health of a water ecosystem, such as fishing and viewing wildlife. In such cases, accounting for water ecosystems is required. Accounts for ecosystems have been identified in SEEA-2003 but are less well defined in practice. Wetland ecosystem stock accounts can be expressed in a combination of area measurements, such as hectares, and qualitative classifications, such as excellent, good, fair and bad. Ecosystem accounts would monitor the numbers and the proportions of key species of flora and fauna that indicate ecosystem integrity.

## 2. Dependence of other resources on the health of the water ecosystem

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 seagrass beds, mangroves, coral reefs, lagoons and other ecosystems. Agricultural land has suffered greatly from the misuse of water for irrigation, resulting in losses of agricultural productivity due to salination and waterlogging of the soil. Natural vegetation depends on river flow and on the level of groundwater. When groundwater is depleted, vegetation may lose its source of water. Wildlife and biodiversity also depend on the health of aquatic ecosystems and an adequate supply of unpolluted water.

Annex I

# Standard tables for the System of Environmental-Economic Accounting for Water

This annex shows the set of standard tables that have been presented in more detail throughout the System of Environmental-Economic Accounting for Water (SEEA-Water).

Table A1.1

**Standard physical supply and use tables for water** (*chap. III*)

| **A. Physical use table** (*physical units*) | | Industries (by ISIC category) 1-3 | 5-33, 41-43 | 35 | 36 | 37 | 38, 39, 45-99 | Total | Households | Rest of the world | 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 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 | | | | | | | | | | |
| **Within the economy** | **2. Use of water received from other economic units** | | | | | | | | | | |
| | **3. Total use of water** (= 1 + 2) | | | | | | | | | | |

| **B. Physical supply table** (*physical units*) | | Industries (by ISIC category) 1-3 | 5-33, 41-43 | 35 | 36 | 37 | 38, 39, 45-99 | Total | Households | Rest of the world | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Within the economy** | **4. Supply of water to other economic units** | | | | | | | | | | |
| | *of which:* | | | | | | | | | | |
| | 4.a. Reused water | | | | | | | | | | |
| | 4.b. Wastewater to sewerage | | | | | | | | | | |
| **Into the environment** | **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) | | | | | | | | | | |
| | **6. Total supply of water** (= 4 + 5) | | | | | | | | | | |
| | **7. Water consumption** (= 3 - 6) | | | | | | | | | | |

**Note:** Dark grey cells indicate zero entries by definition.

Table A1.2

**Emission accounts tables** (*chap. IV*)

**A. Gross and net emissions table** (*physical units*)

| Pollutant | Industries (by ISIC category) | | | | | | | House-holds | 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 inland water resources | | | | | | | | | | |
| 1.a.ii. To the sea | | | | | | | | | | |
| 1.b. To sewerage (ISIC 37) | | | | | | | | | | |
| **2. Reallocation of emissions by ISIC division 37** | | | | | | | | | | |
| **3. Net emissions** (= 1.a + 2) | | | | | | | | | | |

**B. Emissions by ISIC division 37 table** (*physical units*)

| Pollutant | ISIC division 37 |
|---|---|
| **4. Emissions into water** (= 4.a + 4.b) | |
| 4.a. After treatment | |
| *Into water resources* | |
| *Into the sea* | |
| 4.b. Without treatment | |
| *Into water resources* | |
| *Into the sea* | |

Table A1.3
**Hybrid supply and use tables** (*chap. V*)

**A. Hybrid supply table** (*physical and monetary units*)

| | Output of industries (by ISIC category) | | | | | | | | 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:** Dark grey cells indicate zero entries by definition.

**B. Hybrid use table** (*physical and monetary units*)

| | Intermediate consumption of industries (by ISIC category) | | | | | | | | Actual final consumption | | | | | Capital formation | Exports | Total uses at purchaser's price |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | Households | | | Govern-ment | Total | | | |
| | 1-3 | 5-33, 41-43 | 35 | | 36 | 37 | 38, 39, 45-99 | Total industry | Final consumption expenditures | Social transfers in kind from Government and non-profit institutions serving households | Total | | | | | |
| | | | Total | *(of which):* Hydro | | | | | | | | | | | | |
| **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. Total abstraction (U1) | | | | | | | | | | | | | | | | |
| *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:** Dark grey cells indicate zero entries by definition.

Table A1.4

**Hybrid account table for supply and use of water** (*physical and monetary units*) **(chap. V)**

| | Industries (by ISIC category) | | | | | | | | Rest of the world | Taxes less subsidies on products, trade and transport margins | Actual final consumption | | Capital formation | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1-3 | 5-33, 41-43 | 35 Total | 35 (*of which*) Hydro | 36 | 37 | 38, 39, 45-99 | Total industry | | | Households | Government | | |
| **1. 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:** Dark grey cells indicate zero entries by definition.

Table A1.5

**Hybrid account table for water supply and sewerage for own use** (*physical and monetary units*) **(chap. V)**

| | | Industries (by ISIC category) | | | | | | | | House-holds | 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) (*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*) | | | | | | | | | | |
| **Sewerage for 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*) | | | | | | | | | | |

Table A1.6
**Government account table for water-related collective consumption services** (*chap. V*)

| | Government (ISIC division 84) (by Classification of the Functions of the Government category) | | | |
|---|---|---|---|---|
| | 05.2 Wastewater management | 05.3 (part) Soil and groundwater protection | 05.6 Environmental protection not elsewhere classified | 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 A1.7
**National expenditure account tables** (*chap. V*)

### A. For wastewater management (*monetary units*)

| | Users/beneficiaries | | | | | |
|---|---|---|---|---|---|---|
| | Producers | | Final consumers | | Rest of the world | Total |
| | Specialized producers (ISIC division 37) | Other producers | House-holds | Govern-ment | | |
| **1. Use of wastewater services** (CPC 941 and CPC 91123) | | | | | | |
| 1.a. Final consumption | | | | | | |
| 1.b. Intermediate consumption | | | | | | |
| 1.c. Capital formation | n/r | n/a | | | | n/a |
| **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) | | | | | | |

### B. For water management and exploitation (*monetary units*)

| | Users/beneficiaries | | | | | |
|---|---|---|---|---|---|---|
| | Producers | | Final consumers | | Rest of the world | Total |
| | Specialized producers (ISIC division 36) | Other producers | House-holds | Govern-ment | | |
| **1. Use of wastewater services** (CPC 941 and CPC 91123) | | | | | | |
| 1.a. Final consumption | | | | | | |
| 1.b. Intermediate consumption | | | | | | |
| 1.c. Capital formation | n/r | n/a | | | | n/a |
| **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:** Dark grey cells indicate non-relevant or zero entries by definition.
**Abbreviations:** n/r = not recorded to avoid double counting; n/a = not applicable in the case of wastewater management.

Table A1.8
**Financing account tables** (*chap. V*)

**A. For wastewater management** (*monetary units*)

| Financing sectors: | Users/beneficiaries: Producers: Specialized producers (ISIC 37) | Users/beneficiaries: Producers: Other producers | Users/beneficiaries: Final consumers: Households | Users/beneficiaries: Final consumers: Government | Users/beneficiaries: Rest of the world | Users/beneficiaries: Total |
|---|---|---|---|---|---|---|
| 1. General Government | | | | | | |
| 2. Non-profit institutions serving households | | | | | | |
| 3. Corporations | | | | | | |
| 3.a. Specialized producers | | | | | | |
| 3.b. Other producers | | | | | | |
| 4. Households | | | | | | |
| 5. National expenditure | | | | | | |
| 6. Rest of the world | | | | | | |
| 7. Domestic uses | | | | | | |

**B. For water management and exploitation** (*monetary units*)

| Financing sectors: | Users/beneficiaries: Producers: Specialized producers (ISIC 37) | Users/beneficiaries: Producers: Other producers | Users/beneficiaries: Final consumers: Households | Users/beneficiaries: Final consumers: Government | Users/beneficiaries: Rest of the world | Users/beneficiaries: Total |
|---|---|---|---|---|---|---|
| 1. General Government | | | | | | |
| 2. Non-profit institutions serving households | | | | | | |
| 3. Corporations | | | | | | |
| 3.a. Specialized producers | | | | | | |
| 3.b. Other producers | | | | | | |
| 4. Households | | | | | | |
| 5. National expenditure | | | | | | |
| 6. Rest of the world | | | | | | |
| 7. Domestic uses | | | | | | |

**Note:** Dark grey cells indicate non-relevant or zero entries by definition.

Table A1.9

**Asset account table** (*physical units*) **(chap. VI)**

| | 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:** Dark grey cells indicate non-relevant or zero entries by definition.

Annex II

# Supplementary tables for the System of Environmental-Economic Accounting for Water

Table A2.1

**Supplementary information[a] to the physical supply and use tables** (*chap. III*)

| **A. Physical use table** (*physical units*) | | Industries (by ISIC category) | | | | | | | 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 run-off* | | | | | | | | | | |
| | *Cooling water* | | | | | | | | | | |
| | *Other* | | | | | | | | | | |
| | 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. 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) | | | | | | | | | | |

| B. **Physical supply table** (*physical units*) | | Industries (by ISIC category) | | | | | | | 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* | | | | | | | | | | |
| **Into the environment** | **5. Total returns** (= 5.a + 5.b) | | | | | | | | | | |
| | *Hydroelectric power generation* | | | | | | | | | | |
| | *Irrigation water* | | | | | | | | | | |
| | *Mine water* | | | | | | | | | | |
| | *Urban run-off* | | | | | | | | | | |
| | *Cooling water* | | | | | | | | | | |
| | *Losses in distribution because of leakages* | | | | | | | | | | |
| | *Treated wastewater* | | | | | | | | | | |
| | *Other* | | | | | | | | | | |
| | 5.a. To inland 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 leakage | | | | | | | | | | |

**Note:** Dark grey cells indicate zero entries by definition.

**a** Supplementary information is shown in italics.

Table A2.2

**Matrix of flows of water within the economy** (*physical units*) **(chap. III)**

| | User | Industries (by ISIC category) | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Supplier** | | **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 category)** | 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 economic units | | | | | | | | | | | |

Table A2.3
**Supplementary information to the emission accounts** (*chap. IV*)

### A. Gross and net emissions (*physical units*)

| Pollutant | Industries (by ISIC category) | | | | | | | 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 inland water resources | | | | | | | | | | |
| *Surface water* | | | | | | | | | | |
| *Groundwater* | | | | | | | | | | |
| 1.a.ii. To the sea | | | | | | | | | | |
| 1.b. To sewerage (ISIC 37) | | | | | | | | | | |
| **2. Reallocation of emissions by ISIC division 37** | | | | | | | | | | |
| **3. Net emissions** (= 1.a + 2) | | | | | | | | | | |

### B. Emissions by ISIC division 37 (*physical units*)

| Pollutant | ISIC division 37 |
|---|---|
| **4. Emissions into 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 | |

### C. Sludge indicators

| | ISIC division 37 |
|---|---|
| Total sewage sludge produced (volume) | |
| Load in total sewage sludge | |

Table A2.4
**Supplementary information to hybrid and economic accounts** (*chap. V*)

**A. Economic accounts—supplementary information**

| | Industry (by ISIC category) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | 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 | | | | | | | | |

**B. National expenditure accounts for the protection and remediation of soil, groundwater and surface water** (*monetary units*)

| | Users/beneficiaries | | | | | |
|---|---|---|---|---|---|---|
| | Producers | | Final consumers | | Rest of the world | Total |
| | Specialized producers (ISIC division 37) | Other producers | Households | Government | | |
| **1. Use of environmental protection services** | | | | | | |
| 1.a. Final consumption | | | | | | |
| 1.b. Intermediate consumption | | | | | | |
| 1.c. Capital formation | | | | | | |
| **2. Gross capital formation** (for environmental protection 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) | | | | | | |

**C. Financing accounts for the protection and remediation of soil, groundwater and surface water** (*monetary units*)

| | Users/beneficiaries | | | | | |
|---|---|---|---|---|---|---|
| | Producers | | Final consumers | | Rest of the world | Total |
| Financing sectors: | Specialized producers (ISIC division 37) | Other producers | Households | Government | | |
| 1. General Government | | | | | | |
| 2. NPISHs | | | | | | |
| 3. Corporations | | | | | | |
| 3.a. Specialized producers | | | | | | |
| 3.b. Other producers | | | | | | |
| 4. Households | | | | | | |
| 5. National expenditure | | | | | | |
| 6. Rest of the world | | | | | | |
| 7. Domestic uses | | | | | | |

**Note:** Dark grey cells indicate non-relevant or zero entries by definition.

Table A2.5
**Supplementary information to the asset accounts** (*chap. VI*)

**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** | | | | | | | |

A2.6
**Quality accounts** (*physical units*) **(chap. VII)**

| | Quality classes | | | | |
|---|---|---|---|---|---|
| | Quality 1 | Quality 2 | Quality 3 | Quality n | Total |
| **Opening stocks** | | | | | |
| Changes in stocks | | | | | |
| **Closing stocks** | | | | | |

A2.7
**Supplementary information to the water accounts: social indicators** (*chap. VII*)

| |
|---|
| **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

A3.1. Water accounts constitute a very powerful tool for improving 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 modelling scenarios.

A3.2. This annex addresses more thoroughly the links 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 IWRM. Section 2 links the indicators proposed in the *World Water Development Report*[1] to the water accounts, in particular, by looking at which of the indicators in that report can be derived from SEEA-Water.

## A. Indicators derived from the water accounts

A3.3. 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 the IWRM approach, such as the following:

(*a*) Water resource availability;

(*b*) Water use for human activities, pressure on water resources and opportunities to increase water efficiency;

(*c*) Opportunities to increase effective water supply through the management of return flows, reuse and system losses;

(*d*) Water cost and pricing policy: the user-pays and polluter-pays principles;

A3.4. The major indicators for each of these aspects of water management are discussed below. 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, although these are not shown explicitly. The indicators can also be disaggregated by type of resource, for example, surface water and groundwater. While a national overview is important, the indicators would be more useful for IWRM if they were compiled at the level at which IWRM is likely to be implemented, that is, the regional level for a river basin or other water management area.

1 United Nations and the World Water Assessment Programme, *United Nations World Water Development Report 2: Water a Shared Responsibility* (United Nations publication, Sales No. E.06.II.A.4).

## 1. Water resource availability

A3.5. IWRM promotes sustainable, long-term water use that does not compromise the ability of ecosystems to supply water services in the future, including both human water requirements and ecological water requirements. The treatment of water availability in the water accounts is addressed in chapters VI and VII. Table A3.1 lists 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 the 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. It should be noted that these indicators do not provide information on the qualitative status of water resources.

A3.6. 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 enable the evaluation of some natural characteristics of a region: climatic, geographic and topographic. It is important to consider these indicators in addition to those on the pressure caused by human activities in order to link water demand with the supply of water from the environment.

A3.7. **Internal renewable water resources** give an indication of the amount of water that is internally made available through precipitation. These resources are computed by adding up the volume of the average annual surface run-off and groundwater recharge occurring within a country's borders. A method has been developed by FAO/Aquastat to improve the consistency of global data sets by avoiding double counting of the overlap between surface water and groundwater. This indicator can be computed from the matrix of flows between the water resources shown in table VI.2.

A3.8. **External renewable water resources** furnish information on the amount of renewable resources that are generated outside the territory of reference. These resources consist mostly of river run-off but, in arid regions, they may also include groundwater transfers between countries. This indicator corresponds to inflows from other territories, as illustrated in table VI.1. In the definition, external inflows are classified as natural or actual depending on whether 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 corresponds to the actual external renewable resources.

A3.9. **Total natural renewable water resources** represent the amount of water that would be available in a territory if there were no human-induced water consumption in the upstream territories, that is, water abstracted from water resources but not returned to water resources. Should this quantity be available, this indicator can be derived by combining information on the total actual renewable resources and water consumption in upstream countries. If asset accounts are compiled for an international river basin, as described in table VI.4, this indicator could be obtained from the same table.

A3.10. **Total actual renewable water resources** give an indication of the amount of water that is generated through natural processes in a territory as a result of internal precipitation and inflows from other territories. This quantity can be derived from table VI.1 and table VI.2, or obtained as the 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 in order to specify the part of inflows from other territories that is subject to international agreements.

A3.11. **Exploitable water resources** reflect 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.

A3.12. The remaining indicators in table A3.1 reflect pressure on water resources from population, total water use and vulnerability to depletion.

A3.13. **Dependency ratio** indicates the reliance of a country on 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, because both the numerator and the denominator of the ratio can be derived from the accounts (see previous indicators).

A3.14. The dependency ratio varies between 0 and 1. It increases as the amount of water received from neighbouring countries increases compared with the total natural renewable resources. Jean Margat also presented a complementary indicator, the indicator of independence, which measures the degree of autonomy a country enjoys from resources generated

Table A3.1
**Selected indicators of water resource availability and pressure on water derived from water accounts**

| Indicator | Definition and source |
|---|---|
| Internal renewable water resources | Average annual flow of rivers and recharge of groundwater generated from endogenous precipitation.[a] |
| 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 (transboundary groundwater and surface water inflows), and the relevant 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.[a] |
| 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.[a] |
| 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.[a] |
| Dependency ratio | Ratio between the external renewable resources and total natural renewable resources.<br>Indicator expressing the part of the total renewable water resources originating outside the country.[a,b,c] |
| Exploitable water resources<br>(manageable resources) | Part of the water resources which is considered to be available for development under specific technical, economic and environmental conditions.[a] |
| Per capita renewable resources | Ratio between total renewable water resources and population size.[b,c] |
| Density of internal resources | Ratio between the average internal flow and area of the territory.[c] |
| Annual withdrawals of groundwater and surface water as a percentage of total renewable water<br>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.[d] |
| Consumption index | Ratio between water consumption and total renewable resources.[c] |

**a** Food and Agriculture Organization of the United Nations, Aquastat Glossary online, available from http://www.fao.org/nr/water/aquastat/data/glossary/search.html?lang=en.

**b** UNESCO and its World Water Assessment Programme, *United Nations World Water Development Report: Water for People, Water for Life* (Paris, UNESCO, and New York, Berghahn Books, 2003).

**c** Jean Margat, ed., *Les ressources en eau: manuels et méthodes*, *No. 28* (Rome, Food and Agriculture Organization of the United Nations, and Orléans, France, Bureau de Recherches Géologiques et Minières, 1996).

**d** United Nations, *Indicators of Sustainable Development: Guidelines and Methodologies, 3rd ed.* (United Nations publication, Sales No. E.08.II.A.2).

outside its borders.[2] The indicator of independence is obtained as the ratio of internal over total natural renewable resources.

A3.15. It is often important to relate information on water resources to economic, demographic and social information, such as population size and total land area. For example, total renewable water resources compared with the population size would furnish information on the natural ability of a territory to generate water resources in line with its population size. In other words, this indicator would show whether the natural water supply, measured in terms of renewable water resources, is sufficient to meet the demand of the current population. If overexploitation occurs and there is increased pressure on the resource due to an increase in the population, alternative sources of water supply may have to be developed in order to reduce the stress on water resources. Another example would be the comparison of internal (or total) renewable water resources with the area of a territory, which provides some information on the geography of the available water resources.

A3.16. Water availability is an indicator that is often mentioned but rarely defined. It is often used as a synonym for renewable water resources, following from the notion that abstracting water at the same rate as its recharge would not lead to depletion of the water resources. This is a simplified view, however. First, depletion of water resources is a long-term concept; depletion 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 to be available water, if the technology for desalinating the water is in place.

A3.17. The concept of water availability is related to the ability of a country to mobilize water. It therefore includes factors such as the economic feasibility and the level of technology for storing part of 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 not be considered to be available for abstraction. Similarly, the level of technology available has a significant impact on the water that is considered available in a country. 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 for water availability.

A3.18. FAO/Aquastat suggests the use of an indicator of **exploitable (or manageable) water resources**, which is defined as that 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, the extractability of groundwater, the level of minimum flow required for environmental, social and non-consumptive use, etc.[3]

## 2. Water use for human activities

A3.19. Water availability indicators provide policymakers 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 for different uses, the costs of water pollution resulting from economic activities, as

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2 Jean Margat, ed., *Les Ressources en Eau: Manuels et Méthodes, No. 28* (Rome, Food and Agriculture Organization of the United Nations, and Orléans, France, Bureau de Recherches Géologiques et Minières, 1996).

3 Food and Agriculture Organization of the United Nations, Aquastat Glossary online, available from http://www.fao.org/ag/agl/aglw/aquastat/glossary/index.jsp.

well as the broader socio-economic benefits generated by use of water for different economic activities. Table A3.2 presents examples of indicators that can be derived from the supply and use tables in chapters III, IV and V, which are particularly useful for this aspect of IWRM.

## 3. Opportunities to increase effective water supply: return flows, reuse and system losses

A3.20. Water supply and water productivity are not determined solely by natural conditions. The way that water is managed affects (*a*) the amount of water that can be utilized by end-users; and (*b*) the productivity of water. Ways in which water availability and productivity can be increased include the following:

- Increased use of return flows by directing water to storage or other uses and minimizing pollution and the salinity of return flows
- Increased reuse of water
- Reduced system losses from leakages and other causes

A3.21. IWRM focuses strongly on these measures to increase the effective supply of water. Indicators that could be derived from the water accounts for return flows, reuse and losses are listed in table A.3.3.

Table A3.2
**Selected indicators of water intensity and water productivity**

| | |
|---|---|
| **1. Water use and pollution intensity (physical units)** | |
| Cubic metres of water use per unit of physical output | Water use or tons of pollution emitted per unit of output, such as:<br>• Population<br>• Number of households<br>• Tons of wheat, steel, etc., produced |
| Tons of pollution generated per unit of physical output | |
| **2. Water and pollution intensity (monetary units)** | |
| Cubic metres of water use per value added | Water use or tons of pollution emitted per unit of value added, measured in currency units |
| Tons of pollution per value added | |
| **3. Water productivity ratios** | |
| GDP per cubic metres of water used | |
| Value added by industry per cubic metres of water used | |
| **4. Water “pollutivity” ratios** | |
| Industry’s share of pollution per industry’s share of value added | |

Table A3.3
**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 of water as a share of total industrial water use | May distinguish the reuse of water within a plant from water supplied by ISIC 36, water collection, treatment and supply |
| **3. Losses** | |
| Losses in distribution as a share of total water supply | Both the amount of and the reason for these losses are usually known by the water utility |
| Losses unaccounted for as a share of total water use | These losses occur owing to various causes and it is usually not certain how much each cause contributes to the losses |

### 4. Water cost, pricing and incentives for conservation

A3.22. 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 A3.4 presents examples of indicators that can be derived from the hybrid accounts in chapter V.

Table A3.4
**Indicators of 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 cubic metre, by industry | Actual payments by that industry divided by the volume of water purchased |
| Average water supply cost per cubic metre, by industry | Cost of supply to that industry divided by the volume of water purchased |
| Subsidy per cubic metre, by industry | Average water price minus average cost of 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 cubic metre, by industry | Volume of wastewater divided by treatment cost for that industry |
| Average wastewater treatment price per cubic metre, by industry | Volume of wastewater divided by actual payments for treatment by that industry |
| Subsidy per cubic metre, by industry | Average wastewater price minus average wastewater supply cost |

## B. Links between indicators in the *World Water Development Report* and the System of Environmental-Economic Accounting for Water

A3.23. Several indicators can be derived from the water accounts. Chapter IX furnished examples of how countries have disseminated these indicators and used the information derived from the accounts for designing policies. This section focuses on the list of indicators proposed in the second *World Water Development Report (WWDR)*[4] and links them, where possible, to the various modules of SEEA-Water.

A3.24. The focus on the indicator set proposed in *WWDR* (2006) is justified by the fact that the 62 indicators suggested have undergone an extensive review and evaluation by United Nations agencies, academia and non-governmental organizations. They result from an analysis of the indicator sets proposed by various groups, including *WWDR* (2003), and have been recommended by the World Water Assessment Programme.

A3.25. In the second *WWDR* (2006), the indicators are grouped by challenge areas. Table A3.5 (first column) reports only indicators of those seven challenge areas related to the link between the economy and the water resources, namely: global, resources, agriculture, industry, energy, valuing and sharing. Areas such as governance (two indicators), settle-

4 For the sake of simplicity, the acronym *WWDR* (2006) will be used hereinafter in this annex to refer to the following publication: *United Nations World Water Development Report 2: Water a Shared Responsibility* (United Nations publication, Sales No. E.06.II.A.4); and *WWDR* (2003) will be used to refer to the following publication: UNESCO and its World Water Assessment Programme, United Nations and the World Water Assessment Programme, *United Nations World Water Development Report: Water for People, Water for Life* (Paris, UNESCO, and New York, Berghahn Books, 2003).

ments (three indicators), ecosystems (five indicators), health (six indicators), risk (three indicators) and knowledge (one indicator) are not reported in the table as they go beyond the scope of water accounts. Although those indicators cannot be derived directly from the core water accounts, they can be presented side by side with the accounts in supplementary tables to enable integrated analyses.

A3.26. Table A3.5 presents, in the second to fourth 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 profile sheet" of *WWDR* (2006) and its CD-ROM. The last column describes the link with the information provided by the water accounts.

A3.27. As can be seen from the table, 21 of the 38[5] indicators can be derived directly from the accounts; 5 can be partially derived from the accounts; and 12 cannot be derived from the accounts but can be included as supplementary information. Of these 12 indicators, 4 are social indicators, such as the 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.

Table A3.5
**Indicators of selected challenge areas from the United Nations *World Water Development Report 2***

| Challenge area | Indicator[a] | Status[b] | Calculation method | Link with the water accounts |
|---|---|---|---|---|
| **Global** | **Index of non-sustainable water use**<br>This indicator provides a measure of the human water use in excess of natural water supply (local run-off 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.<br>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 follows:<br>Q – DIA, or Q – A<br>where:<br>D = domestic water use ($km^3$/yr)<br>I = industrial water use ($km^3$/yr)<br>A = agricultural water use ($km^3$/yr)<br>Q = renewable freshwater resources ($km^3$/yr) | Derived from the water accounts.<br>Water use by sector is derived from the physical supply and use tables (chap. III) and renewable water resources from the asset accounts (chap. VI). |
| | **Urban and rural population**<br>This indicator provides a measure of 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.<br>This is a social indicator which could be included as supplementary information in the accounts. |
| | **Relative water stress index**<br>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.<br>A threshold of 0.4 (or 40 per cent use relative to supply) signifies severely water-stressed conditions. The combination of a water stress threshold and gridded population data enables 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 follows:<br>DIA/Q<br>where:<br>D = domestic water demand ($km^3$/yr)<br>I = industrial water demand ($km^3$/yr)<br>A = agricultural water demand ($km^3$/yr)<br>Q = renewable freshwater resources ($km^3$/yr) | Derived from the water accounts.<br>Water use by sector is derived from the physical supply and use tables (chap. III) and renewable water resources from the asset accounts (chap. VI). |

5 The indicators in the challenge area called "sharing" and the water pollution index are not included in the analysis, as their definition is not provided in *WWDR* (2006).

Table A3.5
**Indicators of selected challenge areas from the United Nations *World Water Development Report 2 (continued)***

| Challenge area | Indicator[a] | Status[b] | Calculation method | Link with the water accounts |
|---|---|---|---|---|
| **Global** (*continued*) | **Domestic and industrial water use**<br>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 being associated with dense settlement and high 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 follows:<br>(Sectoral per capita water use) x (population)<br>where sectoral per capita water use (in $m^3$/yr/person) and population (number of people) are available at national or subnational scales. | Derived from the water accounts.<br>Water use by sector is derived from the physical supply and use tables (chap. III). |
| | **Water pollution index** | K | Definition not available. | |
| | **Sediment-trapping efficiency index**<br>The residence time of water in large reservoirs and subsequent sediment-trapping efficiencies are calculated as a measure of the impact of these man-made structures on the characteristics of river flow and sediment discharge into 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 follows:<br>$\tau_R$ = 0.67 * Maxcapacity / $Q$<br>TE = 1 – (0.05*$\Delta\tau_R^{0.5}$)<br>where:<br>$\tau_R$ = residence time of water in reservoir<br>TE = trapping efficiency of reservoir<br>MaxCapacity = maximum reservoir capacity<br>Q = local mean annual discharge (pre-impoundment) | Partially derived from the water accounts.<br>Only information on the annual discharge of dams is available in the asset accounts (chap. VI). |
| | **Climate moisture index (CMI)**<br>CMI ranges from –1 to +1, with wet climates showing positive values and dry climates showing negative values. The baseline CMI is important and its variability over multiple years is also critical in defining reliable water supplies.<br>The indicator is based on the following definition: precipitation and potential evapotranspiration (optimum plant water demand). | K | The indicator is computed as follows:<br>Ratio of plant water demand to volume of precipitation. | Partially derived from the water accounts.<br>Precipitation is recorded in the asset accounts (chap. VI). The asset accounts record actual (but not potential) evapotranspiration. |
| | **Water reuse index (WRI)**<br>This index considers 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.<br>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 supporting large populations, industrial development and irrigation water use show water use by society in excess of natural river flow (i.e., >100 per cent).<br>With high values for this index, increasing competition for water can be expected among 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 index reflects the aggregate impact of water competition throughout a river basin. | K | The indicator is computed as follows:<br>_ DIA/Q<br>where:<br>_D = upstream domestic water demand ($km^3$/yr)<br>_I = upstream industrial water demand ($km^3$/yr)<br>_A = upstream agricultural water demand ($km^3$/yr)<br>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 (chap. III). The accounts would also provide information on the upstream water returns to the environment.<br>Renewable water resources can be derived from the asset accounts (chap. VI).<br>It should be noted that in the water accounts, the term "reuse" identifies the water that has been used by an economic unit and is supplied to another for further use. |
| **Resources** | **Precipitation annually** | B | | This indicator can be derived from the asset accounts (chap. VI). |
| | **Total actual renewable resources (TARWR) volume**<br>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 to the country is calculated from data on the following: (*a*) sources of water within a country itself; (*b*) water flowing into a country; and (*c*) water flowing out of a country (treaty commitments). | K | The indicator is computed as follows:<br>TARWR (in $km^3$/yr) = (external inflows + surface water run-off + groundwater recharge) - (overlap + treaty obligations). | Derived from the water accounts.<br>TARWR can be derived from the asset accounts (chap. VI). |
| | Availability, defined as the surface and groundwater resource volume renewed each year in each country, comprises the water that is theoretically available for use on a sustainable basis. Exploitability is a different matter. While availability undoubtedly exceeds exploitability, there is unlikely to be adequate data to define the degree of exploitability at this stage. In more specific terms, TARWR is the sum of: | | | |

| Challenge area | Indicator[a] | Status[b] | Calculation method | Link with the water accounts |
|---|---|---|---|---|
| **Resources** (*continued*) | • External water resources entering the country<br>• Surface water run-off (SWAR) volumes generated in the country<br>• Ground water recharge (GAR) taking place in the country<br>minus:<br>• 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, lakes, 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<br>• The volume that flows to downstream countries based on formal or informal agreements or treaties | | | |
| | **TARWR per capita** | D | The indicator is computed as follows:<br>TARWR PC = (TARWR/population) 109m$^3$/km$^3$. | Partially derived from the water accounts. TARWR is derived from the asset accounts (chap. VI). |
| | **Surface water as a percentage of TARWR**<br>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 run-off (SWAR). | D | The indicator is computed as follows:<br>100 (surface water abstraction)/(surface water run-off). | Derived from the water accounts.<br>This indicator can be derived from the asset accounts (chap. VI).<br>Sectoral breakdown of water abstraction is available in the physical supply and use tables (chap. III). |
| | **Groundwater development (groundwater as a percentage of TARWR)**<br>This indicator illustrates the degree to which a country is exploiting its groundwater resources in terms of groundwater abstraction as a percentage of the groundwater recharge. Groundwater abstraction is the quantity of groundwater resources used by major sectors (municipal, agricultural and industrial). Groundwater recharge is a component of TARWR. | K | The indicator is computed as follows:<br>100 (groundwater abstraction)/(groundwater recharge). | Derived from the water accounts.<br>This indicator can be derived from the asset account (chap. VI).<br>Sectoral breakdown of water abstraction is available in the physical supply and use tables (chap. III). |
| | **Overlap as a percentage of TARWR** | D | | Derived from the asset accounts (chap. VI). |
| | **Inflow as a percentage of TARWR** | D | | Derived from the asset accounts (chap. VI). |
| | **Outflow as a percentage of TARWR** | D | | Derived from the asset accounts (chap. VI). |
| | **Total use as a percentage of TARWR** | D | | Derived from the asset accounts (chap. VI). |
| **Agriculture** | **Percentage of undernourished people**<br>The proportion of undernourished people in a population provides a measure of the extent to which hunger is a problem for a 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.<br>This is a social indicator, which could be included as supplementary information. |
| | **Percentage of poor people living in rural areas**<br>Knowing the proportion of poor people living in rural areas, where agriculture and related activities are the primary source of livelihood, furnishes 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.<br>This is a social indicator, which could be included as supplementary information. |
| | **Relative importance of agriculture in the economy**<br>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 follows:<br>The share of the country's GDP derived from agriculture. | Derived from the monetary accounts (chap. V). |

Table A3.5
**Indicators of selected challenge areas from the United Nations *World Water Development Report 2 (continued)***

| Challenge area | Indicator[a] | Status[b] | Calculation method | Link with the water accounts |
|---|---|---|---|---|
| **Agriculture** (*continued*) | **Irrigated land as a percentage of cultivated land**<br>This indicator furnishes 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.<br>This indicator can be derived from the land accounts. |
| | **Relative importance of agricultural withdrawals in water balance**<br>This indicator measures the importance of agriculture, especially irrigation, in a country's water balance. | K | This indicator is computed as follows:<br>Water withdrawal for agriculture/ renewable water resources. | Derived from the water accounts<br>Agricultural water use from physical supply and use tables (chap. III); renewable water from asset accounts (chap. VI). |
| | **Extent of land salinized by irrigation**<br>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 follows:<br>Area of soil salinized by irrigation as a percentage of total irrigated land. | Not derivable from the water accounts.<br>This indicator can be derived from the land accounts. |
| | **Importance of groundwater irrigation**<br>The purpose of this indicator is to assess the dependency of a country's irrigated agricultural sector on groundwater resources. | K | This indicator is computed as follows:<br>Percentage of land under irrigation that relies on groundwater. | Not derivable from the water accounts.<br>This indicator can be derived from the land accounts. |
| **Industry** | **Trends in industrial water use**<br>In many developing countries, industrial production and hence the sectoral use of water have grown rapidly, 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 follows:<br>Wi = Ci + Ei<br>where:<br>Wi = water withdrawal by industry<br>Ci = water consumption by industry<br>Ei = industrial effluent discharge | Derived from the physical supply and use tables (chap. III). |
| | **Water use by sector**<br>Comparing sectoral use patterns is useful for recognizing potential conflicts. This indicator highlights the water demand from industry compared with other sectoral uses of water. | K | This indicator is computed as follows:<br>100 (Wi/Wt ); 100 (Wa/Wt);<br>100 (Ws/Wt); 100 (Wd/Wt)<br>where:<br>Wi = water withdrawal by industry<br>Wa = water withdrawal by agriculture<br>Ws = water withdrawal by services<br>Wd = water withdrawal by the domestic sector<br>Wt = total water withdrawal | Derived from the physical supply and use tables (chap. III). |
| | **Organic pollution emission by industrial sector**<br>Most industrial sectors discharge effluents containing a load of organic pollutants which can be measured by biochemical oxygen demand (BOD), thus showing the extent to which the water quality has been compromised. Some sectors pollute more than others.<br>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 these data are 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 employment data, which are currently available for every industrial sector in every country. | K | Proportion of organic water pollution discharged by the industrial sector. | Derived from the emission accounts (chap. IV). |

| Challenge area | Indicator[a] | Status[b] | Calculation method | Link with the water accounts |
|---|---|---|---|---|
| **Industry** (*continued*) | **Industrial water productivity**<br>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 follows:<br>Pi = Vi/Wi<br>where:<br>Pi = productivity of water used in industry i<br>Vi = total annual value added by industry i (United States dollars/year)<br>Wi = annual water withdrawal by industry i ($m^3$/year) | Derived from the hybrid accounts (chap. V). |
| | **Trends in ISO 14001 certification, 1997-2002**<br>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, thus reducing pressure on the water resources and the environment. | K | This indicator is computed as follows:<br>100 (Nc/N)<br>where:<br>Nc = number of companies registered per country<br>N = total number of companies registered worldwide | Not derivable from the water accounts.<br>This indicator could be included as supplementary information. |
| **Energy** | **Capability of hydropower generation, 2002**<br>In many countries, hydropower is already well developed and still growing, while in others it has the potential to expand greatly. Hydropower generation is measured on a large scale, that is, in the number of terawatts per hours generated annually (TWh per year). The gross theoretical capability expresses the total amount of electricity which could potentially be generated if all available water resources were turned to such 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 having carried out a feasibility study on each site at current prices, which produces a positive outcome. | K | Gross theoretical capability of hydropower generation; technically exploitable capability; and economically exploitable capability, in TWh/year (terawatt hours per year). | Not derivable from the water accounts.<br>This indicator could be included as supplementary information. |
| | **Access to electricity and water for domestic use**<br>Comparison of secure access to electricity versus access to an 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 means access to a safe, legal and adequate supply). | Not derivable from the water accounts.<br>This is a social indicator, which could be included as supplementary information. |
| | **Electricity generation by energy source, 1971-2001**<br>This indicator enables measurement of the contribution of hydropower to electricity supplies over time compared with other energy sources. | K | Electricity generation by energy source, worldwide, in time series data in gigawatt-hours (GWh) per year. | Not derivable from the water accounts.<br>This indicator can be derived from the energy accounts. |
| | **Total primary energy supply by source, 2001**<br>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 and other combined renewable sources and waste. This enables the computing of hydropower as a proportion of total primary energy supply. | K | The percentage share of any given fuel may be calculated as follows:<br>100 (Ef/E)<br>where:<br>Ef = primary energy supply by fuel, worldwide, in metric tons of oil equivalent (m.t.o.e.)<br>E = total global primary energy supply | Not derivable from the water accounts.<br>This indicator can be derived from the energy accounts. |
| | **Carbon intensity of electrical production, 2002**<br>This is a measure of the carbon dioxide emissions associated with climate change which are produced in the process of electricity generation in various countries. Hydropower is one of the “clean” power options in the sense that it does not generate greenhouse gases. | K | The indicator is calculated as follows:<br>Ce = C/Ee grams of carbon per kilowatt-hour (gC/kWh)<br>where: | Not derivable from the water accounts.<br>This indicator can be derived from the energy accounts. |

Table A3.5
**Indicators of selected challenge areas from the United Nations *World Water Development Report 2 (continued)***

| Challenge area | Indicator[a] | Status[b] | Calculation method | Link with the water accounts |
|---|---|---|---|---|
| **Energy** (*continued*) | | | Ce = carbon intensity of electrical production<br>C = annual carbon emissions from electricity generation measured in kilograms of carbon released per year<br>Ee = electricity generation measured in gigawatt-hours per year | |
| | **Volume of desalinated water produced**<br>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 follows:<br>Volume of desalinated water produced is measured in millions of cubic metres of drinking-quality water produced by these means per annum | Derived from the physical supply and use tables (chap. III). |
| **Valuing** | **Water sector share in total public spending**<br>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 on water.<br>The indicator is based on the following definitions:<br>***National public expenditure*** refers to total public expenditure in all formal and informal economic sectors of the economy.<br>***Water sector expenditure*** 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.<br>***Sectors*** are segments of the economy that are identified in terms of their contributions to the economy and daily quality of life. The water sector generally comprises water supply, sewerage, sanitation, irrigation and drainage infrastructure, and IWRM. | D | The indicator can be computed as follows:<br>100 (PSws/TPSes)<br>where:<br>PSws = public spending in the water sector<br>TPSes = total public spending in all economic sectors. | Derived from the monetary accounts (chap. V). |
| | **Ratio of actual to desired level of public investment in water supply**<br>This ratio would indicate whether investments to meet water-related targets are on track. A ratio of less than 1 would indicate the magnitude by which actual investment in the water sector would need to be increased, thus enabling Governments to adjust their financial responses to meet the water-related Millennium Development Goals.<br>The indicator is based on the following definitions:<br>***Actual level of investment*** is the actual investment in the provision of water supply and services from all sources.<br>***Desired level of investment*** is a value that captures the cost of providing water to different settlements (urban and rural) for given technological choices and targets to be met in terms of providing access to water services. | D | The indicator would be computed as follows:<br>The ratio of actual level of investment to the desired level of investment in providing safe drinking water supply, as warranted under the relevant Millennium Development Goals. | Partially derived from the water accounts.<br>The actual level of investment can be derived from the monetary accounts (chap. V).<br>The desired level of investment is exogenous and may be the result of modelling based on the water accounts. |
| | **Rate of cost recovery**<br>An assessment of the existing water fee collection system could guide institutional reforms for strengthening the financial viability of water utilities, thus improving water governance. This indicator measures the water fees actually collected as a percentage of the total collectable charges billed by the water utility. | D | The indicator can be computed as follows:<br>100 (AWFC/TWFC)<br>where:<br>AWFC = actual water fees collected<br>TWFC = total water fees to be collected. | Partially derived from the water accounts.<br>Actual water fees collected can be derived from the monetary accounts (chap. V). |

| Challenge area | Indicator[a] | Status[b] | Calculation method | Link with the water accounts |
|---|---|---|---|---|
| **Valuing** (*continued*) | The indicator is based on the following definitions:<br>***Water fees*** comprise the rate/tariff structure established by the water utility (in the form of per unit of water used, a flat rate, or block rate, etc.) as a monetary amount of costs to be recovered from consumers for the purposes of sustaining the supply agency, providing incentives for conservation and assuring supplies for the less well-off.<br>**Actual water fees collected** are the amounts collected/received by the water utility from different consumers in return for providing them with water supply and services. | | | 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 that part of the total costs of water supply recovered through water fees. |
| | ***Total water fees to be collected*** 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 fee structure for different consumer groups. | | | |
| | **Water charges as a percentage of household income**<br>Water charges are seen as an important economic instrument for improving water use efficiency and securing the financial sustainability of the water utility. At the same time, it is important that water services be made accessible and affordable to all.<br>This indicator shows the proportion that water charges constitute of household income. The indicator is based on the following definitions:<br>***Expenditure on water charges*** is the actual monetary amount paid by households to the water utility in return for receiving water supply and services.<br>***Household income***, in simple terms, 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 follows:<br>100 (EW/HI)<br>where:<br>EW = the total amount spent on water supply by the household<br>HI = total household income. | Derived from the monetary accounts (chap. V). |
| **Sharing** | **Water interdependency indicator** | C | The definitions for these indicators are 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 (chap. VI). | |
| | **Cooperation indicator** | C | | |
| | **Vulnerability indicator** | C | | |
| | **Fragility indicator** | C | | |
| | **Development indicator** | C | | |

**Source:** Adapted from United Nations and the World Water Assessment Programme, *United Nations World Water Development Report 2: Water a Shared Responsibility* (United Nations publication, Sales No. E.06.II.A.4).

**a** Description based on the indicator profile sheet of *WWDR* (2006).

**b** Level of development, ranging from the highest to lowest: B = basic indicator, K= key indicator, for which an indicator profile sheet and statistical data exist; D = developing indicators, for which there is an indicator profile sheet but not yet a statistical presentation; and C = conceptual indicator, for which only discussion has taken place.

# 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 to be abstraction. Total water abstraction can be broken down according to the type of source, such as water resources and other sources, and the type of use. (EDG)

**Abstraction for distribution**: Water abstracted for the purpose of its distribution. (EDG)

**Abstraction for own use**: Water abstracted for own use. However, once water is used, it can be delivered to another user for reuse or for treatment. (EDG)

**Actual evapotranspiration**: 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 level of moisture content, which is determined by precipitation. (EDG)

**Actual final consumption of households**: The value of the consumption of goods and services acquired by individual households, including expenditures on non-market goods or services sold at prices that are not economically significant and the value of expenditures provided by government and NPISHs. (2008 SNA, para. 9.81)

**Actual final consumption of general government**: The value of the government's total final consumption expenditure less its expenditure on individual goods or services provided as social transfers in kind to households. It is thus the value of the expenditures that the government incurs on collective services. (Based on 2008 SNA, paras. 9.103)

**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 with a salinity content between that of freshwater and marine water. (EDG)

**Catchment** (*synonym*: river basin): An area having a common outlet for its surface run-off. (UNESCO/WMO *International Glossary of Hydrology*, 2nd ed., 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. (SEEA-2003, para. 7.36)

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

**Emission to water**: Direct release of a pollutant into water, as well as its indirect release by transfer to an off-site wastewater treatment plant. (Based on the European Commission, 2000, available from http://www.eper.cec.eu.int/eper/documents/guidance_html/index.htm)

**Evapotranspiration**: The 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 forms of infrastructure. (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. (2008 SNA, para. 9.94)

**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 ed., 1992)

**Gross capital formation**: The total value of the gross fixed capital formation, changes in inventories and acquisitions less disposal of valuables for a unit or sector. (2008 SNA, para. 10.31)

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

**Groundwater recharge**: The 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** (*synonym*: water cycle): The succession of stages through which water passes from the atmosphere to the Earth and returns to the atmosphere: evaporation from the land, 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 ed., 1992)

**Hydroelectric power generation, water use for**: Water used in generating electricity at plants where the turbine generators are driven by falling water. (USGS, available from http://pubs.usgs.gov/chapter11/chapter11M.html)

**Imports**: Water that enters the territory of reference through mains or other forms of infrastructure. (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, the consumption of which is recorded as consumption of fixed capital; the goods or services may be either transformed or used up by the production process. (Based on 2008 SNA, para 6.213)

**Irrigation water**: Water artificially applied to land for agricultural purposes. (UNESCO/WMO *International Glossary of Hydrology*, 2nd ed., 1992)

**Lake**: A generally large body of standing water occupying a depression in the Earth's surface. (EDG)

**Mine water** (*synonym*: 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 carried out as part of mining. Excludes water used for processing, such as smelting and refining, or slurry pipeline (industrial water use). (USGS, available from 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. (UNSD, online glossary of environment statistics)

**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, para. 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 to other resources within the territory. (EDG)

**Perennial river**: A river which flows continuously throughout the year. (Based on UNESCO/WMO *International Glossary of Hydrology*, 2nd ed., 1992).

**Point source of pollution**: Emissions for which the geographical location of the discharge of the wastewater is clearly identified, for example, emissions from wastewater treatment plants, power plants and 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**: The maximum quantity of water capable of being evaporated in a given climate from a continuous stretch of vegetation covering the whole ground 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**: The total volume of atmospheric wet precipitation, such as rain, snow and hail, on a territory in a given period of time. (EDG)

**Recycled water**: The reuse 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**: Bodies of water flowing continuously or periodically in a channel. (EDG)

**River basin** (*see also* **catchment**): An area having a common outlet for its surface run-off. (EDG)

**Run-off**: The part of precipitation in a given country/territory and period of time that appears as stream flow. (EDG)

**Sewage sludge**: The accumulated settled solids separated from various types of water, either moist or mixed with a liquid component, as a result of natural or artificial processes. (OECD/Eurostat joint questionnaire on inland water)

**Social transfers in kind**: Individual goods and services provided as transfers in kind to individual households by government units (including social security funds) and NPISHs, whether purchased on the market or produced as non-market output by government units or NPISHs; the items included are: (*a*) social security benefits and reimbursements; (*b*) other social security benefits in kind; (*c*) social assistance benefits in kind; and (*d*) transfers of individual non-market goods or services. (Based on 2008 SNA, para 8.141)

**Soil water**: Water suspended in the uppermost belt of soil, or in the zone of aeration near the ground surface that can be discharged into the atmosphere by evapotranspiration. (EDG)

**Standard river unit (SRU)**: A river stretch of one kilometre with a water flow of one cubic metre per second. (SEEA-2003, para. 8.128)

**Supply of water to other economic units**: The amount of water that is supplied by one economic unit to another and 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**: The 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. (2008 SNA, para 6.146)

**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 from http://www.unece.org/env/water/pdf/watercon.pdf)

**Transport margin**: Transport charges payable separately by the purchaser in taking delivery of goods at the required time and place. (2008 SNA, para. 6.141)

**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**: A mass of water distinct from other masses of water. (UNESCO/WMO *International Glossary of Hydrology*, 2nd ed., 1992)

**Watercourse**: A natural or man-made channel through or along which water may flow. (UNESCO/WMO *International Glossary of Hydrology*, 2nd ed., 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, wastewater from one user can be a potential supply of water to a user elsewhere. It includes discharges of cooling water. (EDG)

**Water consumption**: That 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, or consumed by households or livestock. It is calculated as the 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 as well as malfunctioning metering. (EDG)

**Water losses in distribution**: The 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; water lost due to evaporation is recorded as water consumption. When computed as the difference between the supply and use of an economic unit, it may also include 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 (water resources and sea water) and to the type of water, such as treated water and cooling water). (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 one economic unit to another. Water supply within the economy is net of losses in distribution. (EDG)

**Water use**: Water intake of an 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 one 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)

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