Integrated Environmental and Economic Accounting for Water Resources

United Nations Statistics Division

in cooperation with the

Subgroup of the London Group on Water Accounting

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Chapter 2 The water accounts framework

A. Introduction

2.1. Integrated environmental and economic accounting for water resources, SEEAW, provides a systematic framework for the organization of the information on water to study the interaction between the economy and the environment. The purpose of this chapter is to provide an overview of the accounting framework and how the various accounts in the framework relate to each others.

2.2. Section B provides a description of the interactions between the hydrological system and the economy in a diagrammatic form. It describes in a non-technical way the hydrological system, the economic system as measured by the 1993 SNA and their interactions. Section C introduces the SEEAW framework as a satellite system of the 1993 System of National Accounts (SNA) (CEC et al. 1993) and describes how the SEEAW expands the 1993 SNA in order to address water related concerns. This section also relates the SEEAW with the general environmental and economic accounting framework, SEEA (UN et al. 2003).

2.3. Section D presents the accounting framework in more detail: it describes the various accounts in the SEEAW framework, and presents concepts, definitions and classifications that are used in the SEEAW. Section E introduces two cross-cutting issues in the compilation of water accounts: namely the identification of the temporal and spatial reference.

B. Water resource system and the economy

2.4. Water is needed in all aspects of life: it is essential for basic human needs such as drinking, for socio-economic development and for the integrity and survival of ecosystems. It provides several functions: (a) it is a material input into production and consumption; (b) it is a sink for residuals; and (c) it provides space for human activities and a variety of services, such as habitat for species. SEEAW focuses on water as material input into production and consumption activities. The other functions of water – described in points (b) and (c) - are not reflected in this handbook even though they are considered in the more general environmental and economic accounting framework of the SEEA-2003.

2.5. Figure 2.1 presents the interactions between the economy and the system of water resources captured by the SEEAW in a simplified scheme. In this figure the in the environment are represented in two separate boxes:

- The inland water resource system which is composed of all water resources in the territory (surface and groundwater) and the natural flows between them;
- The economy which is the system of water users' who abstract water for production and consumption purposes and put in place the infrastructures to store, treat and distribute water.

These boxes are presented in further detail in Figure 2.2 and Figure 2.3 in order to describe the main flows within each system and the interactions between the two systems.

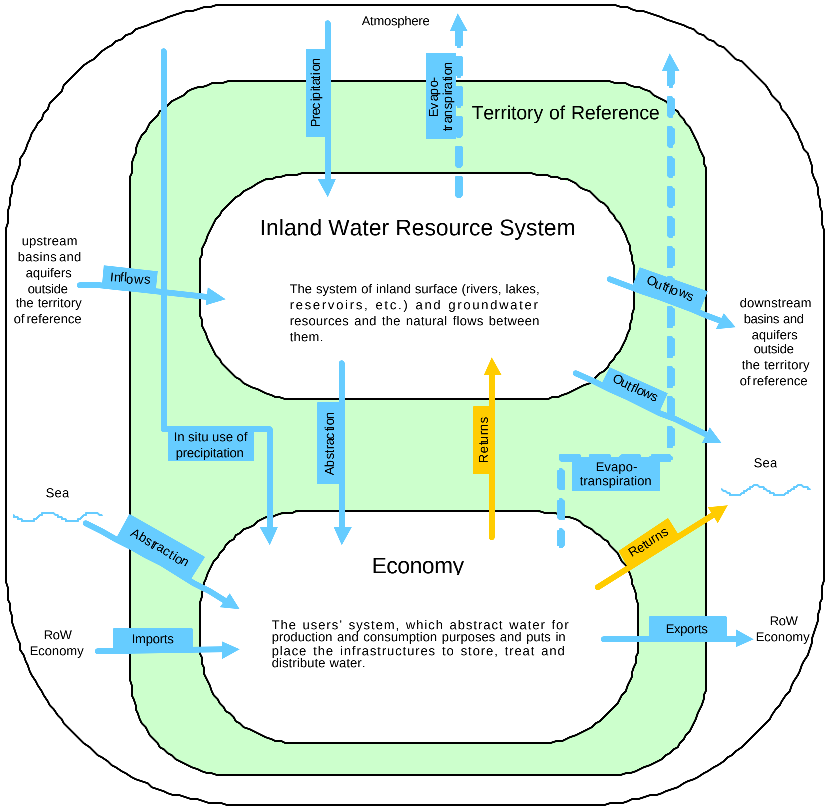
2.6. Figure 2.1 shows the interactions between the inland water resource system and the economy for a given territory which can be a country, a region or river basin. These systems however can also exchange water with those of other territories, for example, through imports/exports of water (exchanges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

2.7. The economy uses water in different ways. It physically removes it from the environment (sea or an inland water body) for production and consumption activities or use it without physically removing it from the environment. The latter includes uses of water for recreational and navigational purposes, fishing and other uses, which rely on the physical presence of water (*in-situ* uses) and, often, also on the quality of water. Even though these uses may have a negative impact on the quality of the water bodies, they are not directly considered in water resources accounting as they do not involve a displacement of water. However, in defining the sustainable water use, considerations are generally made so as to guarantee the availability of water for other uses including in-situ uses.

2.8. Water accounts include uses that involve an abstraction for production and consumption activities; hence they also include the collection of precipitation (e.g. rain-fed agriculture, roof rain harvest) and water used in hydropower generation.

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

Figure 2.1: Flows between the economy and the environment



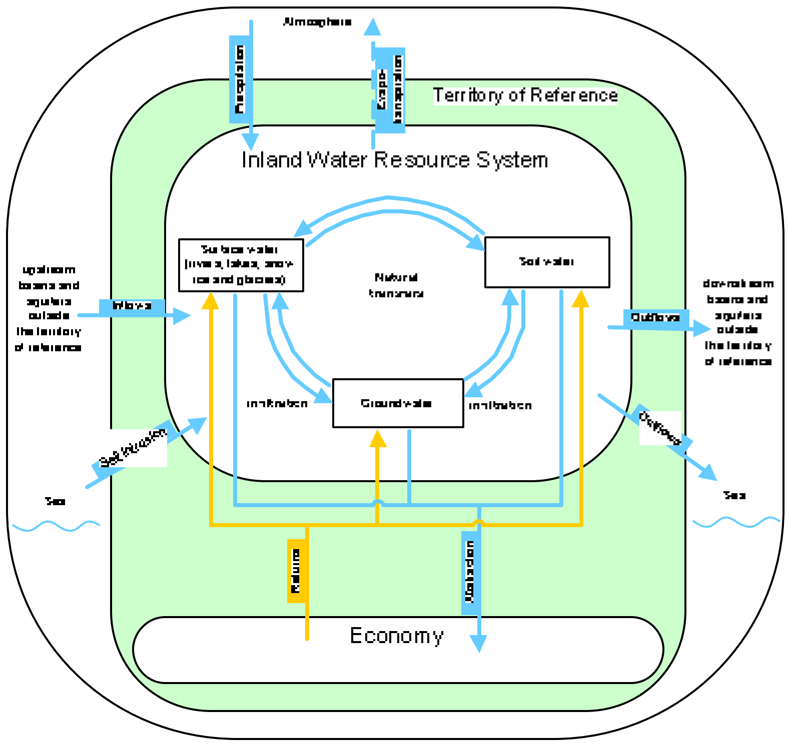
1. The inland water resource system

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

2.11. Figure 2.2 depicts in more details the inland water resource system and its interaction with the economy. The water resources considered in the inland water resource system are rivers, lakes, reservoirs, groundwater, soil-water and glaciers within the territory of reference. The main natural inputs of water for these resources are precipitations and inflows from other territories and from other resources within the territory. The main natural flows that decrease the stocks of water are evapotranspiration, outflows to other water resources within the territory and to other territories. Human activities decrease and increase the water stocks through abstraction and returns. These flows are also shown in Figure 2.1.

2.12. The asset accounts module of the SEEAW describes the inland water resource system in terms of stocks and flows: it provides information on the stocks of water resources at the beginning and end of the accounting period and changes therein. These changes are described in terms of the flows, brought about by the economy, and natural transfers brought about by natural processes. Asset accounts describe in accounting terms the hydrological water balance.

Figure 2.2: Main flows within the physical water resource system



2. The users' system – the economy

2.13. The economy is one user of water. Water accounts describe the relationship between this user - the economy - and the inland water resource system. The economy can be thought of as the system which abstracts water for consumption and production activities, and puts in place the infrastructures to mobilize, store, treat and distribute water.

2.14. Figure 2.3 expands the box representing the economy in Figure 2.1. It shows the flows of water within the economy and between the economy and the environment. It identifies the main economic agents that

- are primarily involved in the collection, purification and distribution of water to households, industries and the rest of the world;
- are primarily involved in the collection, treatment and discharge of water – sewage and refuse disposal;
- use water as an input in their production processes.

The box also separately identifies households as final consumers of water. As such, households use water to satisfy their own personal needs. If water is used by households as an input in the production, for example, of agricultural products, water should be considered as an intermediate consumption input in the production process.

2.15. Figure 2.3 is an oversimplification of all the activities related to water in the economy. As a result, some flows are not shown in the figure. The tables of the SEEAW, however, provide information on

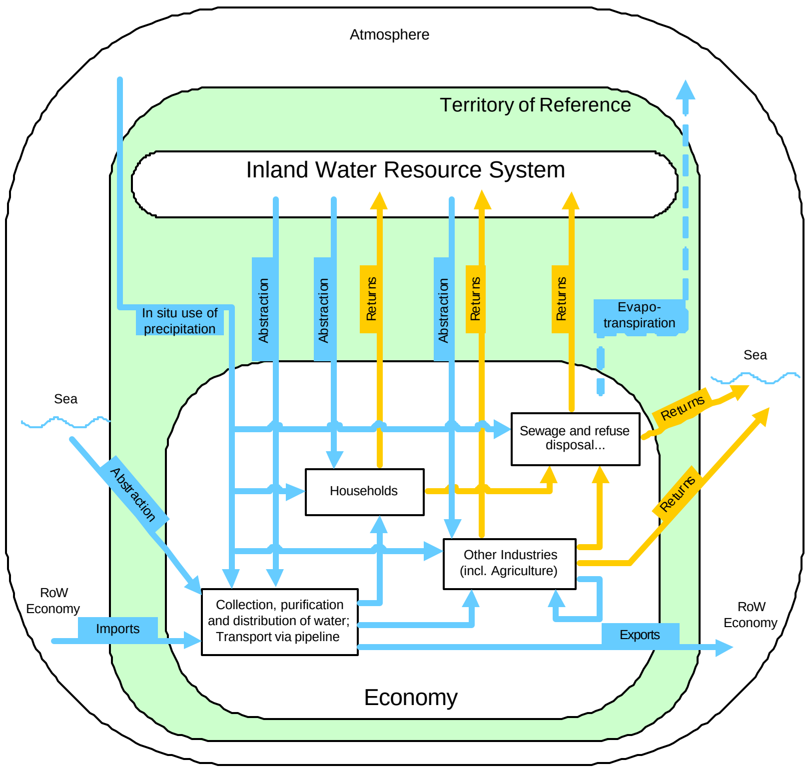
- the costs for environmental protection and resource management. They describe the economy's effort to prevent environmental degradation or eliminate part or all of the effects after degradation has taken place. They include actual expenses incurred by industries, households, government and non-governmental institutions;
- the emissions of pollutants into the environment. They allow for the identification of pressure on the environment in terms of quality;
- the investments in infrastructures. They describe (a) the ability of the economy to provide access to water and sanitation; (b) fees paid for water including taxes; and (c) the financing of these investments.

2.16. Figure 2.3 further describes the sources of water for the whole economy of a given territory. They include: inland water resources in the environment of the territory of reference, precipitation which is either collected or used directly (e.g. rain-fed agriculture) and sea water. Another source of water for the economy is the water distributed by another economy, i.e. imports from the rest of the world. Once water enters the economy, it can be either supplied to other economies (exports) or returned back to the environment (returns of water to inland water resources and to the sea).

2.17. Each economic unit either abstracts water directly from the environment or receives it from other industries. Once water is used, it can either be discharged directly into the environment - with or without self-treatment, supplied to other industries for further use (reused water), and/or supplied to the industry whose primary activity is to collect treat and dispose wastewater (this industry is denoted in Figure 2.3 with the box "Sewage and refuse disposal sanitation and similar activities").

2.18. During use, some water may be retained in the products produced by the industry or evapotranspired during use (note that most of the industrial activities lose water mainly due to evaporation as opposed to agriculture which consumes water mainly due to transpiration by plants and crops). In these cases water is considered "consumed" by the industry. The term consumption has often different meanings depending on the context it is used. In this handbook, the term *consumption* refers to the quantity above mentioned, which is different from *water use* that is the water that is received by an industry or households.

Figure 2.3: Main flows of water within the economy



2.19. Note that Figure 2.1 to Figure 2.3 aim at showing in a simple way situations that are more complex in reality, and therefore they do not contain all the flows that occur in reality and are recorded in the accounts. For example, in Figure 2.3 flows of water lost during distribution are not explicitly shown, but they often occur, at times even in significant quantities. Although not explicitly shown in the figures, these losses are recorded in water accounts.

C. The SEEAW and SNA framework

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

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

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

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

Asset accounts for infrastructure (e.g. pumps, dams, etc.) related to water are also explicitly identified as they provide information on the ability of a country to mobilize water. These assets are actually part of the asset boundary of the conventional accounts as produced assets.

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

While the SNA measures stocks or assets used in the production process and flows of products in monetary terms, the SEEA allows for the compilation of the accounts also in physical terms. In the case of water, physical flows include the quantity of water used for production and consumption activities and the quantity of water reused within the economy and returned to the environment (treated or untreated). Monetary flows include the current and capital expenditures for abstraction, transportation, treatment and distribution of water resources as well as water- and wastewater- related taxes and subsidies received by industries and households.

- Introducing impacts on natural assets caused by production and consumption activities of industries, households and government.

In the case of water, the impacts on the environment caused by human activities affect both the quantity and quality of water resources. Over abstraction and inefficient use of water resources can favour water scarcity problems and emissions of pollutants into water affect the quality of the water bodies.

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

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

2.21. The SEEAW framework is based on the SEEA-2003 (UN et al. 2003). This handbook expands what is presented in the SEEA-2003 by focusing on (a) definitions and classifications related to water; (b) providing compilation tables; and (c) discussing data issues and suggesting indicators that can be derived from the accounts.

2.22. The strengths of using the national accounting framework to describe the interactions between the environment and the economy are manifold. First, the SNA is an internationally agreed framework to measure the economic performance of a country. It provides internationally comparable indicators, and it is the major source of information for economic analysis and modelling. Thus, the integration of environmental information into this framework facilitates the consideration of environmental issues into mainstream economic decision-making and the evaluation of the impacts of the economy on the environment and of environmental policies on the economy.

2.23. Second, since the accounting framework contains a series of identities (for example, that involving supply and use), which in turn can be used to check the consistency of data, organizing environmental and economic information into an accounting framework has the advantage of improving basic statistics. In addition, by using concepts, definitions and classifications consistent with those of the SNA, the SEEA favours the consistency of environmental and economic statistics thus facilitating and improving the analysis of the interrelations between the environment and economy.

2.24. A wide range of indicators can be derived from the accounts. The advantages of using indicators derived from the accounts are numerous. Every indicator is computed from a fully consistent data system and therefore is more precisely defined, consistent and interlinked with other indicators. In particular, in the case of indicators which link economic and physical information, such as water efficiency, it is important that the quantities used to calculate the indicator are consistent in terms of classification (they refer, for example, to the same group of economic activities, etc.).

2.25. The existence of the underlying integrated data system is of essence for integrated economic and environmental analysis: it allows for cost-effectiveness, scenario modelling and economic and environmental forecast. Furthermore, sectoral policies are no longer viewed in isolation but in a comprehensive economic and environmental context, which allows for the evaluation of trade-offs.

D. The SEEAW framework

2.26. The SEEAW framework consists of the following accounts.

Flow accounts

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

Physical supply and use tables

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

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

Emission accounts

2.30. Emission accounts provide information by industry, households and government on the amount of pollutants which are released in the environment with water discharges with or without treatment. Even though they are usually compiled in physical units, they can also be compiled in monetary units using the maintenance cost approach to obtain information on the cost that one would have had to incur during the accounting period in order to avoid current and future environmental deterioration from the impacts caused during the accounting period. Emission accounts are presented in chapter 4

Monetary supply and use tables

2.31. These tables involve the compilation of a set of integrated production and generation of income accounts for industries - that is, groups of establishments as distinct from institutional units--that are able to draw upon detailed data from industrial censuses or surveys. The supply table gives information about the origin of goods and services. The use table gives information on the uses of goods and services, and also on cost structures of the industries.

2.32. Note that 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, the monetary counterpart to the physical SUT does not necessarily report the value of the water exchanged rather the value of the service associated with it as the output of the supplying industry is generally a service (and the monetary SUT records the value of the service). For example, the sewage industry, which collects treats and disposes wastewater from water users, generally charges for the service of collection, treatment and discharge. Monetary supply and use tables for water related products and industries are presented in chapter 5.

Environmental protection and resource management expenditures accounts.

2.33. Environmental protection expenditures are actual expenses incurred by industries, households, government and non-governmental organizations to avoid environmental degradation or eliminate part or all the effects after degradation has taken place. Resource management expenditures are expenditures to manage natural resources. Both environmental protection and resource management expenditures are part of the SNA, but are not separately identified in the SNA production accounts.

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

Asset accounts

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

Produced assets

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

Assets of water resources

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

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

2.39. Asset accounts can also be compiled on the basis of water quality. They describe stocks of water of a certain quality at the beginning and end of an accounting period. Since it is in general hard 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. Quality accounts are presented in chapter 7.

Valuation of non-market flows and environmentally adjusted aggregates

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

2. Main economic agents

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

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

2.43. The classification of industrial economic activities used in the accounts is the International Standard Industrial Classification of All Economic Activities (ISIC). An industry, as defined in ISIC, consists of a group of establishments engaged on the same type of productive activity, whether the institutional units to which they belong are market producers or not (para. 5.41, 1993 SNA). The economic activities primarily related to water are described in more details in the next paragraphs. Table 2.1 provides a schematic summary of these industries.

2.44. Activities for the **operation of irrigation systems**. These activities include all water mobilisation activities corresponding to agricultural and animal breeding uses including groundwater abstraction, construction of dams, catchments for surface flows, etc., and the operation of irrigation systems. These activities are recorded under **ISIC 0140** when they are carried out as a principal activity (that is, the value added exceeds that of any other activity carried out within the same unit). However, these activities could be carried out for own use, for example, by farmers who abstracts water and use for agricultural and animal breeding purposes. These activities may be particularly important and they are recorded in the accounts.

2.45. Activities for the **collection, purification and distribution of water**. They involve operation of water abstraction equipments and plants (protection of abstraction perimeters, pumping stations, etc.), purification and processing of drinking water, pressure build-up, storage and distribution, expenditure for major maintenance. When executed as principal activity, these activities are classified under the division 41 of ISIC, **ISIC 41,** which includes also activities of purification of water for water supply purposes and desalting of sea water to produce water as the principal product of interest. The output of such economic activity is the production of natural water, CPC 18. Abstraction and purification can also be carried out for own use (i.e. households pumping water from a well or an industry abstracting water for their own consumption). The corresponding output should in principle be recorded in national accounts (as output for own final use), but in practice this rarely happens.

2.46. Activities for the **public administration of water**. These activities include the administration of potable water supply programmes, wastewater collection and disposal operations, and environmental protection programmes. These activities are classified under the class 7512 of ISIC, **ISIC 7512**, when carried out as a principal activity.

2.47. Note that activities for the public administration of water are normally carried out by the public administration. However, the legal or institutional status is not, in itself, the determining factor. Often there is the tendency of allocating to ISIC 7512 activities for collection, purification and distribution of water (ISIC 41) and for the sewage, refuse disposal and sanitation (ISIC 90) when they are owned by the government. This can occur, for example, when the local government accounts are not detailed enough to separate water supply or sewage collection from other activities. To the extent possible government activities should be allocated under the relevant ISIC division, that is allocate activities for the collection, purification and distribution of water to ISIC 41 even when owned by the government and similarly in the case of activities for the collection and disposal of wastewater (which should be allocated to ISIC 90 independently on the ownership).

2.48. Activities for **Sewage and refuse disposal, sanitation and similar activities**. These activities involve

- collection and transportation of human wastewater from one or several users, as well as rain water by means of sewerage networks, collectors, tanks and other means of transport (sewage vehicles etc.) and their treatment and disposal;
- treatment of wastewater by means of physical, chemical and biological processes like dilution, screening, filtering, sedimentation etc.;
- treatment of wastewater from industries, swimming pools etc.;
- maintenance and cleaning of sewers and drains;
- emptying and cleaning of cesspools and septic tanks, sinks and pits from sewage, servicing of chemical toilets.

They also include other activities such as street cleaning and snow removal. When carried out as a principal activity, they are recorded under division 90 of ISIC, **ISIC 90**.

2.49. Activities of **transport via pipelines**. These activities include the transport of water via pipelines, the maintenance of pipelines and operation of pump stations. When carried out as principal activity they are recorded under ISIC 6030.

Table 2.1: Main activities related to water in the economy

ISIC 0140 **Agricultural and animal husbandry service activities, except veterinary activities** This class also includes: - operation of irrigation systems.
ISIC 4100 **Collection, purification and distribution of water** This class also includes: - purification of water for water supply purposes; - desalting of sea water to produce water as the principal product of interest. *This class excludes:* *- irrigation system operation for agricultural purposes, see 0140;* *- (long-distance) transport of water via pipelines, see 6030;* *- treatment of waste water in order to prevent pollution, see 9000.*
ISIC 6030 **Transport via pipelines** This class includes: - transport of gases, liquids, water, slurry and other commodities via pipelines - maintenance of pipelines - operation of pump stations *This class excludes:* *- distribution of natural or manufactured gas, water or steam, see 4020, 4030, 4100.*
ISIC 7512 **Regulation of the activities of agencies that provide health care, education, cultural services and other social services, excluding social security** This class also includes: - administration of potable water supply programmes - administration of waste collection and disposal operations - administration of environmental protection programmes *This class excludes:* *- sewage and refuse disposal and sanitation, see 9000*
ISIC 9000 **Sewage and refuse disposal, sanitation and similar activities** This class includes: - collecting and transporting of human wastewater from one or several users, as well as rain water by means of sewerage networks, collectors, tanks and other means of transport (sewage vehicles etc.) and their treatment and disposal - treatment of wastewater by means of physical, chemical and biological processes like dilution, screening, filtering, sedimentation etc. - treatment of wastewater from swimming pools and from industry - maintenance and cleaning of sewers and drains - emptying and cleaning of cesspools and septic tanks, sinks and pits from sewage, servicing of chemical toilets - decontamination of soils and groundwater at the place of pollution, either in situ or ex situ, using e.g. mechanical, chemical or biological methods - decontamination and cleaning up of surface water following accidental pollution, e.g. through collection of pollutants or through application of chemicals - cleaning up oil spills on land, in surface water, in ocean and seas, including coastal seas - outdoor sweeping and watering of streets, squares, paths, markets, public gardens, parks etc. - snow and ice clearing on highways, airport runways, including spreading of salt or sand etc. - specialized other pollution-control activities *This class excludes:* *- purification of water for water supply purposes, see 4100* *- construction and repair of sewer systems, see 4520*

2.50. Note that most of the activities mentioned above produce services related to water (except for ISIC 41). Some of these services are associated to physical exchanges of water (for example, when ISIC 90 produces the collection and treatment services of wastewater, it physically receive, treat and discharge wastewater). There are however, other services which do not have associated a physical exchange of water. For example, the activities of ISIC 7512 involve the administration programmes related to water but there is no physical exchange of water when these services are provided. While monetary supply and use tables are constructed for the outputs of the industries mentioned above, the physical supply and use tables record only the quantity of water exchanged.

2.51. Monetary supply and use tables are constructed for products associated with the industries in Table 2.1 even if they do not involve a physical exchange of water as they give an indication of the effort in terms of costs and investments, for example, to manage water programmes. Products are classified in the SNA according to the Central Product Classification (CPC) Version 1.1 (UN 2002) and they include the following goods and services related to water:

- '*Natural (*distributed[1]*) water*' (**CPC 18000**), and '*Water, except steam and hot water, distribution through mains*' (**CPC 69210**), both products produced by the industry 'Collection, purification and distribution of water' ISIC 41. Note that while distributed water refers to the water that is actually produced by ISIC 41, water, except steam and hot water, distribution through mains refers to the service produced by ISIC 41.
- '*Operation of irrigation systems'*, part of the category of products recorded in **CPC 86110** ('Services incidental to crop production') and produced by ISIC 0140 ('Agricultural and animal husbandry service activities, except veterinary activity');
- '*Administrative housing and community amenity services*' (**CPC 91123**), which corresponds to public administrative services for housing and overall community development, water supply, sanitation and street lighting; services provided by offices, bureaux, departments and programme units involved in developing and administering regulations concerning water supply; public administrative services related to refuse collection and disposal, sewage system operation and street cleaning and pollution standards, dissemination of information on pollution. These services are produced by ISIC 7512.
- '*Sewage treatment services*' (**CPC 9411**) and '*tank emptying and cleaning services*' (**CPC 9412**) produced, among other services, by the 'Sewage and refuse disposal, sanitation and similar activities' industry (ISIC 9000).

2.52. The relationship between an activity and a product classification is exemplified by that between the ISIC and Central Product Classification (CPC) of the United Nations. Each type of good or service distinguished in the CPC is defined in such a way that it is normally produced by only one activity as defined in ISIC. Conversely, each activity of the ISIC is defined in such a way that it normally produces only one type of product as defined in the CPC. Note that a one-to-one correspondence between the two classifications is not always possible: the output of an industry, no matter how narrowly defined, will tend to include more than a single product (based on para. 5.44, 1993 SNA).

3. Principal identities of the SNA accounting framework

2.53. The conventional accounts consist of an integrated sequence of accounts which describe the behaviour of the economy from the production of goods and services – generation of income – to how this income is made available to various units in the economy and how it is used by these units. The

[1]Note that due to the ambiguity of the terminology, 'Natural water', as defined in the CPC classification is referred to in the rest of the document as 'distributed water' in order to avoid confusion with water in nature.

SNA has identities within each account and between accounts that ensure the consistency and the integration of the system.

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

Total Supply = Output + Imports.

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

Total Use = Intermediate Consumption + Final Consumption +

+ Gross Capital Formation + Exports.

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

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

Gross Value Added = Output – Intermediate Consumption

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

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

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

2.58. Another identity of the SNA particularly useful in the SEEA involves assets. This identity describes the stocks of some assets at the beginning and end of an accounting period and its changes. Changes are the results of transactions in the item in question (gross capital formation), consumption of fixed capital, changes in the volume of the asset that are not due to transactions (e.g. changes in classification, discoveries, etc.), changes in their prices (holding gains/losses on assets), and other changes due neither to transactions or changes in prices:

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

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

4. Accounting framework

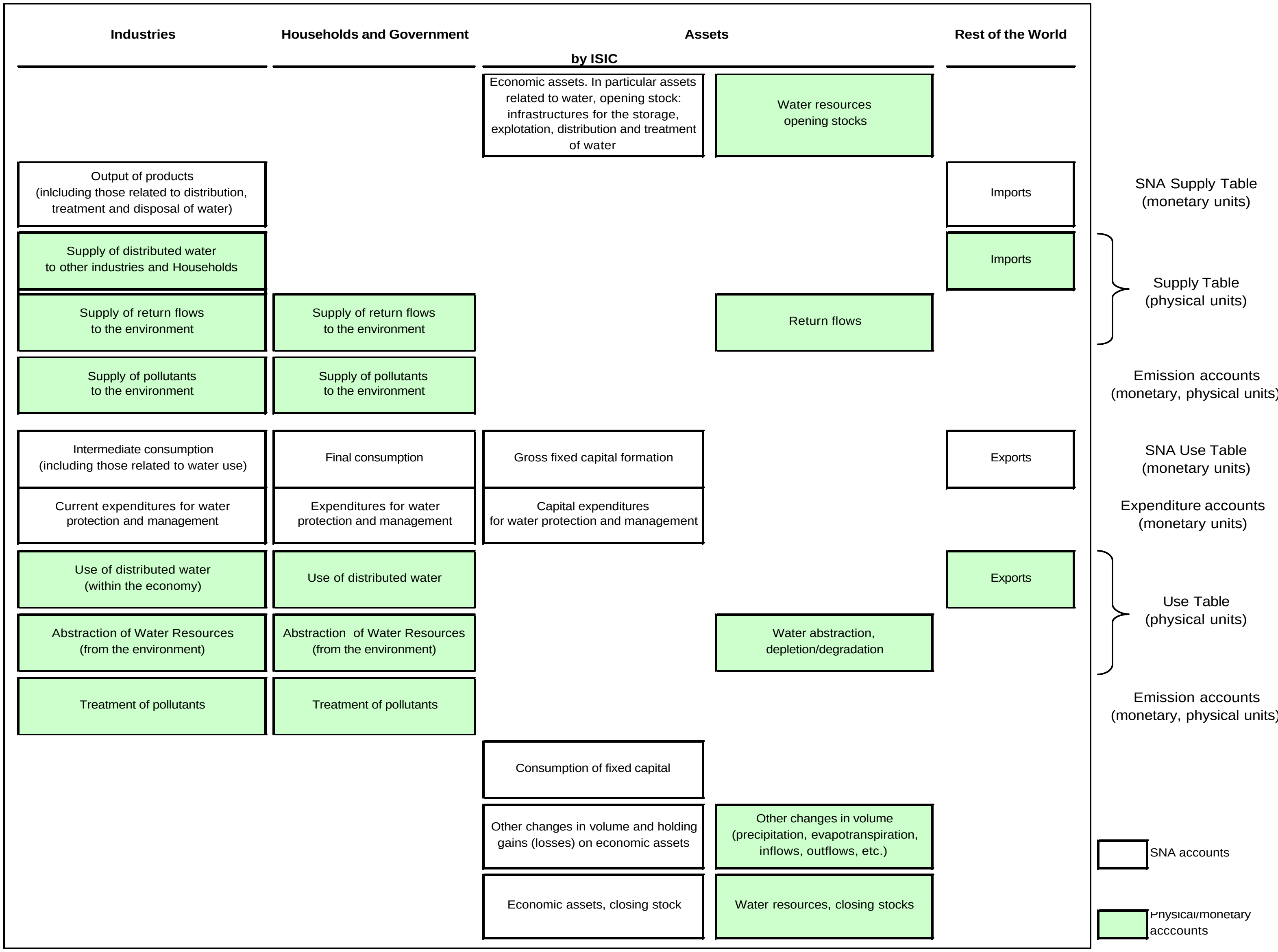
2.59. Figure 2.4 gives a simplified representation of the SEEA accounting framework for water resources and links supply and use tables with the asset accounts. The unshaded boxes represent monetary accounts that are already part, explicitly or implicitly, of the SNA. The grey boxes represent accounts that are introduced in the SEEA and are not covered in the SNA and are measured in physical and monetary units. The various types of accounts are described next.

2.60. Figure 2.4: Framework for Integrated Environmental Economic Accounts for Water Resources shows the SUT's of the SNA with unshaded boxes. While the supply table in monetary terms remains unchanged in the SEEA framework, the use table of the SEEA contains a more detailed breakdown of the costs for water use, which is not usually explicitly available in the SNA. Monetary Supply and Use tables for water are presented in chapter 7.

2.61. Figure 2.4: Framework for Integrated Environmental Economic Accounts for Water Resources does not show separately the water asset covered by the SNA for two reasons: one is that those assets represent a minimal part of all water assets; second, that the valuation of those assets, even if theoretically possible, remains in practise a difficult exercise and it is often embedded in the value of land.

2.62. The framework in Figure 2.4: Framework for Integrated Environmental Economic Accounts for Water Resources can also be presented in a matrix form, which is referred to as National Accounting Matrix including Water Accounts (NAMWA). NAMWA and more in general National Accounting Matrix including Environmental Accounts (NAMEA) have been developed by Statistics Netherlands (CBS). NAMWA, however, should not be seen as an alternative framework rather as an alternative presentation of the information.

Figure 2.4: Framework for Integrated Environmental Economic Accounts for Water Resources



E. Spatial and temporal issues in water accounting

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

Spatial dimension

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

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

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

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

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

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

2.70. For water management, the river basin is the recommended unit which should be used to compile the accounts. However, economic accounts are not constructed at river basin level. The economic information collected at the river basin level is generally on fees and taxes collected for the distribution and treatment of water rather than information on the output or value added of the industries located within the boundary of the river basin. While the compilation of physical water accounts at river basin is feasible, compilation of economic accounts is usually not done at river basin. Some countries have experimented in developing accounts at river basin level from the regional (administrative) economic accounts. These techniques are discussed further in the rest of the handbook.

Temporal dimension

2.71. The collection of hydrological and economic data refers usually to different periods of time: the reference year for hydrological data is the hydrological year which is a 12-month period selected in such a way that overall changes in storage are minimal (and carryover is reduced to minimum[2]); economic accounting data, on the other side, refers usually to the accounting year. It is important that, when compiling the accounts, also the temporal reference remains the same for hydrological and economic data. This often entails adjustments to the data to ensure that the information refers to the same time period.

2.72. The second issue is how to design the accounts to reflect long hydrological cycles. There seems to be two ways of including this temporal dimension in the accounts. One is to compile the accounts at the frequency that would reflect dry and wet years. However, the comparison of the indicators derived from these accounts has to be carefully evaluated. The other way is to compile budgetary asset accounts in conjunction with water use accounts (J. Margat, 1996). The budgetary asset accounts refer to an average year of a long enough series of years to be stable and provide information on the water availability in the environment. These accounts could be also supplemented by accounts for a particular year, e.g. the dry year, which would describe the worse condition of the natural water system. Water use accounts describe water use by the economy in a particular year. Combining in budgetary accounts hydrological information on annual averages with economic information on water use for a specific year can be justified with the fact that while the variability of water resources is pseudo-cyclical and their average is relatively stable in the long term and in a given climatic situation (and it is often the reference for the assessment of water resources), water use tends to change over the years (due, for example, to increasing population and changes in the structure of the economy). Therefore the combination of these two types of information would allow for the analysis of the natural water supply in relation to the evolution of human water demand.

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

2.73. The frequency of the compilation of the accounts depends on the availability of data and the type of analysis. Annual accounts provide detail information on water resources and their use and allow for a detailed time series analysis. However, there may be cases that 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 some water uses, such as agriculture depend heavily on the climatic variations and an increase in water use may lead to assume a structural increase in water use rather when it may just be a short term increase. An alternative could be the compilation of accounts on water use every three or five years. This would allow for a sufficiently complete analysis of the trend of water use (J. Margat, 1996).

Glossary

Capital formation

Consumption of fixed capital represents 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.

Final consumption consists of goods and services used by individual households or the community to satisfy their individual or collective needs or wants. SNA para. 6.49

Hydrological cycle: Succession of stages through which water passes from the atmosphere to the earth and returns to the atmosphere: evaporation from the land or sea or inland water, condensation to form clouds, precipitation, accumulation in the soil or in bodies of water, and re-evaporation. (Unesco/WMO International Glossary of Hydrology, 2nd ed. 1992).

Hydrological year: Continuous 12-month period selected in such a way that overall changes in storage are minimal so that carryover is reduced to a minimum. (Unesco/WMO International Glossary of Hydrology, 2nd ed. 1992)

Intermediate Consumption consists of the value of the goods and services consumed as inputs by a process of production, excluding fixed assets whose consumption is recorded as consumption of fixed capital. SNA para. 6.147

Principal activity: The principal activity of a producer unit is the activity whose value added exceeds that of any other activity carried out within the same unit (the output of the principal activity must consist of goods or services that are capable of being delivered to other units even though they may be used for own consumption or own capital formation). (1993 SNA para.5.7)

Gross value added is the value of output less the value of intermediate consumption; it is a measure of the contribution to GDP made by an individual producer, industry or sector

REFERENCES

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

Margat Jean (1996). *Les ressources en eau*. Ed. BRGM et FAO

Unesco and WMO (1992). *International Glossary of Hydrology*, 2nd Edition.

United Nations, Commission of the European Communities, International Monetary Fund, Organisation for Economic Co-operation and Development, and World Bank (2003). *Handbook of National Accounting on Integrated Environmental and Economic Accounting 2003*. Sales No.. New York.

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

United Nations (2002). *Central Product Classification (CPC) Version 1.1.* Series M, No. 77, Ver.1.1. Sales number: E.03.XVII.3. New York. Available on internet at http://unstats.un.org/unsd/cr/registry/regcst.asp?Cl=16

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

UNESCO (1989) Comparative Hydrology: an Ecological Approach to land and water resources.

Chapter 3 Physical water supply and use tables [NEW VERSION]

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 the quantity of water from its abstraction from the environment by the economy, its use and supply within the economy and its discharge back into the environment.

3.2. The compilation of these tables allows for the assessment and monitoring of the pressure on water quantities exerted by the economy, for the identification of the economic agents responsible for abstraction and discharges of water into the environment, and for the evaluation of alternative options for reducing water pressure. This information is often used together with information on value added and number of employees to measure the water use intensity and productivity.

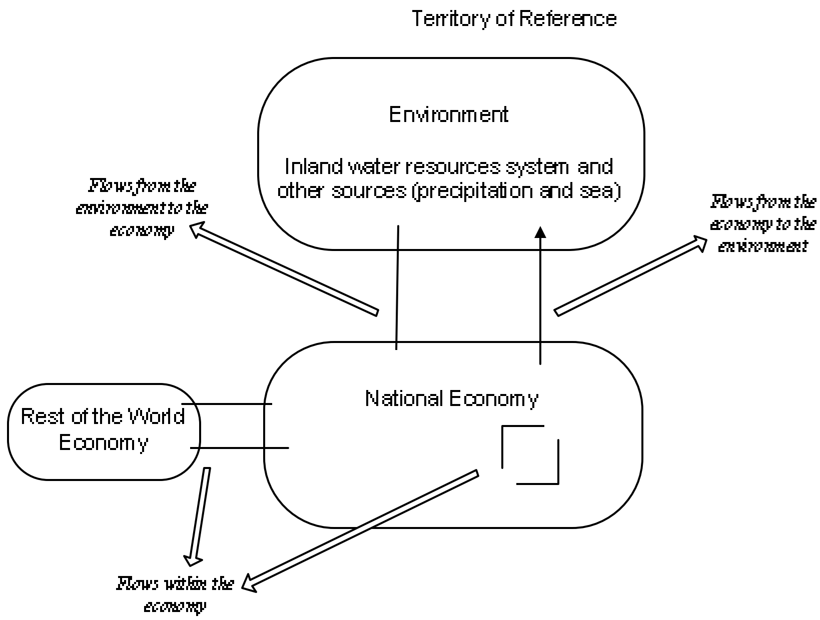
3.3. Section B of this chapter introduces the distinction between flows from the environment to the economy (i.e. abstraction), flows within the economy (i.e. supply and use of water between two economic units) and from the economy back into the environment (i.e. returns). This distinction is used to build physical water supply and use tables and to show the basic accounting rules in section C. Examples of the compilation of physical water supply and use tables are presented in section D. Section E presents some indicators that can be derived from the accounts together with examples of countries which have computed these indicators. Finally, section F presents data sources and methods needed for the compilation of physical supply and use tables.

B. Type of flows

3.4. When constructing a supply and use table for water resources, the SEEA implicitly takes the perspective of the economy and looking at the water exchange with the environment and within the economy. In particular, to facilitate the description of the interaction between the environment and the economy, the SEEA introduces the distinction between flows from the environment to the economy, within the economy and from the economy to the environment. presents a scheme on these flows. Flows between the environment and the economy are distinguished depending on the direction of the flow: flows from the environment to the economy involve the abstraction of water as input into production and consumption activities while flows from the economy to the environment involve the disposal of "used" water. These flows are recorded separately as their impacts on water resources in the environment are quite different.

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

Figure 3.1: Flows in the physical supply and use tables



1. Flows from the environment to the economy

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

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

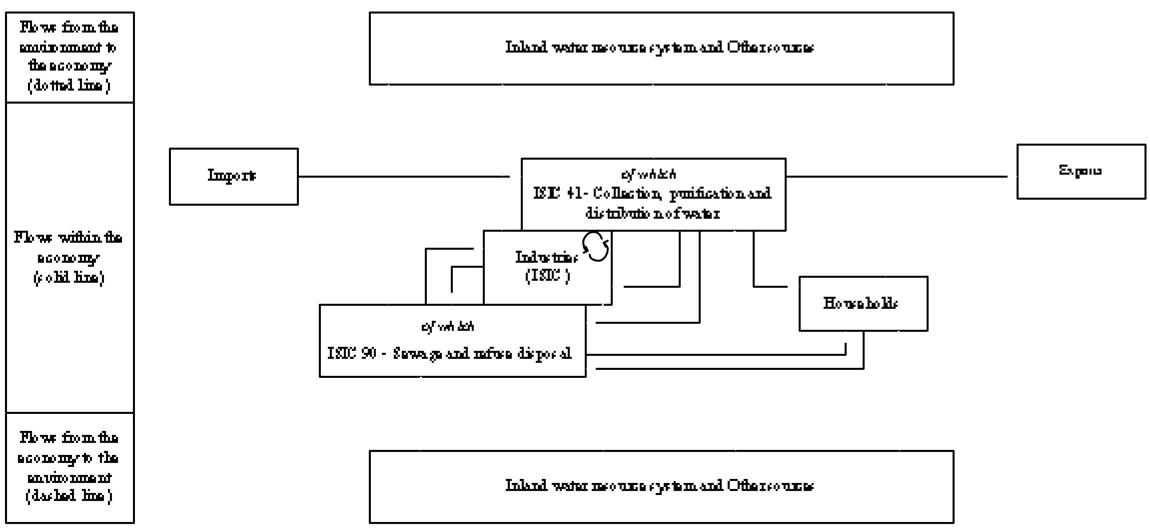
3.8. Typically water abstracted by the industry ISIC 41 — Collection, purification and distribution of water — is for distribution to industries, households and the rest of the world. Other industries can also directly abstract water from the environment and it is usually for their own internal use. These industries carry out the same activities of abstraction as the industry ISIC 41, but, as abstracted water is used by the same economic agent, no transaction is recorded in the SNA framework. (This type of activity is called an "ancillary" activity in the SNA framework.) The same applies to households who abstract water from the environment for their own final use. There are also cases in which industries other than ISIC 41 abstract and supply small amount of water. In Australia (ABS 2004), for example, the mining industry supplies (small amount of) water to other industries.

2. Flows within the economy

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

3.10. presents a more detailed description of exchanges of water within the economy represented by a solid line. Within the economy each economic unit (industry, households and rest of the world) receives (use) water generally from ISIC 41. Once water is used, it leaves (supply) the economic unit and becomes wastewater. Part of this water can be sent to a treatment plant before being discharged into the environment, another part can be sent for further use to another industry (reuse of water) and another part can be discharged directly to the environment. The supply and use table of water within the economy record only the first two flows and the part discharged into the environment is recorded as a flow from the economy to the environment.

Figure 3.2: Detailed description of physical flows within the economy



3.11. The supply table describing the flows within the economy shows the origin of these flows which includes industries, households or the rest of the world (water can be supplied by either of them). Although most of the water is generally supplied by ISIC 41, it can also be supplied by other industries and households. This includes the cases, for example, when water is supplied for further use or supplied to treatment facilities before being discharged into the environment. The physical supply of water by households involves flows of wastewater to the sewage industry (ISIC 90).

3.12. The collection of wastewater by the industry "Sewage and refuse disposal, sanitation and similar activities", ISIC 90, is recorded as use of wastewater by ISIC 90 and a supply of wastewater by the industry or households generating the wastewater. The corresponding monetary transaction is recorded instead in the opposite way: ISIC 90 supplies the service of wastewater collection and treatment which is used by the economic units who physically generate wastewater.

3.13. During distribution of water (between a point of abstraction and a point of use or between points of use and reuse of water) there may be losses[3] of water. These losses may be caused by a number of factors: evaporation when, for example, water is distributed through open channels; leakages when, for example, water leaks into the ground through pipes; illegal tapping when users illegally divert water from the distribution network; malfunctioning meters, etc. In order to match the physical supply and use of water within the economy, the supply of water within the economy is recorded net of these losses. However, it is important to record these quantities as they give an indication of the status and efficiency of the distribution network and they can often be significant in magnitude (up to 65% of the supply). Note that while the losses in distribution due to leakages are recorded as a flow from the economy to the environment, those due to other factors (in which water does not return to water resource immediately) are considered as part of water consumption (see section C.1 for further details).

3.14. The use table describing the flows within the economy shows the destination of these flows: water can be used by industries to produce other goods and services (intermediate consumption); by households for their own use (final consumption); and finally by the rest of the world (exports). Other economic uses, i.e. gross fixed capital formation or change in inventories, will be neglected for water since water is not a capital good and possible changes in inventories, due for example to construction of new water towers, are in most of the cases negligible when compared to the other uses.

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

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

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

3.18. Returns are classified according to the receiving media: water resources which include (as specified in the asset classification in chapter 6) surface-, ground- and soil water, and other sources which consist of seas or oceans.

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

3.19. Discharges of water by the rest of the world would be those locally generated by non-resident unit. However, these would be insignificant in size as, even in the case of tourists, they would generally use resident units for the discharge of water in the environment (examples include hotels, restaurants, etc.).

C. Physical supply and use tables

3.20. Physical supply and use tables for water describe the three types of flows: (a) from the environment to the economy, (b) within the economy, and (c) from the economy to the environment. In particular, the use table is obtained by merging information on water use: the total water intake of an economic unit is the result of direct water abstraction (flow from the environment to the economy) and water received from other economic units (flow within the economy). Similarly, the supply table is obtained by merging information on the two types of water flows leaving an economic unit: one destined to other economic units and the other destined to the environment - return flow. Table 3.1 shows a simplified physical supply and use tables for water.

Table 3.1: Simplified physical supply and use tables for water

(cubic metres)

Use table

		ISIC							Households	Rest of the world	Total
		ISIC 01	ISIC 02	…	ISIC 41	…	ISIC 90	…			
From the environment	U1 - Total Abstraction (= *b.1+b.2* = a.1+a.2): *b.1- Abstraction for own use* *b.2- Abstraction for distribution* a.1- From Water resources: Surface water Groundwater Soil water a.2- From Other sources Collection of precipitation Abstraction from the sea										
Within the economy	U2 - Use of water received from other economic units										
U=U1+U2 - **Total use of water**											
	Supply table										
		ISIC							Households	Rest of the world	Total
		ISIC 01	ISIC 02	…	ISIC 41	…	ISIC 90	…			
Within the economy	S1 - Supply of water to other economic units *of which*: Reused water										
To the environment	S2 - Total returns (= d.1+d.2) d.1- To Water resources Surface water Groundwater Soil water d.2- To Other sources (e.g. Sea water)										
S - **Total supply of water** (= S1+S2)											
Consumption (U - S)											

Number of persons with sustainable access to an improved water source	Urban	
	Rural	
	Total	
Number of persons with access to improved	Urban	

sanitation	Rural
	Total
Total number of persons	

Grey cells denote entries which are not possible.

3.21. Abstraction and return flows are disaggregated according to the source of water and the receiving media respectively. These breakdowns relate to the asset classification of water resources (which are presented in chapter 6 on asset accounts). In particular, abstraction from water resources is further disaggregated in abstraction from surface-, ground- and soil water as specified in the asset classification. The other sources of water, even though not part of the asset classification, are explicitly recorded in the supply and use tables as they can represent a major source of water for the economy. These include abstraction from the sea (for example, for desalination or cooling purposes) and direct collection of precipitation (in the case, for example, of roof rain harvest).

3.22. The disaggregation of return flows also relates to the asset classification. In particular, returns to water resources is further disaggregated into surface-, ground- and soil water as in the asset classification. Returns to other sources of water include the cases when water is discharged into the sea.

3.23. Table 3.1 is supplemented with information on the number of persons with sustainable access to an improved water source and with access to improved sanitation. This information is particularly important for the management of water resources and for poverty reduction: it used to monitor progress towards Target 10 of the Millennium Development goal to “halve, by 2015, the proportion of people without sustainable access to safe drinking water and sanitation”. The definition of “improved" water supply (WHO and UNICEF, 2000) includes household connection, public standpipe, borehole, protected dug well, protected spring, rainwater collection. "Not improved" are: unprotected well, unprotected spring, vendor-provided water, bottled water (based on concerns about the quantity of supplied water, not concerns over the water quality), tanker truck-provided water. "Improved" sanitation technologies are: connection to a public sewer, connection to septic system, pour-flush latrine, simple pit latrine, ventilated improved pit latrine. The excreta disposal system is considered adequate if it is private or shared (but not public) and if hygienically separates human excreta from human contact. "Not improved" are: service or bucket latrines (where excreta are manually removed), public latrines, latrines with an open pit.

3.24. Presenting all water-related information, including social information, in a common framework has the advantage of allowing for consistent analyses and scenario modelling. For example, an analysis of the impact of investing in water infrastructure on the number of people having access to improved water sources could be easily undertaken if the information is organized according to the accounting framework.

3.25. The information provided in the physical water supply and use tables can be supplemented by detailed information on the origin and destination of water flows within the economy by identifying who is supplying water to whom in order to have a complete picture of the water flows. Table 3.2 presents a matrix of transfers within the economy. Each entry represents the origin (by row) and the destination (by column) of water exchanges. For example, the intersection of row “ISIC 90” with column “ISIC 50 - Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel” represents the amount of water that is supplied by ISIC 90 to ISIC 50 in the case, for example, of car washing activities using treated wastewater.

Table 3.2: Matrix of transfers of water within the economy (in m^3)

User ⇨ / Supplier ⇩		Industries: ISIC 01	…	ISIC 41	…	ISIC 90	…	Households	Rest of the world	Total
Industries	ISIC 01									
	…									
	ISIC 41									
	…									
	ISIC 90									
	…									
Households										
Rest of the world										
Total										

3.26. Table 3.1 shows a simplified physical supply and use table which contains very aggregate flows. In practice, when compiling these accounts, a detailed breakdown both on the industry side as well as on the type of water is necessary. The level of detail used in the compilation of these tables depends on the country's priorities and data availability. Table 3.3 presents a numerical example of a more detailed physical SUT.

Table 3.3: Detailed physical water supply and use tables

(Millions m^3)

Use table

		ISIC: ISIC 01	ISIC 2-37, 45	ISIC 40	ISIC 41	ISIC 50-74	ISIC 75-85, 91-99	ISIC 90	Households	Rest of the world	Total
From the environment	**U1 - Total Abstraction** (= *b.1+b.2* = a.1+a.2)	**108.4**	**114.6**	**4 210.8**	**427.6**	**0.3**	**2.0**	**0.1**	**10.8**		**4 874.5**
	b.1 - Abstraction for own use	*108.4*	*114.6*	*4 210.8*	*23.0*	*0.3*	*2.0*	*0.1*	*10.8*		*4 469.9*
	Hydroelectric power generation										
	Mine water										
	Urban runoff										
	Other	*108.4*	*114.6*	*4 210.8*	*23.0*	*0.3*	*2.0*	*0.1*	*10.8*		*4 469.9*
	b.2 - Abstraction for distribution				*404.6*						*404.6*
	a.1 - From Water resources:	108.4	114.6	4 210.8	427.6	0.3	2.0	0.1	10.8		4 874.5
	Surface water	3.1	9.7	1.0	4.5	-	-	0.1	-		18.4
	Groundwater	105.3	104.8	3.2	423.1	0.3	2.0	0.0	10.8		649.5
	Soil water										
	a.2 - From Other sources			4 206.6							4 206.6
	Collection of precipitation										
	Abstraction from the sea			4 206.6							4 206.6
Within the economy	**U2 - Use of water received from other economic**	**38.7**	**45.0**	**3.9**	**-**	**24.0**	**27.1**	**427.1**	**239.5**		**805.4**
	Supplied by ISIC 41										
	Supplied by others										
U - Total use of water (=U1+U2)		**147.1**	**159.5**	**4 214.7**	**427.6**	**24.3**	**29.2**	**427.2**	**250.3**		**5 679.8**

Supply table

		ISIC: ISIC 01	ISIC 2-37, 45	ISIC 40	ISIC 41	ISIC 50-74	ISIC 75-85, 91-99	ISIC 90	Households	Rest of the world	Total
Within the economy	**S1 - Supply of water to other economic units**	**17.9**	**117.6**	**5.6**	**379.6**	**22.8**	**26.3**		**235.5**		**805.4**
	of which: Desalinated water										
	Reused water										

	Wastewater to sewage										
To the environment	**S2 - Total returns** (= *c.1+c.2+c.3+c.4+c.5* = d.1+d.2)	**65.0**	**29.4**	**4 206.6**	**47.8**	**0.5**	**0.3**	**427.1**	**4.8**		**4 781.5**
	c.1 - *Hydroelectric power generation*										
	c.2 - *Mine water*										
	c.3 - *Urban runoff*										
	c.4 - *Losses in distribution because of leakages*				*25.0*						*25.0*
	c.5 - *Other*	*65.0*	*29.4*	*4 206.6*	*22.9*	*0.5*	*0.3*	*427.1*	*4.8*		*4 756.6*
	d.1 - To Water resources	65.0	29.4		47.8	0.5	0.3	170.9	4.6		318.4
	Surface water		23.5			0.1	0.1	170.9	0.5		195.1
	Groundwater	65.0	5.9		47.8	0.4	0.2		4.1		123.3
	Soil water										
	d.2 - To Other sources (e.g. Sea water)		5.9	4 206.6				256.3	0.2		4 469.0
S - **Total supply of water** (=S1+S2)		**83.0**	**147.0**	**4 212.2**	**427.4**	**23.3**	**26.6**	**427.1**	**240.3**		**5 586.9**
Consumption (U - S)		**64.1**	**12.5**	**2.5**	**0.2**	**1.0**	**2.6**	**0.1**	**10.0**		**93.0**
of which: Losses in distribution not because of leakages											

Number of persons with sustainable access to an improved water source	177 000
Number of persons with access to improved sanitation	594 000
Total number of persons	5 376 000

Possibly to add some figures in the shaded rows

Grey cells denote entries which are not possible.

Detailed description of water flows in the physical supply and use table in Table 3.3

3.27. **Abstraction** represents the amount of water removed from any source either permanently or temporarily in a given period of time for consumption and production activities. Water used for hydroelectricity generation is considered as part of water abstraction. In Table 3.3 water abstraction is disaggregated according to the type of source: water resources – surface water, groundwater and soil water as in the asset classification- and other sources which include sea water and precipitation.

3.28. **Abstraction from soil water** includes the case of water use in rainfed agriculture (which is recorded as an abstraction from soil water). It is important to record this flow for several reasons: it shows, for example, the relative contribution of rainfed and irrigated agriculture for food production. In addition, considering the importance of rainfed agriculture worldwide (more the 60% of all food production in the world is produced under rainfed conditions), this information can be used to assess the efficiency of rainfed agriculture (e.g. crop production per volume of water used) thus setting the basis for water management plans.

3.29. Abstraction from soil water for rainfed agriculture is computed as the amount of precipitation that falls onto agricultural fields. The excess of this water, namely the part that is not used by the crop, is recorded as a return flow to the environment from rainfed agriculture.

3.30. **Abstraction from other sources** includes abstraction of sea water and the direct collection of precipitation for production and consumption activities. Water is generally abstracted from the sea either for cooling purposes - the corresponding wastewater flow is generally returned to the original source of water (i.e. the sea or ocean) – or for desalination processes. In this case, desalinated water could be returned to the inland water resource and constitute a resource. Abstraction from other sources also includes the collection of precipitation for production and consumption activities (except for rainfed agriculture which is considered as an abstraction from soil-water). Typical example is roof rain harvest by households.

3.31. In Table 3.3 water abstraction is also disaggregated according to the type of use. Two general categories are distinguished: abstraction for own use and for distribution. As the term suggests, **abstraction for distribution** refers to water abstracted for the purpose of distributing it. This activity is generally undertaken by ISIC 41 "Collection, purification and distribution of water", but other industries may carry out these activities as a secondary or even ancillary activity. In Australia, for example, the mining industry supplies water to Households as a secondary activity (ABS, 2004)

3.32. **Abstraction for own** use refers to water abstracted for own internal use. However, once water is used, it can be delivered to another user for re-use or for treatment. Note that, in the case of ISIC 41, part of the total abstraction is for own use: for example, cleaning of pipes, filter backwashing, etc. In Table 3.3, for example, ISIC 41 abstracts 23 millions cubic metres of water for own use while the rest, 404.6 millions cubic metres, is abstracted for distribution.

3.33. If data are available, water abstracted for own use should be further disaggregated to explicitly include the following uses:

- Hydroelectric power generation
- Mine water
- Urban runoff

3.34. Water used for **hydroelectric power generation** consists of water used in generating electricity at plants where the turbine generators are driven by falling water. Usually this water is directly abstracted by the power plant and returned immediately 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 hydroelectricity may be in competition with other uses.

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

3.36. **Urban Runoff** is defined as that portion of precipitation on urban areas that does not naturally evaporate or percolate into the ground, but flows via overland flow, underflow, or channels or is piped into a defined surface water channel or a constructed infiltration facility. It is also referred to as *urban stormwater*. Note that here the term 'urban areas' may include also rural residential zones. When urban runoff is collected into the sewage system, it is recorded in the use table as an abstraction from other sources (in particular from precipitation) by ISIC 90 and when is discharged into the environment it is recorded as a return flow in the supply table.

3.37. It is important to record the collection and discharge of urban runoff for two reasons: first, for management purposes, in order to design policies to reduce its negative impacts on the water resources as urban runoff usually contains relatively high concentrations of pollutants (including bacteria and viruses, solid waste, and toxics such as heavy metals and petroleum-based compounds) and contributes many pollutants to receiving waters. Second, for practical reasons, in order to measure consistently the total use and supply of water of ISIC 90: since urban runoff ultimately merges into the return flow from ISIC 90 into the environment, the total return of ISIC 90 in the supply table would include urban runoff in addition to the discharges of wastewater collected from industries and households. Thus not recording the collection of urban runoff in the use table would underestimate the water consumption of ISIC 90.

3.38. Although separate estimates for urban runoff may be available in some countries, these flows generally cannot be measured directly: what can be measured is the difference between the volumes of wastewater discharged by economic units (industries and households) into sewers and the volumes of wastewater leaving the sewers with or without treatment. This difference includes therefore urban runoff but also potential leakage from the sewage network as well as potential infiltration of groundwater into sewers. In the Eurostat water accounts standard tables (see Annex ??), the three flows (rainwater, leakages and infiltration) are recorded together in one specific category of abstraction ‘rainwater and net infiltration in sewage network’ and are allocated to ISIC 90.

3.39. Within the economy the **use of water received from other economic units** refers to the amount of water that is delivered to an industry, households and the rest of the world from another economic unit. This water is usually delivered through mans, but other means of transportation are not excluded (such as artificial open channels, etc.). The use of water within the economy is further disaggregated into two categories depending on the supplier: ISIC 41 or other industries.

3.40. The use of water received by other economic unit by the rest of the world corresponds to the **exports** of water. It is generally ISIC 41 which exports water.

3.41. The **supply of water to other economic units** refers, as the term suggests, to the supply of water from an economic unit to another and is recorded net of losses in distribution. It includes a variety of flows such as the supply of abstracted and purified water (generally by ISIC 41), the supply of water already used for reuse, supply of wastewater to the sewage industry (ISIC 90), etc. If data are available, the supply within the economy should be further disaggregated as follows:

- Desalinated water
- Reused water
- Wastewater to Sewage

3.42. The supply of **desalinated water** refers to the production and distribution of water which has undergone desalination processes. Desalinated water is generally produced by ISIC 41 as a principal product.

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

3.44. Note that reuse of water excludes the recycling of water within an industrial site. Reused water is recorded both as a use and a supply of water within the economy. Obviously, once wastewater is discharged into the environment, its abstraction downstream is not considered as a reuse of water in the accounting tables, but as a new abstraction from the environment.

3.45. **Recycled water** refers to the re-use of water within the same industry or establishment (on site). Even though estimating this quantity would provide information on water use efficiency, data on recycled water are generally not available. Thus recycled water is not recorded in the supply and use table. However, a reduction in the total volume of water used, while maintaining the same level of output, can provide an indication of an increase in water use efficiency which, in turn, may be due to the use of recycled water within an industry.

3.46. The **supply of wastewater to sewage** refers to the supply of wastewater from industries and households to the sewage industry (ISIC 90). It is explicitly identified in the table to distinguish it from other water supplies and, in particular, the supply of 'purified water' (physically it involves different distribution system).

3.47. The supply of water received to other economic unit by the rest of the world corresponds to the **imports** of water.

3.48. Within the economy water can be exchanged between water producers and distributors before being effectively delivered to users. These water exchanges are referred to as **intra-sectoral sales**. These are the cases, for example, when the distribution network of one distributor/producer does not reach the water user and has to exchange water with another distributor in order for the water to be delivered. These sales artificially increase the physical supply and use of water within the economy, but do not influence the global (physical) balance of water with the environment thus they are not recorded in the physical supply and use tables.

3.49. The supply table cover also **returns** to the environment which include direct discharges of water into water resources, which are disaggregated according to the asset classification into surface-, ground- and soil water, and other sources which include oceans and seas. If data are available, returns should be further classified according to the type of water such as:

- Hydroelectric power generation;
- Mine water;
- Urban runoff;
- Losses in distribution because of leakages;
- Others.

3.50. Returns of **urban runoff** can be difficult to estimate when urban runoff is discharged together with wastewater from ISIC 90. However, in the cases when a storm sewer system is in place and urban runoff is discharged separately from wastewater, obtaining relevant data can be relatively straightforward. Note that if urban runoff is explicitly identified as return, the "Other" discharges into the environment by ISIC 90 should not contain urban runoff in order to avoid double counting.

3.51. **Storage of water**. Note that water can be temporarily stored in the economy, e.g. in water towers, in closed cooling or heating circuits, etc. Therefore, when comparing the situation at the beginning and end of the period, some changes in economic inventories may occur. They can be positive or negative but are generally rather small in comparison with the other volumes.

1. Losses in distribution

3.52. During distribution of water between a point of abstraction and a point of use, and between points of use and reuse water is generally lost. Losses in distribution refer to the difference between the amount of water supplied and that water delivered. This difference may be the results of a number of factors including leakages, evaporation and unaccounted water such as illegal tapping, malfunctioning metering, etc. While losses in distribution though evaporation generally occur in the case of distribution through open channels (e.g. agriculture), losses in distribution because of leakages generally occur when water is distributed through pipes.

3.53. Losses in distribution are recorded in the physical supply and use tables as follows:

– The supply and use of water within the economy are recorded net of losses in distribution;

– The part of the losses caused by leakages is recorded as return flow to the environment and the rest of the losses is included in water consumption as they do not directly return to water resources;

– Losses in distribution are allocated to the supplier of water.

3.54. For a more detailed analysis of losses in distribution, it might be useful to construct supplementary tables such as Table 3.4 which shows gross and net supply of water within the economy as well as the losses in distribution. This table allows for the direct calculation of losses in distribution as a proportion of the gross water supply thus giving an indicator of the efficiency of the distribution network.

Table 3.4: Supplementary table of losses in distribution

	ISIC							Households	Rest of the world	Total
	ISIC 01	ISIC 2-37, 45	ISIC 40	ISIC 41	ISIC 50-74	ISIC 75-85, 91-99	ISIC 90			
S1 – (Net) Supply of water to other economic units	17.9	117.6	5.6	379.6	22.8	26.3		235.5		805.4
L - Losses in distribution										
Evaporation										
Leakages										
Illegal tapping										
Gross supply within the economy (= S1 + L)	**83.0**	**147.0**	**4 212.2**	**427.4**	**23.3**	**26.6**	**427.1**	**240.3**		**5 586.9**

3.55. There are cases where illegal tapping – that is the illegal removal of water from the distribution network – is a major factor in expla ining the difference between the supply and delivery of water. It not only affects the efficiency of water distribution network but, at times, it could cause major problems within the network (e.g. cause contaminants to be sucked into water mains via back-siphonage). Specific analyses are required to determine the extent of this phenomenon.

3.56. The way illegal tapping should be recorded in the accounts is currently being discussed. In this handbook, it is recorded as part of water consumption. However, recording this quantity simply as part of consumption would not provide information on the units responsible for illegally connecting to the distribution network and supplementary tables would be necessary to show this information when available.

2. Total water use

3.57. For each industry total water use is the sum of the amount of water directly abstracted (row U1 in Table 3.3) and the amount of water received from other economic units (row U2 in Table 3.3). It might be perceived that there is a double counting of water abstracted for distribution since it is counted first as a use when water is abstracted by the distributing industry and then when water is delivered to the user. However *water abstracted for distribution* is a water use of the distributing industry even though this industry is not the end user of this water.

3. Water consumption

3.58. In general the water intake of an industry is greater that the amount of water discharged. This happens because during use part of the water is incorporated into products, evaporated, transpired by plants or simply consumed by households or livestock. This quantity is referred to as *water consumption* and is computed for each economic unit and for the whole economy as a difference between total water use (row U in Table 3.3) and total water supply (row S in Table 3.3). It is important to compute this quantity as it gives an indication of water use efficiency.

3.59. The concept of water consumption used in hydrology and also in water accounts, is different from the concept of consumption in economy. In water accounts, water consumption is the amount of water that after use does not return in to the environment because it has been incorporated into products, consumed by households or livestock, and has evaporated and transpired by plants. In national accounts, the concept of consumption is equivalent to the concept of use. In this handbook, which tries to keep consistency between the terminology between economic and hydrological concepts, the term water consumption is used in its hydrological sense as opposed to water use which is the total intake of water of the economy.

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

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

Note that since the total water supply equals the total water use within the economy, the identity can be rewritten as:

Total abstraction = Total returns + Water consumption.

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

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

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

3.63. Note that water consumption includes the part of the losses in distribution which are not due to leakages. This includes unaccounted water (such as illegal tapping) and the cases when water is lost because of evaporation.

3.64. The concept of water consumption gives an indication of the amount of water that is lost by the economy during use in the sense that it has entered the economy but it has not returned either to water resources or to the sea. However, if we take the perspective of the inland water resource system, the discharges of water into the sea should also be considered as lost water since this water, once in the sea, is not directly available for further use as it would be in the case, for example, of discharges into a river, where discharged water becomes a resources for downstream uses. The concept of *inland water consumption* is introduced to give an indication of the amount of water that is not returned to the inland water system. Inland water consumption is thus calculated as:

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

3.65. The concept of consumption can also be adapted to specific resources. For example, the 2002 Joint OECD/Eurostat Questionnaire on Inland Waters uses the concept of *freshwater consumption* which takes into consideration water which has been abstracted from fresh water sources and is discharged into non-fresh water sources[4].

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

4. Link with asset accounts

3.66. Supply and use tables are consistent with asset accounts in the sense that the breakdown of water abstraction and returns according to the origin and receiving media reflects the asset classification: the category *water resources* in Table 3.3 includes surface-, ground- and soil- water as described in the asset accounts. Hence figures on abstraction and returns are the same as those that appear in the asset accounts.

D. Country examples

1. The Republic of Moldova

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

3.68. Physical water supply and use tables have been compiled for the years 1994, 1998, 2000 and 2002. Table 3.5 and Table 3.6 present the results for 2002. These tables present an example of breakdown of water returns to the environment

Table 3.5: Physical water supply and use tables, Moldova 2002

Million cubic metres

Use table

		ISIC									Household	Rest of the World	**Total**
		ISIC 01 Agriculture	ISIC 05 Fisheries	ISIC 40 Energy	ISIC 10-14 Mining	ISIC 15-37,45 Manufacturing & Construction	ISIC 014 Distribution/ irrigation water	SIC 41 Distribution/ municipal water	ISIC 90 Sewage and refuse disposal.	ISIC 75 (??) Government			
From the environment	**U1 Total abstraction**	**31**	**8**	**558**	**5**	**20**	**64**	**200**	**0**	**5**	**30**	**0**	**921**
	Abstraction for own use												
	Abstraction for distribution												
	a1 - from Water resources												
	Surface water:	6	8	556	0	11	64	108	0	0	0	0	752
	of which: Reservoirs/dams	4	0	540		1	9						554
	Lakes		1										1
	Rivers	1	7	16		10	55	108					197
	Groundwater	26	0	2	5	9	0	92		5	30		168
	a2 - from other sources												0
Within the economy	**U2 Water received by other economic units**	**46**	**0**	**7**	**0**	**12**	**0**	**3**	**143**	**15**	**132**	**0**	**358**
	Wastewater								143				143
U - **Total use** (= U1 + U2)		**77**	**8**	**565**	**5**	**32**	**64**	**203**	**143**	**20**	**162**	**0**	**1 279**

Supply table

		ISIC 01 Agriculture	ISIC 05 Fisheries	ISIC 40 Energy	ISIC 10-14 Mining	ISIC 15-37,45 Manufacturing & Construction	ISIC 014 Distribution/ irrigation water	SIC 41 Distribution/ municipal water	ISIC 90 Sewage and refuse disposal.	ISIC 75 (??) Government	Household	Rest of the World	**Total**
Within the economy	**S1 Supply of water to other economic units**	**21**	**0**	**2**	**0**	**16**	**45**	**145**	**1**	**17**	**111**	**0**	**358**
	of which: Reused water			0		3							
	Wastewater to Sewage	1		2		13			0	16	111		143
From the economy	**S2 Total returns**	**30**	**6**	**557**	**5**	**16**	**19**	**58**	**143**	**3**	**50**	**0**	**888**
	Hydroelectric power generation												0
	Irrigation water (infiltration)	15											15
	Treated wastewater	2		3		4			160	1			170
	Untreated wastewater	9	6		5	4	24		1	1	26		76
	Cooling water			533									533
	Water losses during transport	2		0	0	1	13	**52**		0			69

Other	2		21	0	7	-18	6	-18	1	**24**		25
S - **Total supply** (= S1 + S2)	**51**	**6**	**559**	**5**	**32**	**64**	**203**	**143**	**20**	**161**	**0**	**1 243**
Consumption (U – S)	**26**	**2**	**5**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**33**
Evaporation	26	2	5	0								33

Source:

3.69. Table 3.6 presents the matrix of transfers within the economy.

Table 3.6: Matrix of transfers within the economy, Moldova 2002 (to be revised)

Millions cubic metres

	ISIC 01 Agriculture	ISIC 05 Fisheries	ISIC 40 Energy	ISIC 10-14 Mining	ISIC 15-37,45 Manufacturing & Construction	ISIC 014 Distribution/ irrigation water	SIC 41 Distribution/ municipal water	ISIC 90 Sewage and refuse disposal.	ISIC 75 (??) Government	Household	Rest of the World	**S2 Total water supplied**
ISIC 01 - Agriculture					0		0	1	0	20		**21**
ISIC 05 - Fisheries												**0**
ISIC 40 – Energy	0				0			2	0			**2**
ISIC 10-14 - Mining								0				**0**
ISIC 15-37,45 - Manufacturing & Construction	0		0				3	13				**16**
ISIC 014 - Distribution/ irrigation water	45											**45**
SIC 41 - Distribution/ municipal water	1		6	0	12				15	111		**145**
ISIC 90 – Sewage and refuse disposal.					1							**1**
ISIC 75 (??) - Government	0				0			16		0		**17**
Household								111				**111**
Rest of the World												**0**
U2 Total water received (use)	**46**	**0**	**7**	**0**	**12**	**0**	**3**	**143**	**15**	**132**	**0**	**358**

Source:

2. *Germany*

3.70. In the German environmental accounts (UGR[5]), water is a major element. Table 3.7 presents the physical supply and use table of Germany for the year 2001. This table is adapted to conform to the standard tables presented in this chapter. The original physical supply and use tables for Germany presents few differences:

- The flow of wastewater from economic units to ISIC 90 is recorded in the German SUT's in two stages: first as a flow from the economic unit to the environment representing the generation of wastewater; second as a flow from the environment to the economy representing the collection of wastewater for treatment by ISIC 90. In the SEEAW tables this flow is recorded only as a flow within the economy, in particular as a flow of wastewater from the economic unit generating it to ISIC 90.

In the German environmental accounts, returns of water into the environment are presented gross and net. While gross returns represent the amount of wastewater that is generated, net residuals are direct discharges of wastewater into the environment. The collection of wastewater by ISIC 90 is recorded in Table 3.7 as use of a return flow (in the table 4 792 millions cubic metres of wastewater are used by ISIC 90).

[5] Umweltökonomischen Gesamtrechnungen.

- In the German SUT's, abstraction from other sources (in particular the collection of rain water for production and consumption activities excluding rainfed agriculture) is recorded as a use of ecosystem inputs.
- The row describing consumption is recorded as a "Balance" row between the use and supply of water in the German SUT's. The negative figure for households' consumption is explained by the significant use by households of water incorporated into beverages and food. Thus households discharge more water than the amount directly abstracted or received though mains.

Table 3.7: Physical supply and use table, Germany, 1995 (to be revised)

millions m^3

Use table

		ISIC						Households	Rest of the world	Total
		ISIC 01 Agriculture	ISIC 41 Electricity, gas, steam and hot water supply	ISIC 41 Water supply	ISIC 90 Waste water disposal	Others	Total			
From the environment	U1 - Total Abstraction (= b.1+b.2 = a.1+a.2):	309	26 144	6 137	5 235	6048	43 873	26		43 899
	a.1 - From Water resources:	309	26 144	6 137	0	6 048.49	38 638.49	26		38 664
	Surface water									
	Groundwater									
	Soil water									
	a.2 - From Other sources									
	Collection of precipitation				5 235		5 235			5 235
	Abstraction from the sea									
Within the economy	U2 - Use of water received from other economic units	158	410	0	4 778	1 691	7 037	3 198	7	10 243
	Supplied by ISIC 41	158	410	0	9	1 691	2 268	3 198	7	5 474
	Supplied by others				4 769		4 769			4 769
U=U1+U2 - **Total use of water**		467	26 554	6 137	10 013	7 740	50 911	3 224	7	54 142

Supply table

		ISIC						Households	Rest of the world	Total
		ISIC 01 Agriculture	ISIC 41 Electricity, gas, steam and hot water supply	ISIC 41 Water supply	ISIC 90 Waste water disposal	Others	Total			
Within the economy	S1 - Supply of water to other economic units	30	92	5 607	0	1 419	7 148	3 095	0	4 769
	of which: Reused water	0	0	0	0	0	0	0		0
	Wastewater to Sewage	30	92	133	0	1 419	1 674	3 095		4 769
From the economy	S2 - Total returns (= c.1+c.2+c.3+c.4+c.5 = d.1+d.2)	163	26 461	530	10 012	6 282	43 448	279		43 727
	Waste water discharged	0	25 628	0	4 792	5 696	36 116	180		36 296
	Cooling water	0	25 628	0	0	2 940	28 568	0		28 568
	Other waste water	0	0	0	4 792	2 756	7 548	180		7 728
	Water vaporised	163	833	0	1	586	1 583	99		1 682
	Water losses	0	0	530	0	0	530			530
	Infiltration and rain water	0			5 219	0	5 219			5 219
S=S1+S2 - **Total supply of water**		193	26 553	6 137	10 012	7 701	50 596	3 374		48 496
Consumption (U - S)		274	1	0	1	39	315	-150	7	172

Source: Based on "Water flow accounts as part of material and energy flow accounts in Germany", Statistisches Bundesamt 2000.

E. Physical supply and use table at river basin level

3.71. The river basin is the recommended spatial unit for integrated water management in order to fully understand and measure the impact of human activities on the waters in the basin and guarantee that measures in respect of surface water and groundwaters belonging to the same ecological, hydrological and hydrogeological system are coordinated (WFD, Johannesburg plan of Action, etc.). Physical supply and use tables can also be compiled at river basin level

3.72. When basic data are collected for administrative regions, one of the main difficulties in the compilation of physical supply and use table at river basin level is the disaggregation of data by river basins regions. Usually this disaggregation makes use of a Geographical Information Systems (GIS). An increasing number of countries have already started the compilation of physical supply and use tables at river basin level (South Africa, Sweden, the Netherlands and Australia). The examples of Sweden and the Netherlands show two criteria for the allocation of information on supply and use at the administrative level to different river basins: in Sweden the number of people leaving in urban areas was used to disaggregate data for municipalities crossing more than one river basin, while in the Netherlands the number of employees was used. ABS investigated a method of re-constructing water use at river basin level from small area estimation. The criterion for allocating water use to different river basin regions for those small areas which overlap with several river basins is based on the proportion of overlap.

3.73. A problem that may arise in the compilation of river basin accounts arise when there are few industries in the river basin and the presentation of the accounts would present confidentiality issues.

1. Sweden

3.74. Statistics Sweden has compiled water accounts (physical supply and use tables and expenditures accounts) for river basins for the year 2000. A project (Statistics Sweden, 2003) was carried out to test methods for disaggregating national water accounts to water districts. The accounts have been compiled for the eight river basins – connected to major sea basins - for which information is usually presented on water issues in Sweden. These river basins cover the whole national territory. Thereafter, in autumn 2004, data have been revised according to the five Water districts in Sweden.

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

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

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

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

3.77. Table 3.8 presents data on freshwater abstraction by river basin.

Table 3.8: Abstraction of fresh water in 2000 by sea basin, 1000 m^3

	Public waterworks	Abstraction for own use			
		Agriculture	Industry	Households	
Sea basin	ISIC 41	ISIC 01	ISIC 10-40		**Total**
Bothnian Bay	39 566	1 446	212 490	3 097	**256 599**
Bothnian Sea	125 698	7 076	635 327	15 882	**783 983**
Baltic proper,north	377 680	28 452	196 623	23 315	**626 070**
Baltic proper, middle	32 880	16 463	27 632	6 747	**83 722**
Baltic proper, south	52 755	29 622	72 063	7 004	**161 444**
The Sound	28 978	9 831	3 209	2 438	**44 456**
Kattegat	272 446	40 734	345 985	25 619	**684 784**
Skagerrak	11 675	1 280	8 065	5 269	**26 289**
Total	**941 676**	**134 906**	**1 501 393**	**89 385**	**2 667 360**

Source: Water accounts 2000- with disaggregation to sea basins. (2003) Statistics Sweden ISBN 91-618-1139-9

2. The Netherlands

3.78. In the Netherlands, regional accounts are composed at the level of 40 regional economic units distinguished by Statistics Netherlands (COROP). These COROP areas are larger than the approximately 500 local authorities (municipalities) and smaller than the 12 provinces.

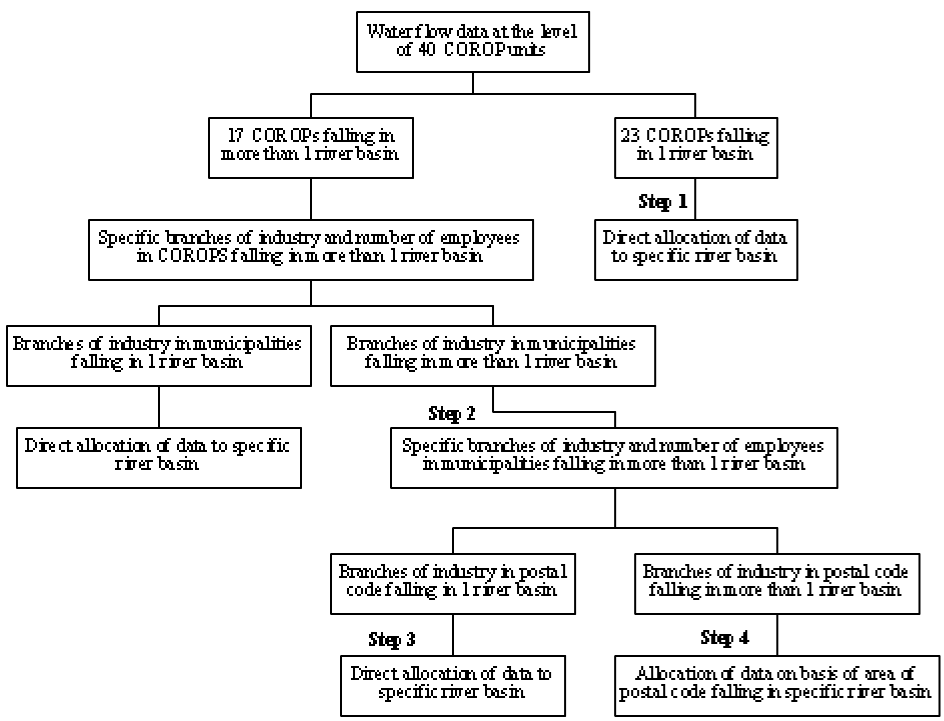
3.79. Regional water flow data in the Netherlands are collected with the National Water Survey, conducted by Statistics Netherlands once every five years. The most recent surveys were in 1996 and 2001. This survey comprises business level data on water use by industry, mining and electricity companies. Data are collected on the use of three types of water: groundwater, surface water and tap water. For groundwater a distinction is made between fresh and brackish groundwater and for surface water between fresh and salt water. Water use is further broken down into water use for cooling water purposes and other purposes. Total freshwater use equals the use of drinking water, fresh groundwater and fresh surface water net of freshwater used for cooling purposes, as cooling water is only extracted temporarily and recycled again into the surface water. Additional information about water use in agriculture is supplied by the Agricultural-Economic Institute (LEI). The regional water flows add up to the total of the national water flow.

3.80. The regional water flow data at the level of the 40 COROPs are disaggregated to the seven river basins in a number of steps (Figure 3.1). In a first step, data for COROPs which are situated entirely in one river basin are allocated directly to this river basin. This is the case for 23 of the 40 COROPs in total. For the remaining 17 COROPs, data are allocated in subsequent steps on the basis of the distribution of employees in the specific branches of industry. The regional water flow data are allocated to two or more river basins with the help of the estimated percentage of employees working in a specific river basin. These percentages are estimated by identifying:

- the specific branches of industry in the remaining 17 COROPs;
- the total number of employees working in these branches of industry;
- the municipalities in which the business units in these branches of industry are located**;**
- which municipalities in which these business units are located fall entirely in one specific river basin, and which municipalities overlap with other river basins.

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

Figure 3.3: Allocation of water flow data over river basins



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

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

3.84. Confidentiality is an important issue when disaggregating data to the level of river basins as individual companies or business units could be identified. Confidentiality only plays a role in monetary and physical supply and use tables. The Netherlands tries to overcome problems of confidentiality by imposing some conditions: a sector should consist at least of three or more companies; and, for economic data, the largest company cannot employ more than 75 percent of all employees in a specific region, or, for physical data, the largest company in a specific branch of industry in a specific region cannot use more than 70 percent of the total freshwater use in that region.

3.85. When these conditions are not met, data for specific sector are combined with those of another making sure, however, that confidential data remain confidential when combining information at national level and for each river basin (the case, for example, that two sectors are combined in just one river basin, then national and river basin figures can reveal information for a particular business).

3. Australia

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

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

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

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

> Step 1: Calculation of the average application rate (water use per hectares) for the State and crop. For example, in NSW in 2001, the Water Account estimated that there was 174,000 Ml of water used for Grapes. The Agricultural Census estimated that there were 31,600 ha of land

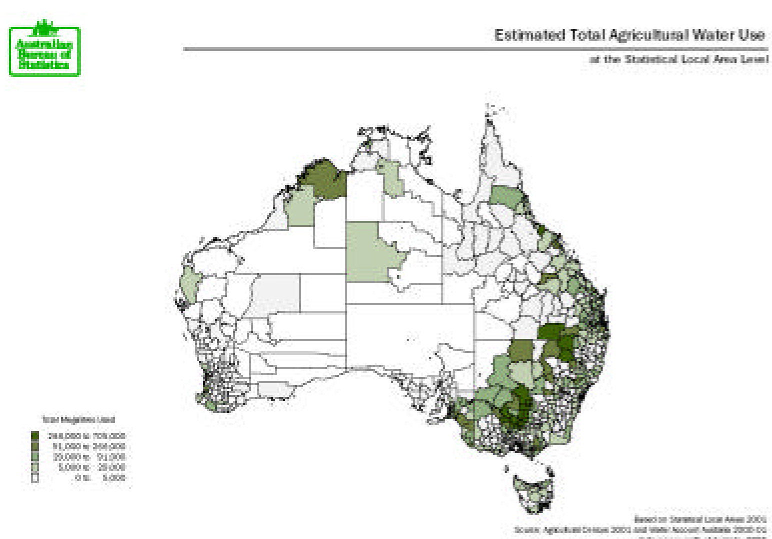
irrigated for grapes. From this information, the application rate for grapes grown throughout NSW in 2000/2001 is estimated to be 5.5 Ml/ha and it is assumed that it applies homogeneously for the entire state.

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

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

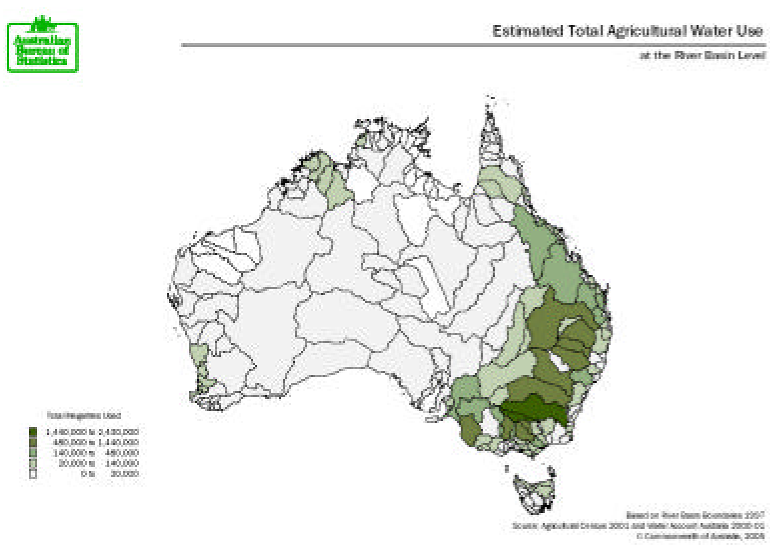
3.91. For the intervening years, only estimated at the level of SD are available and the estimates of total water use for river basins can be significantly different that that obtained using information on SLA's. Research is currently being done at ABS to improve the estimates of water use for river basin. Figure 3.4 and show the estimated of total agricultural water use for SLA's and river basins in Australia.

Figure 3.4. Estimates of total agricultural water use at the SLA level



Source: Hawthorne (2005)

Figure 3.5. Estimates of total agricultural water use at the river basin level



Source: Hawthorne (2005)

F. Derived indicators

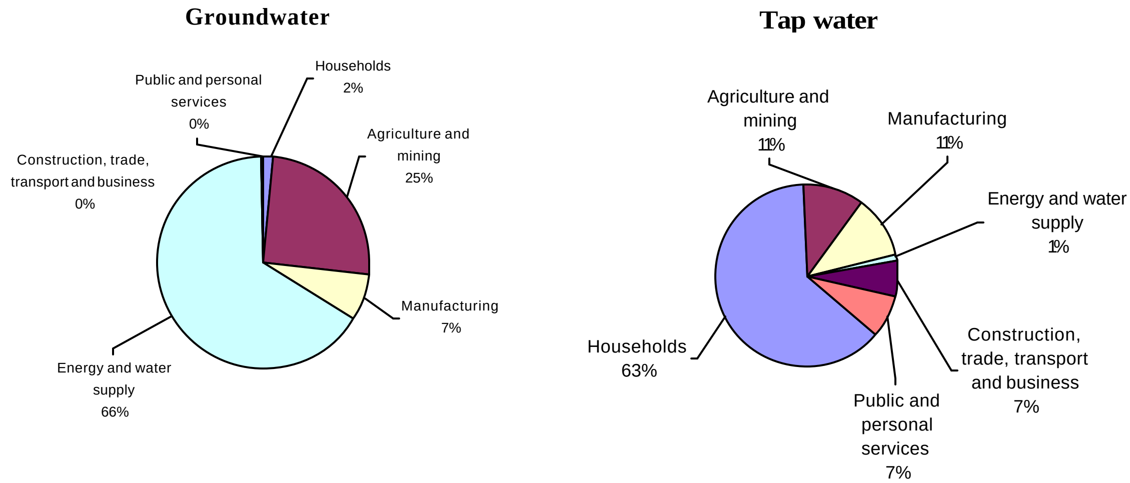
3.92. A number of indicators can be derived from the physical supply and use tables to analyse how water is used by the economy. Some of the indicators presented in this section are solely based on the information presented in the physical supply and use tables (these include, for example, water use, abstraction and consumption by industry). Other indicators presented here, are based on additional information, such as population size in order to compute the per capita water use, and gross domestic product (GDP) and value added in order to compute water productivity indicators.

Water abstraction, use and consumption by industry

3.93. Indicators on water abstraction, use and consumption by industry allow for comparisons between different types of water use. Figure 3.6 shows the breakdown of groundwater abstraction and use of tap water in Denmark in 2001. This type of analysis helps to identify the industries that place the most pressure on water resources.

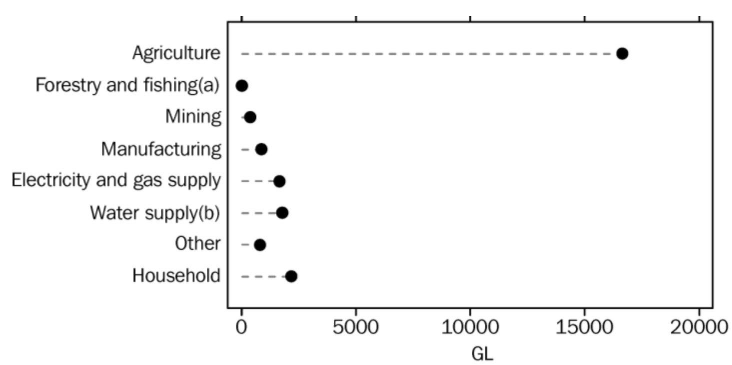
Figure 3.6 Abstraction of groundwater and use of tap water, Denmark 2001

Source: Statistics Denmark. *Danish Environmental Accounts* 2002 (publication in Danish)



3.94. The indicator of water consumption has been used by Australia. Figure 3.7 shows water consumption by industry for the years 2000-2001. The figure shows that agriculture is the highest consumer of water followed by households and water supply industry.

Figure 3.7 Water consumption, Australia, 2000-2001



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

Source: Australian Bureau of Statistics (2004): *Water Accounts Australia 2000-2001.*

Water use per capita

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

3.96. Table 3.9 presents a comparison of water use among Botswana, Namibia, and South Africa. Among the three countries, total water use in 1996 was lowest in Botswana. However, the population and economy of South Africa is much bigger than either Botswana or Namibia, so comparison of total water use is not that useful. Per capita water use shows that Botswana has the lowest per capita use of water at 95 cubic meters per person per year; Namibia, a country fairly similar to Botswana in terms of population, follows with a per capita consumption that is 50% higher at 144 cubic meters of water per person. South Africa's per capita water use is more than four times that of Botswana's at 412 cubic meters per person.

3.97. The second part of Table 3.9 shows the structure of water use in 1996, which provides a clue to these differences. Botswana uses only 48% of its water for Agriculture compared to 62% in Namibia and 69% in South Africa. Per capita water use excluding agriculture is much more similar among the three countries: Botswana uses only 49 cubic meters of water per person, Namibia 55, and South Africa about twice that of the other two at 128.

Table 3.9: Water use in Botswana, Namibia, and South Africa, 1996

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

Source: Lange and Hassan, 1999 and Table 2.

3.98. Table 3.10 presents a comparison of water use by households between some European countries. Presenting information on total and per capita water use side-by-side helps to explain some of the differences between countries in terms the population size. For example, the difference in the total domestic water use in Poland and in the Czech Republic which is around 1000 million cubic metres, is explained by the different population size as the per capita water use in the two countries is the same.

Table 3.10: Domestic water use in some European countries

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

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

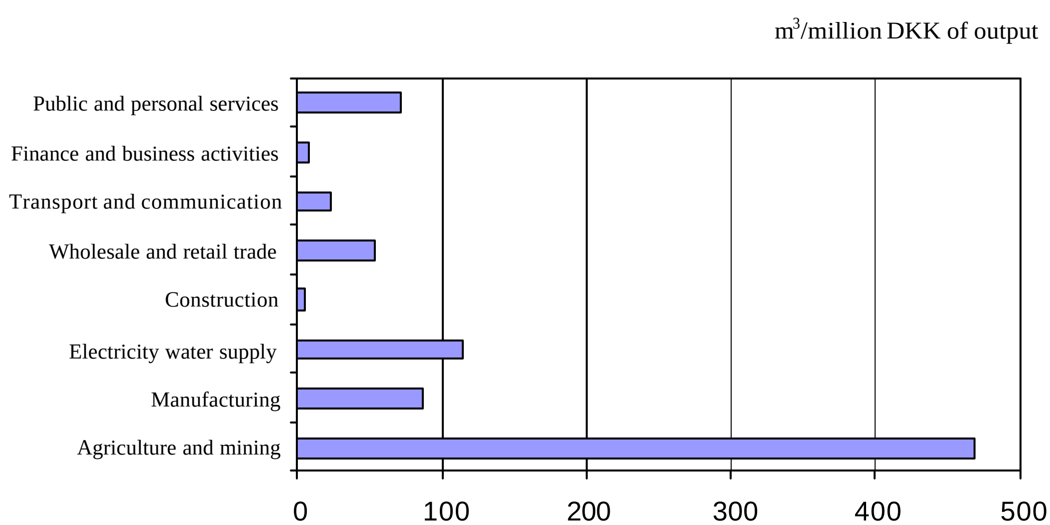
Indicators of water use intensity/productivity per industry

3.99. Indicators of water use intensity per industry link quantities of water used to some economic characteristics of the sector. The economic characteristics considered most frequently are output, value added or the number of employees. Depending on the type of analysis, these indicators can focus on total water use or on the use of water supplied by ISIC 41 only. Water use intensity is defined as the ratio of the volume of water used and GDP/output:

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

3.100. Figure 3.8 presents an example of water use intensity for Denmark: it shows the use of tap water per unit of output. Although water intensity is limited to "tap" water that is to say water distributed by ISIC 41 and 014, it shows that in Denmark agriculture is an intensive consumer of such water.

Figure 3.8: Water use intensity of "tap" water, Denmark in 2001, 1995-prices



Source: Statistics Denmark. Danish Environmental Accounts 2001 (publication in Danish)

3.101. The indicator of water productivity is similar to the "productivity" indicators used in economic analysis (e.g. capital productivity, labour productivity) and it is computed as a reciprocal of water intensity. This indicator is computed as:

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

and measures how many units of output are generated by one unit of volume of abstracted water. Water productivity can be computed for the whole economy as a ratio of GDP and volume of water used.

3.102. Table 3.11 presents a comparison of GPD per unit of water used in Botswana, Namibia and South Africa. The differences in water productivity among the countries occur in all sectors: more income is generated for each sector in Botswana than either of the other countries. Of course, among countries that differ in water scarcity, one would expect to see such differences in water use. Where water is abundant, there is less environmental need to conserve it (although the economic argument to maximize the resource output remains valid).

Table 3.11: National income generated per cubic meter of water used by sector in Botswana, Namibia, and South Africa, 1996

(Pula per cubic meter of water used)

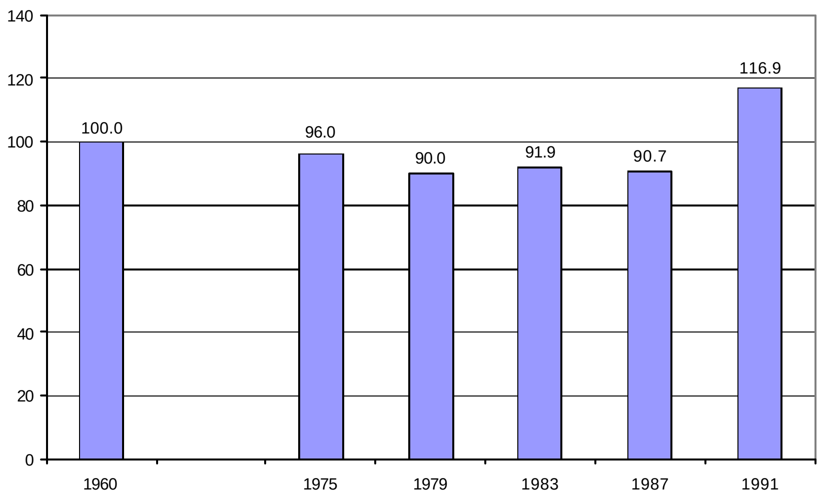
	Botswana	**Namibia**	**South Africa**
Agriculture	9	6	2
Mining	420	54	44
Manufacturing	437	189	98
Trade, Services, Government	724	542	302
GDP per m^3 of water input	**124**	**45**	**20**

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

3.103. Figure 3.9 presents an example of how water productivity has changed over time in Germany. In the former territory of the Federal Republic of Germany, the annual abstraction of water more than doubled during the 1960 to 1991 period (increasing from 20.6 to 45.9 billion m3). The bulk of this increase actually occurred before 1979. In terms of water productivity, it declined until 1979 which means that during this period, the water use rose more rapidly than the economic output. From 1979 to 1987 water productivity remained practically steady, and then it sharply increased in 1991.

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

Figure 3.9: Water productivity index, Germany (base 100 in 1960)



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

G. Data sources and methods

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

1. Use of administrative data

3.106. Environmental Protection Agencies may provide data on physical flows when they are in charge in the monitoring of abstractions and discharges. In some cases, however, it can be difficult to get harmonised data due to e.g. a federal organisation.

3.107. An example of use of administrative data is the analysis of the content of licenses or taxation registers (license to abstract water and taxes when they are based on volumes of abstracted water or discharged wastewater, etc.). Countries where taxes are linked to the water use generally have a very detailed source of information readily available in particular for the building of the use table (e.g. Denmark, France): the tax payer is identified with the nature of its activities and with the volumes it is assumed to abstract or discharge.

3.108. In some countries, in parallel to their annual economic accounts, large enterprises are asked to produce environmental reports, from which information about water may be derived. Again, the difficulty is to get harmonised data when these reports are not compulsory.

2. Surveys

3.109. Information on the physical supply and use of water can also be obtained from specific surveys: economic units (or a sample of them) are asked about their behaviour in regards to water related issues. These surveys can be specific, i.e. entirely dedicated to water issues or include questions about water in a multipurpose questionnaire (for instance surveys gathering Structural Business Statistics in the EU). These surveys may include actual measurements (of a sample of water flows). They are generally carried out every 3 or 5 years on an extensive scale and updated with the help of coefficients in the meantime.

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

3. Application of coefficients

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

3.112. Modelling is an extension of the application of coefficients but is more sophisticated in that sense that several variables are used and that the link can be non linear. For instance, estimating the water use by agricultural enterprises can take into account their geographical location (with specific meteorological conditions), acreage, crop variety, livestock composition, irrigation system, etc.

3.113. In general, it is a good practice to check the validity of data given that there are a number of possible sources of errors in any of the data sources presented above: sampling error, measurement error, and variability in time, by region, etc. The checks and balances of the accounting system provide one tool to check the consistency of the data once they are brought together.

4. Data sources according to type of information

Abstraction

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

3.115. Physical information on abstraction could be obtained through surveys and licenses/permits when they exist and are based on the volumes of water abstracted.

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

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

Supply and use within the economy

3.118. Within the economy most of the water is supplied by ISIC 41 which generally also keeps the records on physical water supply and use including imports and exports. Volumes of wastewater and urban runoff collected by ISIC 90 are generally monitored by this industry hence they could be obtained by surveys of sewage establishments or using administrative records.

3.119. Water use by those industries for which no record is available and water is used mainly for their employees' personal needs, is often estimated by applying coefficients based for example on the number of employees. When the number of employees is not representative of the actual water use, e.g. hospitals, schools etc., adjustments could be made to include for example the number of patients or pupils.

Returns to the environment

3.120. Data sources for the return flows to the environment vary according to the industry discharging water. Discharges of water by ISIC 90 are generally monitored hence they are usually obtained through surveys or administrative records. When not regulated or metered, direct discharges of water can be estimated through the application of coefficients (based, for example, on water consumption).

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

References

Australian Bureau of Statistics (2004). Water Account Australia 2000-2001.

Australian Bureau of Statistics (2005). *Water use on Australian farms 2002-2003*. ABS Cat No. 4618.0. ISBN 0642479844.

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

Environmental-Economic Accounting in Germany 2001 – Abstract of the press conference report 2001 Water and wastewater – Statistisches Bundesamt – April 2002.

Hawthorne K. (2005). *Calculating Regional Estimated of Agricultural Water Use*. Presented at the International Statistical Institute 55th Session, 5-12 April 2005, Sidney, Australia.

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

Water flow accounts as part of material and energy flow accounts in Germany – Statistisches Bundesamt – 2000.

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

Statistics Denmark. Danish Environmental Accounts 2001 (publication in Danish)

Statistics Sweden (2003) Water accounts 2000- with disaggregation to sea basins. ISBN 91-618-1139-9

Glossary

Hydroelectric power water use: Water used in generating electricity at plants where the turbine generators are driven by falling water. (http://water.usgs.gov/pubs/chapter11/chapter11M.html)

Inland water consumption: Part of water use which is not distributed to other economic units and does not return to the inland water resources because it has evaporated, transpired, been incorporated into products and crops, consumed by man or livestock, ejected directly to the sea, or otherwise removed from the inland water system.

Losses in distribution: water lost during transport between a point of abstraction and a point of use, or between points of use and reuse. Losses in distribution may be caused by leakages, evaporation, illegal tapping, malfunctioning metering etc.

Mining water use: Water used for the extraction of naturally occurring minerals including coal, ores, petroleum, and natural gas. Includes water associated with quarrying, dewatering, milling, and other on site activities done as part of mining. Excludes water used for processing, such as smelting and refining, or slurry pipeline. (http://water.usgs.gov/pubs/chapter11/chapter11M.html)

Reused Water: Wastewater delivered to a user for further use with or without prior treatment. Recycling within industrial sites is excluded. (EDG)

Water Consumption: Part of water use which is not distributed to other economic units and does not return to the environment (to water resources, sea and ocean) because it has been incorporated into products, consumed by households or livestock, and has evaporated and transpired by plants. It is computed as: Water consumption = total water use – Total water supply. *Water losses due to leakages during the transport of water between the point or points of abstraction and the point or points of use are excluded.* (modified from the EDG)

Total Abstraction: Amount of water removed from any source either permanently or temporarily in a given period of time for consumption and production activities. Water used for hydroelectricity generation can be considered as part of water abstraction. Total water abstraction can be broken down according to the type of source (i.e. Water Resources and Other sources) and the type of use. (EDG)

Urban runoff*:* That portion of precipitation *on urban areas* that does not naturally percolate into the ground or evaporate, but flows via overland flow, underflow, or channels or is piped into a defined surface water channel or a constructed infiltration facility (Washington Department of Ecology, 1992). (http://www.epa.gov/owow/nps/MMGI/Chapter4/ch4-8.html) [slightly modified in italic]

Water losses during transport: Volume of water lost during transport between a point of abstraction and a point of use, and between points of use and reuse *because of leakages* and evaporation. (Changed from the EDG). *Part of these losses are considered returns (leakages), the other is considered as water consumption*

Return flows : Water that is returned into the environment during a given period of time after use. Total returns can be classified according to the receiving media (i.e. water resources and sea water) and to the type of water (e.g. treated water, cooling water, etc.). (EDG)

Chapter 4 Emission accounts

A. Introduction

4.1. This chapter presents emission accounts, which describe flows of pollutants transported in the water from its abstraction, supply and use within the economy and discharge into the environment. Emission accounts can be used for the assessment of measures against water pollution, the development of new regulations to reduce emissions, impact studies of new technologies, and the analysis of the relationships between economic activities and state of the environment.

4.2. In particular, water emission accounts allows for the identification of the pollutants released into water resources and the economic agent (industry or households) responsible for such emission. Knowing which economic agent emits what in which water resources (e.g. surface or groundwater) may help in designing targeted measures for the improvement of water resources' status.

4.3. Section B presents some basic concepts used in the compilation of emission accounts, defines which emissions are recorded in the accounts and presents examples of pollutants for which accounts are compiled. Section C describes in detail the tables in the emission accounts. Section D presents some of the major indicators that can be derived from emission accounts. Section E discusses data sources most commonly used for the compilation of these accounts.

B. Basic concepts

4.4. With the term emission we refer in this handbook to the release of pollutants contained in the wastewater generated by an economic agent - industries, households as final consumers and the rest of the world. In particular, they report the amount of a pollutant added to the water by an economic activity during a reference period (a year in most cases) and are expressed in terms of weight (kilograms or tonne, depending on the pollutant under consideration).

4.5. The emissions considered in the accounts are those associated with the physical supply and use of water. Thus they include:

- Pollutants discharged with wastewater into the sewage network;
- Pollutants discharged with wastewater directly into the water resources;
- Pollutants subtracted by economic activities which occur during purification and treatment processes.

4.6. Most of the emissions recorded in the accounts are point source emission that is they are discharged into water resources from a single point such as pipes, ditches, wells, etc. Others are considered as non-point source of pollution as the discharge of wastewater and the pollutants in it are discharged into water resources through indirect or scattered sources such as drainage or runoff from agricultural fields (returns of Agriculture).

4.7. There are a number of other non-point source emissions which are not captured in the accounts even though they affect the quality of water resources. This is the case, for example, of pollutants that leak from a dumping site and reach a groundwater body and of pollutants that infiltrate through natural land with precipitation which has absorbed pollutants present in the air, infiltrates to reach surface and groundwater.

4.8. In general, point source emissions are easier to measure as the point of emission to the water resources is clearly identified by the geographical location of the discharge of the wastewater. In addition, it is also easier to identify the emitter and to measure the pollution content of the discharge at the precise location. As for the non-point source of emissions captured in the accounts, they usually cannot be measured directly, but they can be estimated either by coefficients or indirectly measured as the residual between the pollution ascertained in the water resources and the total of known sources. In addition the allocation of non-point source of emission to specific economic activities as well as to specific water resources may not always be straightforward: for example, the structure of the soil and the climatic conditions may determine the delay that the pollutant takes to reach groundwater after infiltrating the soil.

Water pollutants

4.9. Before starting the compilation of emission account, a list of pollutants has to be defined. Most often this list is determined based on the country's concerns. It could include, for example, organic matter, metals, pesticides, pathogen germs, etc. Some substances have multiple impacts: for example, ammonia is both an oxygen consumer and a nutrient. The legislation on water (and, notably, the international agreements supported by the country) should help in the selection of pollutants for which to compile the accounts.

4.10. In the EU, for example, a list of the most important pollutants in terms of either their quantity or their dangerousness, had been drawn taking into account the recommendations of the various EU directives related to water and the feasibility of the monitoring. This list included isolated pollutants as well as measurements of aggregated forms of pollution:

Heavy metals:

- Arsenic (As)
- Cadmium (Cd)
- Mercury (Hg)
- Copper (Cu)
- Chromium (Cr)
- Nickel (Ni)
- Lead (Pb)
- Zinc (Zn)

Eutrophication agents:

- Phosphorus (P)
- Nitrogen (N)

Synthetic indicators

- BOD (biological oxygen demand, i.e. the mass concentration of dissolved oxygen consumed under specific conditions by the biological oxidisation of organic and/or inorganic matter in water)
- COD (chemical oxygen demand, i.e. the mass concentration of oxygen consumed under specific conditions by the chemical oxidisation with dichromate of organic and/ or inorganic matter in water)
- Suspended solids

4.11. In the EU list of pollutants, biologic pollution such as germs, coliforms, salmonella, etc., had not been selected, although potentially important for sanitary reasons. This pollution is generally removed from abstracted water by ISIC 41 during the purification of water before distributing it to the users.

4.12. Examples of other pollutants that can be included in the emission accounts are: pesticides, polychlorinated biphenyls (PCBs), halogenated hydrocardons, ammonium salts, chlorine, sulphates

C. Emission accounts

4.13. As mentioned above, emission accounts record the amount of pollutants added to water by an economic unit during water use and the amount of pollutants removed from water by an economic unit (generally ISIC 90 and ISIC 41). The removal of pollutants occurs during water treatment processes. It is important to record both these flows to capture the overall direct emission of pollutants to the sewers and to the environment and the effectiveness of the de-polluting activities carried out principally by ISIC 90. The analysis of emission accounts in combination with expenditure account and with the cost of water treatment would also allow for cost-benefit analyses such as studying the effectiveness in depolluting to its costs.

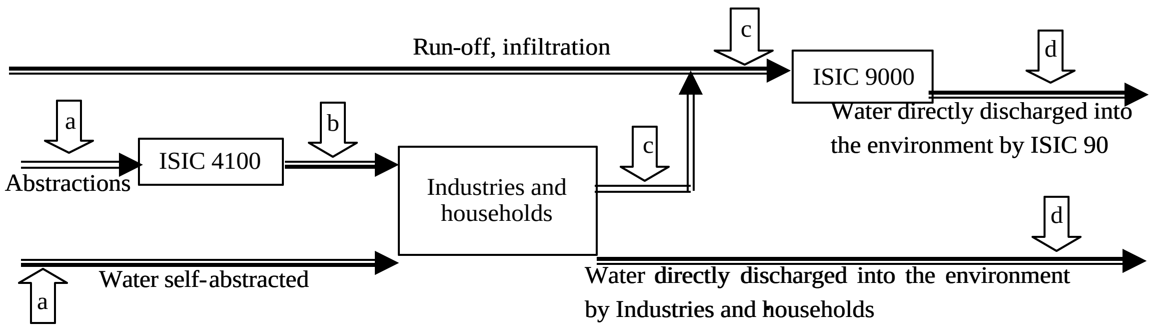
4.14. Emissions are not directly measured: what is measured is the concentration of the pollutants in the incoming and outgoing flows of water for each economic unit and, once the total volume of a pollutant is calculated from the concentration for each of these flows, the emission by an economic unit is obtained as a difference of total pollutants in the incoming and outgoing flows.

4.15. Note that emission accounts record the pollution added to water by an economic unit and not the total pollution discharged with wastewater. For example, if an industry abstracts (or receives) 1 cubic metre of water which already contains *x* kg of a pollutant and returns to a river 1 cubic metre of wastewater containing *y* kg of the same pollutant, even though the total discharge of the pollutant to the river is *y* kg, only (*y*-*x*) kg is recorded as it represents the pollution generated by the industry.

4.16. Figure 4.1 shows the water flows that need to be measured in terms of pollution concentration in order to compile emission accounts. The double arrows represent water flows from abstraction to water returns into the environment. The vertical arrows indicate the water flows for which measurements of pollutants concentration are needed. These include:

- pollutants already contained in abstracted water (by ISIC 41 for further water supply and as direct abstraction by other industries and households). These are denoted in the figure with the letter a;
- pollutants contained in the water supplied to other economic units (except ISIC 90), which are denoted with the letter b;
- pollutants contained in wastewater discharged into the sewage network (ISIC 90) which are denoted with the letter c;
- pollutants finally discharged into the water resources, either by industries or households not connected to the sewage network or by ISIC 90 industry which are denoted with the letter d.

Figure 4.1: Points of measurement of the concentration of pollutants



Note: The vertical arrows (⇩) indicates the location of the points of measurement

4.17. In general, pollutants are added to water except when the pollution is removed from water that is during purification and treatment processes. Emission accounts provide information on the amount of pollutants removed from water by an economic unit in particular, by ISIC 90 and ISIC 41. The industry "Sewage and refuse disposal, sanitation and similar activities", ISIC 90, may reduce the polluting load of the collected wastewater through wastewater treatment. The industry "Collection, purification and distribution activities", ISIC 41, may also remove some pollutants: during the process of purification of water some pollutants contained in the abstracted water may be removed before distributing water. This results in negative emissions of pollutants for these industries.

4.18. In emission accounts a distinction is made between gross and net emissions for each economic activity. *Gross emissions* correspond to the pollutants added to the water by an activity, assessed at the point where the wastewater leaves the activity's site (or the dwelling, in the case of households). *Net (or final) emissions* correspond to the pollutants discharged into the water resources. Thus, for the whole economy, the difference between gross and net emissions totals would correspond to the pollution removed by wastewater treatment plants.

4.19. Emission accounts consist of supply and use tables of pollutants contained in the water exchanged within the economy and between the economy and the environment. The supply table, presented in Table 4.1 describes the amount of pollutants generated (added to water during use) by industries and households. By row, information is disaggregated according to the type flows: those destined to other economic units (which, in practice, occurs mainly in the case of wastewater supplied to the sewage) and to the environment (which includes the discharges of wastewater by the sewage industry and the direct discharges from other industries and households).

4.20. The use table presented in Table 4.1 describes the amount of pollution that is removed by industries and households from water abstracted and from water received by other industries. In practice, there are only two industries involved in the removal of pollutants as part of their principal activities: ISIC 41 and ISIC 90. The first abstracts water and often remove pollutants from it before distributing it to other users. The second, ISIC 90, removes pollutants from the wastewater generated by other industries and collected into the sewage network. The use table could contain other entries which represents own treatment facilities before discharging water directly into the environment.

Table 4.1: Supply and use table for emissions to water

Supply table

	Pollutant	ISIC				Households	RoW	Total
		…	ISIC 41	ISIC 90	…			
Within the economy	A							
	B							
	…							
To the environment	A							
	B							
	…							
Total (Gross emissions)								

Use table

	Pollutant	ISIC				Households	RoW	Total
		…	ISIC 41	ISIC 90	…			
From the environment	A							
	B							
	…							
Within the economy	A							
	B							
	…							
Total								

Net emission								
Total sludge production								
Number of people connected to the sewage network								

4.21. Table 4.2 presents side-by-side information on the load of pollutants in the incoming and outgoing flows by industries and links it to the emission generated by each industry. In particular, Table 4.2 records, for each pollutant, the amount of pollutants in (a) water directly abstracted, (b) water received by other industries, (c) water discharged into the sewage system and (d) water discharged directly into the environment. The gross emissions generated by an industry are then computed as a difference between the load of pollutants in the outgoing (c+d) and incoming flow (a+b). Net emissions are computed as a difference between gross emission and the load of pollutants in water discharged into sewage.

4.22. For analytical purposes, it is useful to reallocate the emissions generated by ISIC 90 to the activity which has originally generated the wastewater flow in order to assess the overall impact (direct and indirect) of the emissions generated by an activity. ISIC 91 collects and treats aggregated flows of wastewater coming from different industries and households wastewater from different thus the discharge of pollutants contained in water returned into the environment by ISIC 90 is the result of the combined emission generated by economic activities and households. In general, the allocation of emissions in the return flow of ISIC 90 to the original economic unit responsible for generating that pollution is obtained by applying global abatement rates of the treatment plant to every gross emission collected by the treatment plant.

Table 4.2: Water emission account

	Economic agent:⇨		Industries					Households	Rest of the world	Total
			ISIC 01	ISIC 02	…	ISIC 90	…			
Pollutant:⇩										
Pollutant A	Load in water directly abstracted	a								
	Load in water received by other industries	b								
	Load in water discharged in the sewers	c								
	Load in water discharged directly to water resources	d								
	Gross emission	c+d-a-b								
	Net emission	d-a-b								
Pollutant B	Load in water directly abstracted	a								
	Load in water received by other industries	b								
	Load in water discharged in the sewers	c								
	Load in water discharged directly to water resources	d								
	Gross emission	c+d-a-b								
	Net emission	d-a-b								
…..										

4.23. Some assumptions can reduce the number of points of measurement. These obviously are country specific. For instance, the European water accounts standard tables assumed that:

3.122. water abstracted for distribution and water distributed to industries and households is free of pollutants as purification of water generally involves other pollutants than those followed in the European water accounts (microbiological pollutants).

3.123. water flows for irrigation purposes (from abstraction to returns into the environment) do not contain pollutants (or contain the same amount of pollutants) thus they are not recorded in the European water accounts. This stems from the fact that emissions due to irrigation are very difficult to assess: plants and soil may absorb pollutants and the fertilizers spread on the soil may introduce an ‘indirect’ emission to water.

3.124. pollutants in flows of non-fresh water are not studied because the focus of the European water accounts is on fresh water (furthermore, most of these flows are for cooling purposes in the electricity process, use which should not introduce much changes in the pollutant content of water). The inland water system in the European water accounts includes only freshwater resources.

4.24. When compiling emission accounts some problems may arise when dealing with urban runoff. Urban runoff is storm water from city streets and gutters that usually contains a great deal of litter and organic and bacterial wastes as oil, antifreeze, detergents, pesticides and other pollutants get washed from driveways, backyards, parking lots, and streets and are usually collected through storm sewers (drains usually at street corners or at low points on the sides of the streets). Because urban runoff is highly polluted, there is an increasing awareness in the potential danger of discharging urban runoff into the environment without treatment.

4.25. When urban runoff is collected in a separate sewer system than the one carrying domestic and commercial wastewater (sanitary sewers), the concentration of pollutants can be in theory easily measured. The problem arises when urban runoff and wastewater from industries and households drain into the same sewage system as it is difficult (a) to measure the concentration of pollutants removed by ISIC 90 as the pollutants content of urban runoff arriving at the treatment plant is generally not measured and (b) to allocate the concentration of pollutants in the outgoing water flow leaving ISIC 90 to the various sources.

4.26. In order to assess the impact of emissions on water resources, it is important to report emissions according to the type of water resource receiving the discharged wastewater (hence the pollutants). The breakdown should be consistent with the asset classification. The information on the destination of the wastewater flow is important to link emissions to the quality of the receiving water body. However, this link is not direct as the geographical dispersion of pollutants depends on various factors including the type of pollutants, the quality of the receiving body, temperature and so on. Specific analysis should be carried out on a case by case basis.

4.27. When data are available, emissions from treatment plants could be disaggregated according to the type of treatment wastewater is subject to. The UNSD/UNEP Questionnaire on water resources distinguishes three types of treatment: mechanical, biological and advanced (see the glossary for the definitions) according to the type of treatment process. The Eurostat/OECD Questionnaire classified treatment plants according to the (designed) treatment efficiency. The breakdown of ISIC 90 into different categories of treatment process allows for the assessment of the efficiency of the treatment process calculated as a percentage of pollutant removed from wastewater over the original quantity received by the treatment plant.

4.28. It is also useful to report in the emission accounts supplementary information regarding the sludge production and the number of households connected to the treatment plants. Sewage sludge consists of decanted matter resulting from wastewater treatment, including sludge treatment. Since there may be legislation regulating the generation and disposal of sewage sludge, it is important to report its production (usually in dry weight as, depending on the methods of water treatment and sludge treatment such as digestion, filter-pressing etc., the concentration of dry solids can be very variable). The number of people connected to the treatment plant is an important indicator of the ability of a country to prevent damages to human and environmental health originating from wastewater discharge (by avoiding, for example, the spread of excreta-related diseases and by reducing pollution of water resources).

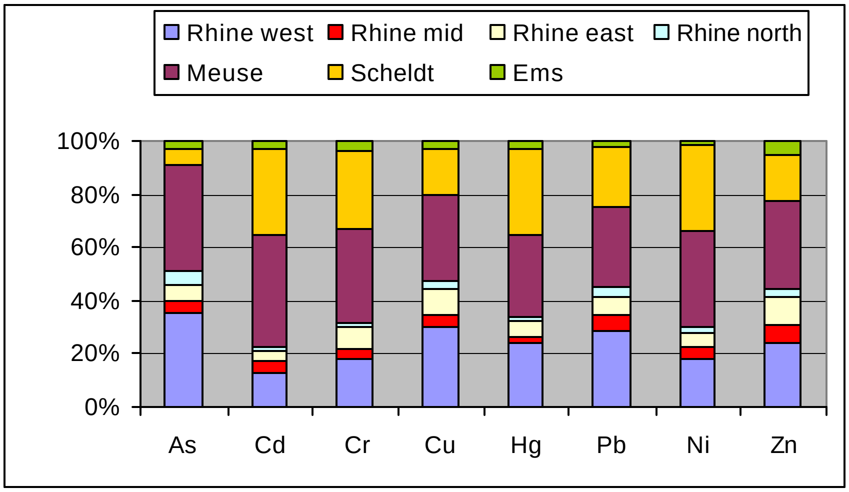
1. Emission Accounts by river basin

4.29. The compilation of emission accounts at river basin level provides information on the spatial distribution of the economic pressure on water resources. Often emission registers, in addition to emitted substances, provide information on the activities which emit pollutant as well information on their location. This allows the allocation of emission to river basins.

4.30. In the Netherlands, regional emission data are supplied by the Regional Emission Registration and include the same substances as the national emission data. Most data are available at the level of individual plants, including their spatial coordinates, making it relatively easy to attribute these emissions to one of the river basins. The regional emissions add up to the national totals. Accordingly, emissions can be allocated to the different river basins. For example, **Error! Reference source not**

found. shows the distribution of the emission of heavy metals to the different river basins in the Netherlands.

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



4.31. In some cases a problem arises if the location of an economic activity does not correspond with the location of the emission source. For instance, a factory is located in one river basin, but its wastewater is transported to and discharged in another river basin. In the Netherlands these emissions are allocated to the river basin in which the economic activities take place, i.e. where the factory is located, although the actual pressure occurs in another river basin.

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

D. Derived indicators

4.33. Emission accounts allow for the identification of the activities responsible for the emission of polluting substances into water. This information can be shown through straightforward tables or graphs showing the distribution of emissions between the various activities. Pollution intensity ratios can be used to assess the relative contribution of an industry for the emission of a specific pollutant.

1. Pollution intensity ratios

4.34. Pollution intensity ratios can be defined with reference to other environmental data, to economic data such as the value added or the employment by sector. Examples of these indicators are:

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

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

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

4.35. These ratios allow for a comparison between activities, not in absolute terms, but relatively to the wastewater generated, their relative contribution to the GDP, and employment.

4.36. Table 4.3 presents an example of calculation of pollution intensity ratios in Belgium for six pollutants. The table shows that the power and water distributors industries contributed very little to the global pollution even though they produce more than half of total wastewater discharges in Belgium in 1998: the pollution intensity ratio of the volumes of water they discharge is not higher than 0.1 percent whichever pollutant is considered (not all heavy metals have been reproduced in the table).

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

Table 4.3: Breakdowns of emissions in Belgium in 1998 and corresponding pollution intensity ratios

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

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

2. Environmental themes

4.38. For presentation to the users, it may be useful to aggregate the different pollutants to show a synthetic view of the contribution of the different economic activities to the pollution. For instance, in the Netherlands, pollutants are aggregated into environmental “themes”: eutrophication, dispersion of heavy metals and a general “wastewater” theme (organic pollution). In France, the emission of toxic substances (mainly heavy metals) has been expressed in kilo-equitox, a kilo-equitox being a measurement unit which evaluates the capacity of a substance to inhibit the biological functions of living beings.

E. Data sources and methods

4.39. A combination of different sources is used to compile emission accounts as different sectors of the economy often require specific methods for the assessment of their emissions. For instance, emissions by manufacturing industries can often be evaluated through the exploitation of administrative data such as licences to pollute that may not be available (requested) for services industries which, however, mainly receive and discharge water through public networks and therefore their emission can be obtained from records of the public network. Emissions by manufacturing industries may also be assessed through specific surveys. Emission by households can be estimated by applying grossing-up coefficients to average emissions measured on a sample. Some of these methods include surveys, the use of coefficients, licenses to pollute and emission registers which are described next.

4.40. However, it should be mentioned that this part of the accounts is still in development: countries are in a period of test: they compare the results obtained by the diverse methods and it is difficult at this step to suggest definitive recommendations.

1. Surveys

4.41. Surveys can be used to estimate the emissions to water. Questions about emissions to water can be added to annual business surveys, not necessarily every year. However, given the technical complexity of the evaluation of the emissions, it may be more appropriate to build a specific survey on an ad hoc sample.

4.42. It should be mentioned that there are some intrinsic difficulties to consider when preparing a survey for water emission: measurement issues and statistical inference from the sample to the whole population. Regarding the measurement issues, the assessment of the emissions is based on measurements of concentrations (emissions are obtained as a difference in the concentration of pollutants between the outgoing and ingoing water flows). Concentrations measurements, unlike, for example, water volumes which can be measured permanently through meters, are only measured from time to time and they require rigorous experimental procedures (against time, frequency, volumes, conditions of the sampling, etc.) to ensure the representativeness of the results. Once the survey is carried out, the results have to be extrapolated to the whole statistical population. Particular care should be used to make inference from the sample as there are a number of factors that may affect the results including the seasonality in the observations, number of working days during the period, etc. The extrapolation coefficients themselves must be established with care.

2. Use of coefficients

4.43. The use of coefficients for the compilation of emission accounts consists first in the identification of coefficients (for example, emissions per person for households, or per employee for industries), then in the application of these coefficients to demographic or economic data. Coefficients are usually based either on (a) preliminary surveys or (b) other studies. The surveys needed for the identification of coefficients are generally on a smaller scale than the surveys described above. This method is mostly applied when the economic units to survey are very numerous and have a rather homogeneous behaviour in their water use.

4.44. Coefficients based on other studies are generally applied in pilot compilations of the accounts when preliminary results are needed and it is too costly to develop a complete collecting system. Coefficients could be taken from studies in other countries, other regions, other sources, etc.

4.45. Care is necessary when applying coefficients especially those taken from other studies: emissions vary a greatly depending on a number of determining factors (e.g. time, technology in place, company size, region) and the use of coefficients relies on the assumption that these determining factors are similar.

4.46. In Belgium, for example, where data are regionally organised, in order to estimate emissions by households, emission coefficients for households calculated from one region (Flanders) were applied to the rest of the country using population data. Table 4.4 presents average discharge of water pollutants per person in Flanders.

Table 4.4: Average (gross) discharge of water pollutants per person per day in Flanders in 2001

BOD........44 g	Zinc........30.72 mg	Arsenic........0.55 mg
COD........94 g	Copper........26.38 mg	Chromium........0.47 mg
Suspended solids........55 g	Nickel........0.95 mg	Nitrogen........10 g Kjeldal N
Mercury........0.05 mg	Lead........4.19 mg	Phosphorus........1.7 g
Cadmium........0.14 mg		

Source: VMM (Vlaamse Milieumaatschappij) background document for MIRA-T 2001 (Environment and Nature Report of Flanders) cited in the NAMEA Water for Belgium (1998) - Bureau Fédéral du Plan - February 2002.

3. Exploitation of licenses to pollute

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

4.48. However, experience suggests that the exploitation of such records can be difficult. The United Kingdom, for example, tried to confront the emission consents granted to the industries with their measured emissions[6]. This comparison was based on data from water companies from the England and Wales regions. Actual emissions as a ratio of the consented emissions were calculated per industry: out of the 300 ratios calculated, about two thirds were nil (no actual emissions at all) and a further quarter was below 10% of the consented level.

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

[6] Emission coefficients for pollutants discharges to sewer – Final report to Eurostat – ONS – July 2000

4. Emission registers

4.50. Emission registers are multi-purpose databases, which record at least four types of information: the emitted substances, the activity of the emitter (e.g. industrial enterprise, wastewater treatment plant), its location and the water recipient. In the EU, maintenance of Polluting Emissions Registers (PER) has been required by the Integrated Pollution, Prevention and Control (IPPC) Directive.

4.51. The registers are themselves fed by sampling monitoring of the emissions, at least for the most polluting sources. This monitoring can be completed by estimates based on coefficients for small sources. In some countries, a model estimates the emission using detailed information on each factory, in particular the process used.

4.52. The information from the registers does not prevent from making further estimates to fulfil the objectives of the emission accounts: for instance the registers will indicate the pollution emitted by urban wastewater treatment plants (UWWTPs). This total emission should be re-allocated to the diverse economic units that use the UWWTPs: households, trade, small industries, and to urban run-offs.

Box 4.1: Much information with limited effort

In the Netherlands, there are about 40 000 industrial companies, of which 730 are included in the Individual Emission Inventory.

In France, there are about 25 000 industrial emitters inventoried by the Water Agencies, of which 11 000 pollute less than 400 inhabitant equivalent (IE). Among the remaining emitters, 27% of the total load came from the 100 largest sites and 74% from the 1 700 largest sites.

Similar figures are observed in the UK, where the largest treatment plants (>15 000 IE) make a very high proportion of the total load (e.g. 91% of the population).

A European inventory of emissions to inland waters – A first proposal – EEA – Technical report n°8, Copenhagen 1998

4.53. In some countries, emissions are registered above a certain threshold. For urban wastewater treatment plants, this threshold is itself often determined in *IE* (inhabitant equivalent) or *PE* (population equivalent), unit corresponding to the average daily emission of substances by one person. This daily emission also varies from one country to another, since the consumption patterns are not the same. In the longer term, emissions registers should integrate emissions to air, water and soil in order to model total environmental impacts of an activity.

5. Calculation of nutrient surplus for agriculture

4.54. Specific devices are needed to estimate diffuse emissions by agricultural activities (in their extensive meaning, including cattle breeding), since, as indicated before, some of these emissions should be accounted for to respect the global coherence of the accounts. The most frequently applied methods calculate the nutrient surplus brought by agriculture through models taking into consideration the types of crops, the characteristics of the soil, the meteorological conditions.

4.55. A technical report of the EEA[7] explains how this estimates has been undertaken in France on the basis on five sources of information:

- the land cover analysis provided by CORINE Land cover,
- corresponding administrative, hydrographical and geographical layers (municipalities, drainage basins, etc.),
- information derived from the agricultural census (crops, livestock, etc.),
- agronomic data on fertilisers spread and yields obtained,
- technical coefficients such as the nutrient content of the crops or the manure per head of cattle.

6. International sources

4.56. Within a more or less long period, the pollution discharged into rivers, lakes or groundwater reaches a regional sea and adds to its other pollution sources. Encouraged by the UNEP (United Nations Environment Programme), a number of international conventions have been signed with the aim of preserving the oceanic resource shared in common by several countries. Among them can be cited the Barcelona convention (within the Mediterranean Action Plan), the OSPAR convention (Convention for the Protection of the Marine Environment of the North-East Atlantic, derived from the Oslo and Paris former conventions), the HELCOM convention (Helsinki Convention on the Baltic sea).

4.57. In most of these conventions, a reporting obligation is included. For instance, article 9 of the OSPAR convention states that: "*The information]…[is any available information in written, visual, aural or data-base form on the state of the maritime area, on activities or measures adversely affecting or likely to affect it and on activities or measures introduced in accordance with the Convention*." Article 16 of the HELCOM convention requires that: "*On the request of a Contracting Party or of the Commission, the Contracting Parties shall provide information on discharge permits, emission data or data on environmental quality, as far as available*". The Mediterranean Land-Based Sources Protocol asks for: "*…(c) Quantities of pollutants discharged from their territories;…*"

4.58. As can be seen from these extracts, emission data are very often required in order to identify the sources upon which to act. Commissions or other forms of organisations (for example MEDPOL, Programme for the Assessment and Control of Pollution in the Mediterranean Region) have been designed to collect and analyse this information. When necessary, models have also been built to estimate the emissions to report to the Conventions (for instance TEOTIL in Norway, NOPOLU in France). Whatever the method chosen for its assessment, a lot of basic information has already been produced in these frameworks, which could be usefully re-organized to produce emission accounts at a low cost.

GLOSSARY

Stormwater: Rainwater which has run off the ground surface, roads, roofs, paved areas etc. and is usually carried away by drains. (Water and river commission, Department of environment, Australia, http://www.wrc.wa.gov.au/waterdef/index.html)

[7] Calculation of nutrient surpluses from agricultural sources – Technical report n° 51 – EEA – Copenhagen, 2000

Urban runoff*:* 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 (based on http://www.epa.gov/owow/nps/MMGI/Chapter4/ch4-8.html)

storm sewer--a sewer that carries only surface runoff, street wash, and snow melt from the land. In a separate sewer system, storm sewers are completely separate from those that carry domestic and commercial wastewater (sanitary sewers). (USGS)

Biological treatment: Processes which employ aerobic or anaerobic micro-organisms and result in decanted effluents and separated sludge containing microbial mass together with pollutants. Biological treatment processes are also used in combination and/or in conjunction with mechanical and advanced unit operations. To avoid double counting, water subjected to more than one type of treatment should be reported under the highest level of treatment only. (UNSD/UNEP Questionnaire 2004)

Advanced treatment: Process capable of reducing specific constituents in waste water not normally achieved by other treatment options. For the purpose of this questionnaire, advanced treatment technology covers all unit operations which are not considered to be mechanical or biological. In waste water treatment this includes e.g. chemical coagulation, flocculation and precipitation, break-point chlorination, stripping, mixed media filtration, microscreening, selective ion exchange, activated carbon adsorption, reverse osmosis, ultra-filtration, electroflotation. Advanced treatment processes are also used in combination and/or in conjunction with mechanical and biological unit operations. To avoid double counting, water subjected to more than one treatment should be reported under the highest level of treatment only. (UNSD/UNEP Questionnaire 2004)

Mechanical treatment. Processes of a physical and mechanical nature which result in decanted effluents and separate sludge. Mechanical processes are also used in combination and/or in conjunction with biological and advanced unit operations. Mechanical treatment is understood to include at least such processes as sedimentation, flotation, etc. To avoid double counting, water subjected to more than one treatment should be reported under the highest level of treatment only. (UNSD/UNEP Questionnaire 2004)

Point Source of Pollution: anthropogenic source of emissions that is located at an identifiable point in space. The term covers stationary sources such as sewage treatment plants, powerplants, other industrial establishments, and similar buildings and premises of small spatial extension. (On-line glossary of environment statistics, UNSD).

Non-point Source of Pollution: Description pollution sources that are diffused and without a single point of origin or not introduced into a receiving stream from a specific outlet. The pollutants are generally carried off the land by storm-water run-off. The commonly used categories for non-point sources are agriculture, forestry, urban areas, mining, construction, dams and channels, land disposal and saltwater intrusion. (On-line glossary of environment statistics, UNSD)

Chapter 5 Accounts for economic activities and products related to water and other transactions

A. Introduction

5.1. This chapter analyses monetary accounts for water related activities and products. The accounts presented in this chapter are fully consistent with the conventional accounts. However, since SNA accounts are not compiled at such level of disaggregation necessary to be used for water management purposes, a disaggregation and reformatting of the conventional accounts – obtained by focussing on specific economic activities and products – are made to describe in more details the economy of water.

5.2. In a first step, activities, products and transactions related to water are explicitly identified within the national accounts framework using detailed classifications. In a second step, the SNA accounts are expanded in order to explicitly identify activities carried out for own use (ancillary activities). These activities can be important in the case of water as, in some instances, they can be the largest water users in physical terms.

5.3. Many economic agents abstract water directly for own use: farmers practising irrigation, electric hydropower plants or other industrial establishments that abstract water directly etc. The same applies to wastewater treatment: enterprises and households may operate their own wastewater treatment facilities (industrial wastewater treatment plants, septic tanks, etc.). Even though the value of an individual ancillary activity's output is likely to be small compared with the other activities of an enterprise, the full extent of national expenditures on water can be understood only when all these activities are accounted for.

5.4. Section B presents monetary supply and use tables for products related to water. Section C describes accounts for the economic activities related to water which include also the case when these activities are carried out for own use. Section D introduces water protection and management expenditures. This section also shows the structure of the financing of these expenditures: the units that use water protection services, for example, do not always finance the total of their uses (that is they do not necessarily bear all the cost associated with the use) because they benefit from environmental protection transfers in the form of subsidies, investment grants, etc. These accounts show information on how the expenditures are financed, by which agent and by means of which instrument (sales of services, environmental taxes, etc.). Information on the financing of water related expenditures allows to determine the contribution of the various institutional sectors to the financing of expenditures and, more in general, to evaluate the burden of the various economic sectors on the environment. This information is also very relevant for assessing the implementation of the polluter/user-pay principle as it allows for the assessment of the portion of the total cost paid by the polluter/user.

5.5. Section E presents other monetary flows related to water (such as taxes and subsidies). Section F presents a brief discussion about pricing; Section G presents some of the indicators that can be derived from the accounts and section H presents data sources for the compilation of these accounts.

B. Monetary water supply and use tables

5.6. Monetary water supply and use tables record the output of water related products (supply table) and their uses (use table) - such as intermediate and final consumption.

5.7. The supply table of water related product is presented in Table 5.1. It describes the economic output related to water as well as imports to determine the total supply, in monetary units, of water related products. These products include natural water, operation of irrigation systems for agricultural purposes, sewage collection and treatment services and water related administrative services. The main water related products shown in the table include:

- CPC 18000: Natural water. This product is primarily associated with the output of the activity "collection, purification and distribution of water", ISIC 41;
- CPC 86110: Services incidental to crop production - operation of irrigation systems for agricultural purposes. This product is primarily associated with the output of "agricultural and animal husbandry service activities, except veterinary activities", ISIC 0140;
- CPC 91123: Administrative housing and community amenity services. This product is primarily associated with the output of "regulation of the activities of agencies that provide health care, education, cultural services and other social services, excluding social security", ISIC 7512. Note that ISIC 7512 provide a number of services, part of which is related to the administration of water supply, wastewater collection programmes;
- CPC 94120: Tank emptying and cleaning services and CPC 94110: Sewage treatment services. These services are primarily associated with the output of "sewage and refuse disposal, sanitation and similar activities", ISIC 9000.

5.8. There could be other minor products related to water which do not fit the breakdown presented in Table 5.1. These products include, for example, those associated with activities aimed at controlling water flows, including flood control, treating polluted water bodies or surveying water quality. These products are classified according to different classes of CPC. They could be recorded in another row "minor products" (Eurostat 2002b).

5.9. Even though the output is recorded at basic prices, Table 5.1 provides figures on total supply at purchaser's price (thus linking it to the use table which is recorded at purchaser's price) by adding information on taxes and subsidies and transport costs and trade margins which are not separately invoiced. These charges are not explicitly reported in supply table as they are often insignificant in the case of water.

5.10. The bulk of the (market or non-market) supply of water-related products should be recorded in columns relative to ISIC 0140, 41, 7512 and 90 and the other entries in the table should record zeros. Note that activities for the collection, purification and distribution of water, ISIC 41, and sewage and refuse disposal, ISIC 90, even when owned by the government should be classified under the relevant ISIC division (in this case, ISIC 41 and ISIC 90) and not under ISIC 75 (see paragraph 2.47 in chapter 2).

Table 5.1: Monetary supply of water related products

(monetary units)

	ISIC							Total output, at basic prices	Taxes on products	Subsidies on products	Imports	Total supply at purchaser's price
Type of products ⇩	ISIC 01	…	ISIC 41	…	ISIC 75	…	ISIC 90					
Operation of irrigation systems (CPC 86110)												
Total distributed water (CPC 18)												
Drinking water												
Non-drinking water												
Water distribution services												
Water related administrative services (CPC 91123)												
Sewage services (CPC 94120)												

Note: Shaded cells represent the significant non-zero entries in the table.

5.11. The use table records the uses of water related products for intermediate and final consumption, exports and changes in inventories. Table 5.2 shows the general structure of the use table for water related products.

5.12. Final consumption should be recorded as actual final consumption which includes "…the value of the consumption of goods acquired by households, whether by purchase (final consumption expenditures) or by transfer from government units or Non-profit Institutions Serving Households (NPISHs), and used by them for the satisfaction of their needs and wants" (para. 9.11, 1993 SNA). There are cases when water related services are not purchased directly by households, but they are provided to them by government and NPISHs for free of charge. The value of household actual final consumption is given by the sum of three components:

(a) The value of households' expenditures on consumption of goods or services, including expenditures on non-market goods or services sold at prices that are not economically significant. This include the expenditures incurred by households for the purchase of water related products (e.g. for water delivery or sewage collection) in the case that fees paid are symbolic and do not recover a substantial portion of the production costs.

(b) The value of the expenditures incurred by government units on individual consumption goods or services provided to households as social transfers in kind. This would include the difference between the imputed values of water related products supplied by the government and the expenditures incurred by households.

5.13. The information on actual final consumption for households is particularly useful for two reasons: it keeps the consistency between the monetary and physical use of water as the amount of money spent directly and indirectly for the receiving water corresponds to the volume of water used. Moreover, this information is particularly useful for the analysis of the cost recovery of water related services as it provides information on the total costs of water supply and how much of these costs are incurred by households. This is analysed in more detailed through the financing of expenditures in section D.

5.14. In Table 5.2, actual final consumption of general government includes the value of the collective (as opposed to individual) consumption services provided to the community, or large sections of the community, by general government, the actual consumption of which cannot be distributed among individual households or even among groups of households (1993 SNA para. 9.91). In the case of water, for example, administrative services of water control or water quality monitoring are services provided to the community and their use is attributed to the government as a collective consumer.

5.15. Changes in inventories are not explicitly mentioned in the table as they are generally insignificant: they correspond to changes in the volumes of already purified water, e.g. water stored in reservoirs (water towers).

Table 5.2: Use table of water related products in monetary terms

	ISIC							Total intermediate consumption	Final consumption		Exports	Total uses at purchaser's price
	ISIC 01											
Type of products ⇩	ISIC 0141	other	…	ISIC 41	ISIC 75	…	ISIC 90		by Government	by Households		
Operation of irrigation systems (CPC 86110)												
Total distributed water (CPC 18)												
Drinking water												
Non-drinking water												
Water distribution services												
Water related administrative services (CPC 91123)												
Sewage services (CPC 94120)												

Note: Shaded cells represent the significant non-zero entries in the table.

C. Accounting for water related activities

5.16. This section presents production and generation of income accounts for the major industries related to water. These accounts include information on the output (at basic prices), intermediate consumption (at purchaser's prices) and value added. Value added is then disaggregated into the components of the generation of income accounts. The accounts are described separately for activities carried out as principal (whose gross value added exceeds that of any other activity carried out within the same unit) or secondary activity and for activities are carried out for own use (ancillary activities).

1. Accounts for activities related to water

5.17. Accounts for principal or secondary activities related to water are constructed for the following four major activities when they are carried out as principal or secondary activity of an establishment:

- Operation of irrigation systems (ISIC 0140);
- Collection, purification and distribution of water (ISIC 41);

- Sewage and refuse disposal, sanitation and similar activities (ISIC 9000);
- Administration of potable water supply programmes and waste collection and disposal operations (ISIC 7512).

5.18. Table 5.3 shows the production and generation of income accounts for each industry. In particular, the table presents information on

- *Total output*. It consists of the value of those goods or services that are produced within an establishment and that become available for use outside that establishment, plus any goods and services produced for own final use (1993 SNA, para. 6.38).
- *Intermediate consumption*. It consists of the value of the goods and services consumed as inputs by a process of production, excluding fixed assets whose consumption is recorded as consumption of fixed capital; the goods or services may be either transformed or used up by the production process (1993 SNA, para. 6.147).
- *Value added (gross)*. It is obtained as output less the value of intermediate consumption. It is a measure of the contribution to GDP made by an individual producer, industry or sector; gross value added is disaggregated in
  - *Compensation of employees*. It is the total remuneration, in cash or in kind, payable by an enterprise to employees in return for work done by the latter during the accounting period.
  - *Taxes on production and imports*. They consist of taxes (compulsory, unrequited payments, in cash or in kind, made by institutional units to government units) payable on goods and services when they are produced, delivered, sold, transferred or otherwise disposed of by their producers and other taxes on production which consists mainly of taxes on ownership or use of land buildings or other assets used in production (see also section E).
  - *Subsidies* which are current unrequited payments that government units, including non-resident government units, make to enterprises on the basis of the levels of their production activities or the quantities or values of the goods or services which they produce, sell or import.
  - *Consumption of fixed capital* which represents 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.
  - *Net operating surplus* which measures the surplus or deficit accruing from production before taking account of any interest, rent or similar charges payable on financial or tangible non-produced assets borrowed or rented by the enterprise, or any interest, rent or similar receipts receivable on financial or tangible non-produced assets owned by the enterprise.

In addition, information on the fixed capital and labour inputs is also reported in the table as it represents important information on the profile of the producing industries.

5.19. The output is measured at basic prices. It is disaggregated in market and non-market output. Market output is output that is sold at prices that are economically significant or otherwise disposed of on the market, or intended for sale or disposal on the market. Non-market output refers to “goods and individual or collective services produced by non-profit institutions or government that are supplied free, or at prices that are not economically significant, to other institutional units or the community as a whole" (SNA glossary).

5.20. Non-market output is valued at cost of production which includes intermediate consumption, compensation of employees, other taxes less subsidies on production and consumption of fixed capital.

5.21. In Table 5.3 the producing units are grouped by column according to the institutional sector they belong to. In particular, three sectors are distinguished: the general government, corporations and households. The government sector includes non-market non-profit institutions (NPI) which are controlled and financed by the general government and government units whose accounts cannot be separated from those of the general government and, therefore, cannot be explicitly classified as quasi-corporations. The corporations sector includes all legal entities created for the purpose of producing goods or services for the market. They include unincorporated enterprises owned by government units (e.g. NPIs) which are engaged in market production and which are operated in a similar way to publicly owned corporations. These units are called quasi-corporations in the 1993 SNA. The households sector includes NPISHs which provide goods and services to their members or to other households without charges or at prices that are note economically significant. They are financed by the households. If they are financed by the government, they would be recorded either in corporations or in the government sectors according to whether they behave as corporation and whether their accounts are separately identifiable. Examples of NPISHs are local water supply associations of households in rural areas.

Table 5.3: Accounts for water related activities

Type of activity:	Operation of irrigation systems (part of ISIC 01)			Collection, purification and distribution of water (ISIC 41)			Water related administrative services (ISIC 75.12)	Collection and treatment of sewage (ISIC 90)		
Institutional sector:	Government sector	Corporations sector	Households	Government sector	Corporations sector	Households	Government sector	Government sector	Corporations sector	Households
1. Total output at basic prices										
1.1 Market output										
1.2 Non-market output										
2. Total intermediate consumption										
3. Total value added (gross) [=1-2]										
3.1 Compensation of employees										
3.2 Other taxes on production										
3.3 Less other subsidies on production										
3.4 Consumption of fixed capital										
3.5 Net operating surplus										
Fixed capital										
Gross fixed capital formation										
Closing stocks of fixed assets										
Labour inputs										
Total hours worked/ Number of workers										

2. Accounts for ancillary activities related to water

5.22. Many economic agents abstract water directly for own use: farmers may abstract water directly for irrigation purposes, electric power plants and other industrial establishments abstract directly water for their own use, etc. The same applies to wastewater treatment: enterprises and households may operate their own wastewater treatment facilities (industrial wastewater treatment plants, septic tanks, etc.). Since the accounts presented in the previous sections involve only those industries whose primary or secondary activities are relevant to water, focusing only on such industries would portrait a partial picture of the total water-related expenditures. It is therefore important to take into account ancillary activities related to water as in some cases they may be significant. Table 5.4 shows the general form of the accounts for ancillary activities of abstraction for own use. A similar table can be constructed for ancillary activities of wastewater treatment.

5.23. The 1993 SNA treats ancillary activities as integral part of the principal or secondary activities with which they are associated. As a result, all inputs consumed by an ancillary activity – materials, labour, consumption of fixed capital, etc. – are treated as inputs into the principal or secondary activity which it supports, and it is not possible to identify the value added of an ancillary activity because that value added is combined with the value added of the principal or secondary activity. Table 5.4 selects within their total production only those related to the self-supply of water or of wastewater treatment.

5.24. Whereas in national accounts no output is explicitly recognized and recorded for ancillary activities, in the SEEAW an output is recorded separately the value of which is given by costs of production. Table 5.4 shows the output of ancillary activities related to water valued at costs where costs include intermediate consumption, compensation of employees, other taxes less subsidies on production and consumption of fixed capital related to these ancillary activities. For example, when a manufacturing establishment treats its own wastewater, the value of the output of this ancillary activity is given by the costs of all inputs necessary for the operation of the industrial wastewater treatment plant: energy, chemicals and labour, as well as the corresponding other taxes and subsidies, and the economic depreciation (consumption of fixed capital) of the equipment for treatment.

5.25. The accounting method consisting in recording an output for ancillary activities is called 'externalisation'. Although this increases the total output of the economy, it does not modify the value added and hence the Gross Domestic Product (GDP), as this output (of ancillary activities) is offset by a corresponding intermediate (self)-consumption. For water policy it is important to have information on the total expenditures incurred by industries for abstracting water for own use and treating wastewater. For this reason, the SEEAW recommends the externalisation of ancillary activities related to water.

5.26. In addition to describing accounts for ancillary activities by industries (e.g. direct abstraction of water from a river by a manufacturer of basic metals for cooling purposes), Table 5.4 provides information on the costs of activities related to water carried out by households for their own consumption (e.g. self-supply of water with individual pumps).

5.27. The information required for Table 5.4 will often be available for wastewater management from established specific data collection systems such as national environmental protection expenditure surveys and other sources on environmental expenditure. Some of these sources may not provide all variables. For example, compensation of employees, intermediate consumption and taxes on production may only be available as a sum of 'current expenditure'; data on consumption of fixed capital may not be available directly and will have to be estimated using established national accounts procedures. For self-supply of water such specific sources are not likely to be available in many countries at present. Physical quantities of water abstracted for self-supply and average costs could be used to estimate these data.

Table 5.4: Economic accounts for ancillary activities of abstraction for own use

	ISIC				Total industries	Households	Total
	ISIC 01	ISIC 02	…	…			
Total output (at costs)							
Intermediate consumption							
Compensation of employees							
Other taxes on production							
Less other subsidies on production							
Consumption of fixed capital							
Gross fixed capital formation							
Closing stocks of fixed assets							
Labour inputs in total worked hours/ Number of workers							

D. Water protection and management expenditure accounts

5.28. Accounts can be compiled for environmental activities defined according to their purposes. In particular, two activities are considered: environmental protection and natural resource management and exploitation expenditures (para 5.26, SEEA 2003).

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

29.1. In particular, in the environmental domain of water resources, activities for wastewater management and for the protection and remediation of soil, groundwater and surface water are considered for the protection of the environment and are part of the Classification of Environmental Protection Activities and Expenditure (CEPA). Wastewater management is an activity identified within ISIC: it corresponds to (a part of) the ISIC 9000 industry. The protection and remediation of soils, groundwater and surface water is also a part of ISIC 9000, however, the output is rarely recorded at a sufficient level of detail, so that the activity and matching product rarely appear in economic statistics. A more detailed description of environmental protection expenditure accounts (EPEA) can be found in the manuals of Eurostat (Eurostat 2002a, 2002b)

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

5.31. Table 5.5 and Table 5.6 present an example of accounts for wastewater management services (which are classified as environmental protection activities). Similar tables can be constructed for water management and exploitation expenditures.

5.32. Table 5.5 provides information on the supply of these services. By column, producers of wastewater management services are classified into specialised and non-specialised producers. Specialised producers are defined as those producers that execute an environmental protection activity as their principal activity. They mainly correspond to producers classified in the class ISIC 9000. Non-specialised producers are those producers which execute an environmental protection activity as their secondary or ancillary activity. Some industries other than ISIC 9000 may have some secondary output of wastewater management services; others may have their own wastewater treatment plants (ancillary activities). In both cases capital and current expenditures linked to these activities are recorded in the expenditure accounts.

5.33. Since in many countries general government units (municipalities) carry out wastewater services, a disaggregation is made between specialised producers of the general government, corporations and household sector. Furthermore, most often, even if the service is provided by private enterprises, general government units are still legal owners of the sewage networks, of the treatment plants, etc., and by recording only expenditures by the corporations, a large part of capital expenditures would be missing.

5.34. Table 5.5 presents by row information on output, intermediate consumption, compensation of employees, taxes and subsidies on production, consumption of fixed capital and net operating surplus. Information on gross fixed capital formation for environmental protection is also reported in the table.

Table 5.5: Accounts for producers of wastewater management services

	Characteristic producers				
	Specialised producers			Non-specialised producers	Total
	Government sector	Corporations sector	Household sector		
Output					
Market					
Non-market					
Intermediate consumption					
of which EP services					
of which adapted and connected products					
Compensation of employees					
Other taxes on production					
Other subsidies on production					
Consumption of fixed capital					
Net Operating surplus					
Gross fixed capital formation					

5.35. Table 5.6 presents information on the use of wastewater management services. The objective of this table is to derive aggregate "national expenditure for environmental protection" and describe it by its components (by row) and by the categories of units to which the expenditure is allocated (by column).

5.36. The various components of national expenditure for environmental protection consists mainly in the following:

- uses of environmental protection services (except by specialised producers)
- uses of connected and adapted products. Connected products are products whose use by resident units directly and exclusively serves an environmental protection objective but which are not environmental protection services produced by an environmental protection activity. Adapted (or 'cleaner') products are defined (SERIEE § 2026) as products that meet the following criteria: (a) on the one hand, they are less polluting when consumed and/or disposed than equivalent normal products. Equivalent normal products are products that provide similar utility, except for the impact on the environment. (b) on the other hand, they are more costly than equivalent normal products. Only the extra cost paid in order to make an adapted product available to the user is considered as environmental protection expenditure in the EPEA. In the wastewater domain, connected products consist of septic tanks.
- capital formation for environmental protection (including net acquisition of land).
- specific transfers for environmental protection.

5.37. In general, national expenditure for environmental protection measures the total of economic resources that a nation uses for environmental protection. It is defined as follows:

	Uses of environmental protection services by resident units (final, intermediate consumption and capital formation)
plus	Capital formation for environmental protection
plus	Uses of connected and adapted products by resident units
plus	Specific transfers for environmental protection
	Total domestic uses
less	Financed by the rest of the world
	National expenditure

5.38. The categories of units to which the expenditure is allocated are:

- households as actual consumers of individual environmental protection services and connected and adapted products, or as beneficiaries of specific transfers
- government in its capacity as consumer of collective services (i.e., as collective consumer of non-market output)
- specialised producers of environmental protection services for their investment for environmental protection
- other producers as they use environmental protection services (including the use of environmental protection services produced in-house, i.e. ancillary environmental protection services) and connected and adapted products for their intermediate consumption, invest for their ancillary environmental protection activities and benefit from specific transfers
- the rest of the world as it benefits from specific transfers.

Table 5.6: Environmental protection expenditure for wastewater management

	Users							
	Industries				Final consumers		Rest of the world	Total
	Specialised producers			Non-specialised producers				
	Government sector	Corporations sector	Household sector		Government	Households		
1. Use of wastewater treatment services								
Intermediate consumption								
Final consumption								
2. Use of adapted and connected products (e.g. septic tanks)								
3. Capital formation for environmental protection								
4. Specific transfers								
5. Total domestic uses (1 + 2 + 3 + 4)								
6. Of which: financed by the rest of the world								
National expenditures (5-6)								

1. *Financing of environmental protection and water management expenditures*[8]

5.39. For policy purposes, additional information is often necessary to understand the financing of the environmental protection and water management expenditure undertaken by the different sectors of the economy. It is important to answer the following questions: who finances the expenditure? What are the consequences on production and employment? What is the net cost burden for different industries? For example, the demand for wastewater collection and treatment leads to investments, intermediate consumption, employment, etc. Information on the expenditure for environmental protection can be used to analyse the consequences of a given policy on the costs of production, employment of different activities, etc. In this way environmental policies can be based on sound cost-benefit analyses. The discussion on financing is presented mainly for environmental protection expenditures, but similar arguments and table are valid also in the case of water management and exploitation expenditures.

5.40. The units that consume environmental protection services or connected and adapted products or invest for environmental protection are not necessarily the financing units, i.e. those actually bearing the costs. The EPEA framework allows determining the financing units, for the different components of the national expenditure.

5.41. General information on the financing of environmental protection expenditure is found in SEEA 2003 (paragraphs 5.135 to 5.144) and SERIEE 2002 (Environment Protection Expenditure Accounts Compilation Guide, section 5.7). The general structure of the environmental protection expenditures financing table, as recommended by the SEEA and SERIEE, is presented in this section. Table 5.7 presents information on how national expenditures for environmental protection are financed by category of users/beneficiaries of the financing.

5.42. Table 5.7 presents by column different categories of users/beneficiaries which corresponds to those in the use table of environmental protection presented in the previous section. They include:

[8] This section is based on the Eurostat Manual on *Environmental Protection Expenditures - A compilation Guide*, Eurostat (2002a).

producers (specialised and non-specialised), consumers (government and households) and rest of the world.

5.43. In Table 5.7 national expenditure are disaggregated by row according to the financing units (actually bearing the cost) which are classified according to the institutional sectors of the national accounts: general government (classified in central and local government), non-profit-institutions serving households (NPISHs), corporations, and households.

5.44. The expenditures recorded in the column for specialised producers (e.g. waste water operators, ISIC 9000) correspond to their capital formation. Entries therefore describe how capital formation by specialised producers is financed. In general, specialised producers finance their capital formation themselves. However, the government may finance, through investment grants, a part of the capital formation of specialised corporations.

5.45. Expenditure recorded for other producers corresponds to their intermediate consumption of EP services (including ancillary services) and connected and adapted products plus their capital formation for ancillary environmental protection activities and specific transfers they receive. Entries in the column describe how this expenditure is financed. In general, other producers finance themselves, their intermediate consumption and capital formation. However, specific transfers can exist that lower the price they pay for EP services or connected and adapted products. In this case the government finances a part of their expenditure. In the same way, investment grants can exist for their capital formation.

Table 5.7: General structure of environment protection expenditure financing table

	USERS/BENEFICIARIES						
	Producers		Consumers		Rest of the world	Total	Of which current expenditure
FINANCING SECTORS:	Specialised Producers	Other Producers	Households	Government			
General government							
Central govt	X	X	X	X	x	X	X
Local govt	X	x	X	X	x	X	X
NPISHs	x	-	x	-	x	x	x
Corporations							
Specialised producers	X	x	x	x	x	x	x
Other producers	x	X	x	x	x	x	X
Households	x	x	X	x	x	x	X
National expenditure	X	X	X	X	x	X	X
Rest of the world	x	x	x	x	x	x	x
Domestic uses	X	X	X	X	x	X	X

Source; Eurostat 2002, p. 96

Note: X means 'important item', x 'often small', - 'not relevant or zero by definition'.

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

- Government finances the part of household consumption that takes the form of government expenditure on individual consumption goods and services. For example, where the government provides a grant (or rebate) for the purposes of installing water saving devices, such as reduced flow showerheads or dual-flush toilets.

- Government finances the subsidies that lower the price of environmental protection services or products. For example, governments may subsidise sewage providers, thus lowering the cost of sewage provision to households that use this service. However, when subsidies originate in earmarked taxes it is assumed that the units that pay the taxes (in general households and other producers) are the financing units.

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

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

An example of financing of expenditure for wastewater and water protection services in Australia

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

5.50. Table 5.8 presents the financing of national expenditure on wastewater management and water protection by sector, taking into account subsidies, grants and other transfers whenever it was possible to identify them. It was not possible to identify some transfers – these are shown as "not available" (n.a.) in the table.

Table 5.8: Financing of National Expenditure for Waste Water and Water Protection Services – Australia 1996-97

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

Source: Environment Protection Expenditure Australia, 1995-96 and 1996-97 (ABS cat. no. 4603.0)

(a) General government as collective consumer. Not collected for local government.
(b) Households as actual consumers.
(c) n.a = not available

Note: Sums will not necessarily equal totals as some of the breakdown was not available.

5.51. The table shows that in Australia in 1996-97 households financed AUD$1750 million or 58% of total expenditure in this area. The bulk of this was paid as charges for sewage services provided by specialist producers, with very small amounts paid for septic systems (on-site treatment and storage) and urban stormwater drainage. In Australia NPISH are not separated from households. The data in Table 5.8 is a rearrangement of other data presented on environmental protection expenditure published in Environment Protection Expenditure Australia, 1995-96 and 1996-97 (ABS cat. no. 4603.0) by ABS.

5.52. Data sources for the compilation of environmental expenditure accounts in Australia included:

- ABS collections (e.g. waste management industry survey; water and sewage survey);
- Additional questions on existing surveys (e.g. manufacturing, mining, agricultural, utilities, and service industry surveys);
- Special environment protection expenditure surveys (of local governments and mining and manufacturing industries);
- Public reports from governments, corporations and industry associations;
- Government budget papers.

E. Taxes, subsidies, rent and water rights

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

1. Taxes, subsidies and rent

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

5.55. It must first be clarified that sometimes taxes and fees are used as a payment of a service (e.g. water delivery or collection of wastewater). In many countries, notably where water use is not metered, water services are recovered through local 'taxes' paid to the municipality, the county etc. In the accounts, these taxes are to be considered as payments in counterpart to a service, equivalent to a price (see 1993 SNA paragraph 8.54(c)) although they may not cover the total cost of the service. These taxes are therefore recorded in the use table, Table 5.2, as a purchase of water related products.

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

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

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

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

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

5.58. Thus payments to government on access (including abstraction and exploitation) of water resources, granted with little or no work on the part of the government, are recorded as other taxes on production (1993 SNA, D29) when paid by enterprises and other current taxes (1993 SNA, D59) when paid by households (IMF 2001, para. 5.38) when the resource is not owned by the government. However, when government uses the issue of license to exercise a regulatory function (for example, by carrying out some sort of control that it would otherwise not be obliged to) the sale of licenses should be recorded as a sale of services (based on para. 5.54 IMF 2001). Payment on access to water resources owned by the government units are recorded as rent (, IMF 2001, para. 5.94)

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

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

2. Water rights

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

- Governments devise plans to share the volume that is available for consumption among the holders of each class of right. Water rights are defined in volumetric terms, with a statement of the probability that the nominal volume will be delivered in full in any given year.

- Governments and courts recognize historic claims to access fixed volumes of water on a strict priority basis determined by the length of time each right has been held (Productivity Commission 2003).

5.62. Governments generally also seek to ensure that sufficient water is available for a variety of environmental purposes. Water for the environment may be allocated in volume terms or by using rules (see ABS 2004, Water Account, Australia).

5.63. In countries and jurisdictions using the 'planning' approach, governments explicitly set out to achieve a balance between the economic, social and environmental objectives of the community, despite uncertain community preferences and environmental effects. For example, in Australia several state governments issue licenses which can be adjusted to obtain additional water for the environment. The timing and volume of water requested by right holders may also be varied administratively.

5.64. In countries with secure and tradable permanent water rights, such as in the states of California and Colorado of the United States of America, agencies obtain additional water for the environment by purchasing existing rights from the current right holders; harvesting additional water; or investing in water savings programs.

5.65. Restrictions on water trading and problems associated with determining how a volume of water in one area can be compared to a volume of water in another area can impact on the ability of owners to exercise water rights. Similarly, subsidies and differences in the level of cost recovery in the pricing of infrastructure by water suppliers (ISIC 41) potentially reduce the efficiency of water trading.

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

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

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

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

5.70. No country has put the values of water rights into the water accounting framework. However, the volumes of surface water rights have been tabulated for each river basin in Australia for the year 2000 (see NLWRA 2001) and many countries report the price paid for water supplied by water utilities (ISIC 4100). Water and water rights are traded in several nations. For example in Australia, Chile, Mexico, South Africa and USA (Productivity Commission 2003). Data on the volume and value of trading has been summarised in the Australian water accounts (ABS 2004) and by other agencies in Australia (e.g. Appels et al. 2004). See Table 5.9 and Table 5.10 respectively.

Table 5.9: Volume and number of water rights transferred in South Australia, 2000-01

	Temporary transfers		Permanent transfers		Total transfers	
	no.	ML	no.	ML	no.	ML
Angas Bremer	—	—	1	5	1	5
Barossa Valley	4	165	3	31	7	195
Comaum-Caroline	10	1 114	31	1 867	41	2 981
Ladepede Kongorong	1	48	6	932	7	981
Mallee	2	217	3	719	5	936
McLaren Vale	—	—	7	6 723	7	6 723
Northern Adelaide	32	697	25	311	57	1 008
Narracoorte	10	1 424	26	1 708	36	3 132
Padthaway	2	206	2	130	4	336
River Murray	157	45 846	71	40 692	228	86 538
Tatiara	9	1 069	9	758	18	1 827
Total	**227**	**50 787**	**184**	**53 876**	**411**	**104 663**

Source: ABS 2004 Water Account. p. 112.

— nil or rounded to zero (including null cells).

Note: Sums may not necessarily equal totals due to rounding.

Table 5.10: Value of water rights traded in Australia.

Estimated value of water traded [(a)(b)] – 1988-99 to 1999-2000

Size of purchase (ML)	No. of purchases	Estimated value ($)
0 to 99	24	823 830
100 to 499	21	3 834 600
500 to 999	3	2 118 900
1000	3	3 150 000
Total	**51**	**9 927 330**

Source: ABS 2004 Water Account. p. 112

(a) Based on average price data from survey of purchasers (n=23, average price of $1.05/KL)

(b) For New South Wales, Victoria and South Australia only.

F. Pricing

5.71. Water pricing is an important policy instrument to create incentives for water conservation and efficient water allocation. There may be several objectives behind a water pricing policy including cost recovery, redistribution of income, improvement of water allocation and water conservation. A more general perspective of water pricing in water policy is presented in chapter 10. This section presents how to determine the average prices of water from the physical and monetary accounts and how to use this information to determine whether water pricing recovers the costs of water servic es. The EU Water Framework Directive and the Johannesburg Plan of Action both require water prices be set to recover the costs of water services (see Box 5.1). These costs usually coincide with the cost of water supply even though some might argue that these costs should include more in general costs for water management.

5.72. The costs of water supply include both the operation and maintenance costs – current costs - and the capital costs of constructing the distribution system. These costs should be charged to the user. However, it is often the case that only the current costs are actually recovered while the cost of fixed capital (such as the meters) are often left unrecovered (Dinar and Subramian 1997). Current and capital costs can be derived from the monetary accounts in Table 5.3 and they include: intermediate consumption, compensation of employees, [other taxes and subsidies on production] and consumption of fixed capital.

5.73. Often the cost of water supply differs depending on the end-user as the distribution scheme may involve different capital and current costs. For example, delivering water to households may involve higher maintenance costs than delivering water to industries. If data are available , it could be useful to distinguish the cost of water supply according to the end-user. In Namibia (Department of Water Affairs “Draft Summary of Waster Accounts”, 2004) detailed information is available on the full cost recovery unit price (which includes capital, operational and maintenance costs) for each of the water supply scheme of Namwater’s which is the bulk water supplier in Namibia. By multiplying the full cost recovery unit price by the amount of water supplied to each customer it is possible to obtain the total cost of water supply by end-users (classified according to the economic sector they belong to).

Box 5.1: Policy requirements for water pricing

Johannesburg Plan of Action:

"Develop integrated water resources management and water efficiency plans by 2005, with support to developing countries, through actions at all levels to: (b) Employ the full range of policy instruments, including regulation, monitoring, voluntary measures, market and information -based tools, land –use management and cost recovery of water services, without cost recovery objectives becoming a barrier to access to safe water by poor people, and adopt an integrated water basin approach; (Johannesburg Plan of Action, para. 26(b))

Water Framework Directive:

"Member States shall take account of the principle of recovery of the costs of water services, including environmental and resource costs, having regard to the economic analysis conducted according to Annex III, and in accordance in particular with the polluter pays principle. Member States shall ensure by 2010:

- that water-pricing policies provide adequate incentives for users to use water resources efficiently, and thereby contribute to the environmental objectives of this Directive,
- an adequate contribution of the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services, based on the economic analysis conducted according to Ann1ex III and taking account of the polluter pays principle.

Member States may in so doing have regard to the social, environmental and economic effects of the recovery as well as the geographic and climatic conditions of the region or regions affected." (Article 9). (EU Water Framework Directive).

5.74. When such detailed information is not available, a good approximation of the costs of supply by end-users is given by information on the costs of water supply by type of water (namely, drinking, non-drinking, irrigation water, etc.).

5.75. The average purchaser's price of water can be obtained by dividing information on the amount of money paid for receiving water by its use in physical terms. This can be achieved by dividing information in Table 5.2 by the corresponding information in physical units from Table 3.4. The results are average prices that allow comparing prices across industries and countries (or regions, according to the geographical level at which these tables have been built). This average price is often referred to as the implicit (unit) price of water. Table 5.11 presents the implicit price of water related products in Spain. It shows that irrigation water (83% of the volumes supplied, excluding self-supplies) is provided almost free. This table also displays that households are generally charged for distributed water more than industries, but less for services of collection and treatment of wastewater.

5.76. When available, information on the tariffs charged to end-users could also be used to calculate the average unit price of water. However, attention should be paid to the way tariffs are set as they may not be set for unit of water used, but be composed by a flat and variable rate. In these cases, the average unit price of water is better estimated by dividing the total costs of water used by its quantity.

Table 5.11: Implicit prices of water related products in Spain in 1999 in ESP/m^3

	Part operation of irrigation systems	Drinking water	Non drinking water	Distribution services of drinking water	Distribution services of non-drinking water	Total distributed water	Water related administrative services
Total of intermediate consumption by economic activities	**3.04**	**67.83**	**25.33**	**8.98**	**79.2**	**82.73**	**30.81**
O1 Operation of irrigation systems		86.26		29.87			18.07
A Agriculture, Hunting and forestry	3.04	8.92	26.73	1.16	11.7	27.26	19.89
B Fishing		88.31		11.66		108.23	17.44
CA Mining and Quarrying of energy producing materials		22.76		3.16		44.88	33.2
CB Mining and Quarrying except energy producing materials		24.24		3.46		63.19	7.49
DA Manufacture of food products; beverages and tobacco		76.03		9.88		107.4	42.13
DB Manufacture of textiles and textile products		87.01		11.36		169.89	45.83
DC Manufacture of leather and leather products		75.31		8.99		167.49	39.08
DD Manufacture of wood and wood products		59		7.58		81.41	33.29
DE Manufacture of pulp, paper and paper products; publishing and printing		62.78		8.16		121.96	30.53
DF Manufacture of coke, refined petroleum products and nuclear fuel		51.43		6.69		70.83	39
DG Manufacture of chemicals, chemical products and man-made fibers		64.31		8.35		91.71	37.52
DH Manufacture of rubber and plastic products		60.61		7.87		99.62	34.03
DI Manufacture of other non-metallic mineral products		70.32		9.33		91.21	26.48
DJ Manufacture of basic metals and fabricated metal products		76.02		9.87		94.97	28.75
DK Manufacture of machinery and equipment n.e.c.		75.26		9.77		101.77	41.74
DL Manufacture of electrical and optical equipment		71.64		9.33		95.24	25.73
DM Manufacture of transport equipment		60.28		7.86		71.66	24.82
DN Manufacturing n.e.c.		61.92		8.1		82.64	28.75
41 Collection, purification and distribution of water							53.89
E Electricity, gas and water supply		83.27		10.85		113.24	45.86
F Construction		73.42		9.55		85.71	17.38
75 Public administration and defense; compulsory social security		88.24		12.64		103.59	24.74
90 Sewage removal and treatment							
R Others activities (G to Q, except 75 y 90)		56.36	16.74	7.37	29.81	51.94	
Total final consumption		**80.76**	**48.23**	**10.65**	**19.5**	**90.26**	**28.16**
By government		86.39	28.14	9.73	0	92.95	36.44
By NPISH							
By households		86.39	28.14	9.73	0	92.95	36.44
Total use	**3.04**	**79.32**	**25.97**	**9.44**	**61.26**	**88.58**	**35.11**

Source: *Eurostat Working Paper n°2/2001/B6 – Water Satellite Accounts for Spain 1997-1999.*

5.77. Water pricing schemes vary among countries responding to different situations and policy concerns. In general uniform tariffs and minimum prices do not provide incentives for water conservation and efficient water use. Tariffs that reflect the volume of water used are often preferred as they would signal inefficiencies in water use. In general tariffs include two components: a fixed and a variable part. The fixed part is not related to the volume of water used but to characteristics of the user: in the case of irrigation, for example, they relate to the crop, unit of area, year, season, month, water entitlement or water velocity. This choice depends on the specific policy objective of the water pricing (cost recovery, income distribution etc.). The variable component of the water prices reflects the amount of water used.

5.78. A collection of country experience on water pricing prepared by Dinar and Subramanian (1997) revealed that "…prices for cubic meter for agriculture and domestic sector were relatively similar across countries, while prices for industrial water vary more widely across countries, probably because some countries view industry as an easy source of revenue capable of subsidizing consumption in other sectors. In addition some countries include pollution taxes in industrial water prices."

5.79. Recently countries are exploring the possibility of charging different prices for irrigation water of different quality (saline, freshwater, freshwater), adjusting prices to reflect water supply reliability, and implementing a resource depletion charge and including charges for safer drinking water by including treatment costs in the water tariffs(Dinar and Subramanian, 1997).

G. Derived indicators

5.80. A number of indicators can be derived from the accounts presented in this chapter. In order to compare expenditures between regions or countries, care must be used to eliminate possible sources of distortions in the comparisons such as the size effect of either population, gross domestic product (GDP) etc. Examples of these indicators include: expenditure per capita, expenditure per cubic metre of water used, expenditure as a percentage of the GDP or of gross fixed capital formation (GFCF). Table 5.12 shows how different the expenditure for environmental protection of water within the OECD can be. The table also displays which units in the country are the major contributors to these expenditures. Within a country, such comparisons can be undertaken at the level of the river basins. This kind of indicators can also be used in order to study changes over time.

Table 5.12: Investment and current expenditure in Pollution Abatement Control for Water

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

Source: OECD PAC Expenditure – OECD – 1996.

* at current purchasing power parities

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

5.82. For instance, the pilot water accounts elaborated in Sweden[9] displayed that receipts (essentially fees paid by the users) cover about 93% of the current costs. In this country, municipalities generally carry out the water services and a balance of the current costs is requested from them, the capital costs being born by general government. This aim is not entirely reached.

5.83. In Ireland, unlike in many OECD countries, no contribution is directly asked to the households. All related costs are now financed through the budget of the counties. Table 5.13 presents a comparison between costs and receipts of water related services in Ireland. From this table a lot of information can be derived, directly or indirectly: the evolution of the unit costs, the differences in the costs of domestic and non-domestic uses, the rate of recovery for each type of users, etc.

Table 5.13: Comparison between costs and receipts of water related services in Ireland (national accounts data in 1 000 IEP)

	1994	1995	1996	1997	1998
PUBLIC WATER SUPPLY					
Current					
Expenditure incl. Admin.	99 917	106 427	112 002	116 974	123 294
Of which: Domestic	63 947	67 049	69 441	71 354	73 977
Non-domestic	35 970	39 378	42 561	45 620	49 318
Receipts from charges	72 030	77 650	74 920	45 860	42 310
Of which: Domestic	39 780	44 880	40 870	10 400	2 310
Non-domestic	32 250	32 770	34 050	35 460	40 000
Capital					
Expenditure incl. Admin	30 418	68 080	66 173	82 208	n.a
Quantity of water consumed (million m^3)	259	265	272	279	287
Domestic	161	162	164	166	168
Non-domestic	98	104	109	113	119
Current cost per m^3 (IEP)	0.39	0.40	0.41	0.42	0.43
Of which: Domestic	0.40	0.41	0.42	0.43	0.44
Non-domestic	0.37	0.38	0.39	0.40	0.42
WASTEWATER SERVICES					
Current					
Expenditure incl. Admin	43 652	45 212	48 449	51 483	56 518
Of which: Domestic	37 105	38 431	41 181	43 761	48 040
Commercial	6 548	6 782	7 267	7 722	8 478
Receipts from charges	7 390	9 490	9 230	8 580	7 630
Of which: Domestic	1 340	3 250	2 740	1 820	10
Commercial	6 050	6 240	6 490	6 760	7 620
Capital					
Expenditure incl. Admin	65 905	56 654	67 615	104 440	n.a.

Source: Environmental accounts: Time series + eco-taxes – ESRI, February 2001

H. Data sources and methods

5.84. There is a variety of data sources that are used to compile the monetary accounts presented in this chapter. The choice of one versus the other depends on the organizations of the national water management system (for example, whether it is centralized or decentralized system, or whether the water supply is generally metered or not, etc.).

[9] Water accounts – Physical and monetary data connected to abstraction, use and discharge of water in the Swedish NAMEA – Statistiska centralbyrån – Report to Eurostat –December 1999

5.85. Data sources for the compilation of monetary accounts include:

- **Surveys**: economic units are asked information on their water use, cost structure of water related activities;
- **Administrative data**: information about water is a by-product of administrative records collected for other purposes: for instance, the sale of enterprises producing water-related services can be derived from the yearly declaration of these enterprises to the tax offices. Information on water can also be obtained through the analysis of the content of licenses or taxation registers (licenses to abstract water or to discharge wastewater, taxes on water abstraction or water pollution, etc.).
- **Environmental reports of enterprises**: in some countries large enterprises produce environmental reports in parallel to their annual economic accounts from which information about water is derived.
- **Application of coefficients**: a certain behaviour of the economic units has been observed in the past, or on a small population to be extrapolated (monographs), or has been noted in the literature: the economic units with the same characteristics are supposed to have a behaviour directly linked to another economic variable, for instance the same consumption of litres of water per euro of sales. In a way, this method is very close to the survey method but is based on a weaker foundation.
- **Modelling**: this method is similar to the method of coefficients but is more sophisticated in the sense that several variables are used and that the link can be non-linear.
- **Mixed methods**: in a large number of cases, the information given by one method is insufficient and has to be completed: for instance, for manufacturing industries survey results are available, coefficients are used for the services industries and a model is applied to agriculture.

5.86. Data sources for water protection and management expenditures also vary according to the type of economic activity for which information needs to be collected. For example, for environmental protection expenditures, types of data sources[10] include

National accounts

5.87. Where the national accounts are sufficiently detailed much of the data necessary for compiling expenditure accounts is directly available. The compilation of national accounts includes the establishment of tables at a very detailed level (e.g. production accounts for detailed divisions or groups of ISIC, supply-use tables for specific products of the CPC), and the construction of comprehensive databases on the various sectors of the economy (sales and commercial accounts for corporations by detailed categories of ISIC, disaggregation of government transactions, etc.). It is important for the compilation of the EPEA to have access to these database and tables.

Production statistics

5.88. Specialised EP producers are subject to regular surveys in the general statistical process (production statistics). These producers are mainly found in class 9000 of the ISIC. Through these surveys several variables are collected: sales (by product according to CPC or specific national

[10] Based on Eurostat (2002) SERIEE environmental protection Expenditure accounts – Compilation guide.

classification of products), intermediate consumption, compensation of employees, taxes paid on production, subsidies received for production, investments, employment, etc.

5.89. Surveys of producers of other classes of the ISIC could also be useful. Although the principal activity of these producers is not environmental protection, they may produce EP services as secondary output (e.g. producers classified under recycling, construction, water distribution, etc.). Specific Environment Industry surveys can provide useful data on secondary output of EP services as well as data on producers of equipment and facilities specific to environmental protection (e.g. pipes for sewage systems, incineration plants, etc.) which constitute a source of data for the assessment of gross fixed capital formation for EP.

Analysis of accounts of government and finance statistics

5.90. As concerns activities of government units several data sources exist. The most widely used is the detailed analysis of budgets (in particular for central and regional governments and large cities) or government finance statistics. This analysis is part of the process of compilation of national accounts for the general government institutional sector. However, generally the results are rather aggregated and a specific analysis has to be made for assessing environmental protection outlays of government. Starting from the list of the government units involved in environmental protection, the objective of this analysis is to derive the outlays for the production of EP services as well as other outlays and receipts (transfers given and received, receipts from fees and charges, etc.).

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

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

Industry expenditure surveys

5.93. As concerns ancillary activities, i.e. the measures undertaken by firms to reduce their environmental impact, specific surveys are the main data source. These surveys provide data on investments made for environmental protection (end of pipe equipment or installations, extra cost of integrated technologies) and often also on current EP expenditure (intermediate consumption, compensation of employees, etc.). Data from business associations and engineering estimates could also be a useful data source.

Other sources

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

5.95. Various other sources allow to complement the previous data. Examples are construction statistics (investments in sewerage systems, wastewater treatment or incineration plants, etc.), business associations (domestic production or domestic market of connected and adapted products, level of environmental protection in the main industries), environmental reports of large firms (e.g. in the noise domain transportation firms or airport management entities; in the air domain refineries, power plants, etc.).

5.96. Other sources may be R&D statistics, physical data on sewage networks and waste disposal facilities to estimate capital stocks, environment industry market estimates, price statistics, employment statistics, etc. Some of the data needed will have to be based largely on estimates and calculations. For example, expert knowledge and specialised literature may offer coefficients for the costs of adapting vehicles to meet environmental requirements. The total expenditure can then be calculated based on the total number of new vehicles.

Glossary

Actual final consumption of households: Actual final consumption of households is the value of the consumption goods and services acquired by households, whether by purchase in general, or by transfer from government units or NPISHs, and used by them for the satisfaction of their needs and wants; it is derived from their final consumption expenditure by adding the value of social transfers in kind receivable. (1993 SNA on-line glossary)

Ancillary activity: An ancillary activity is a supporting activity undertaken within an enterprise in order to create the conditions within which the principal or secondary activities can be carried out; ancillary activities generally produce services that are commonly found as inputs into almost any kind of productive activity and the value of an individual ancillary activity's output is likely to be small compared with the other activities of the enterprise (e.g. cleaning and maintenance of buildings).

Consumption of fixed capital: Consumption of fixed capital represents 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. (1993 SNA on-line glossary)

Final consumption: Final consumption consists of goods and services used up by individual households or the community to satisfy their individual or collective needs or wants.

Generation of income account: The generation of income account shows the types of primary incomes and the sectors, sub-sectors or industries in which the primary incomes originate, as distinct from the sectors or sub-sectors destined to receive such incomes

Intermediate consumption: Intermediate consumption consists of the value of the goods and services consumed as inputs by a process of production, excluding fixed assets whose consumption is recorded as consumption of fixed capital; the goods or services may be either transformed or used up by the production process. (1993 SNA on-line glossary)

Principal activity: The principal activity of a producer unit is the activity whose value added exceeds that of any other activity carried out within the same unit (the output of the principal activity must consist of goods or services that are capable of being delivered to other units even though they may be used for own consumption or own capital formation).

Secondary activity: A secondary activity is an activity carried out within a single producer unit in addition to the principal activity and whose output, like that of the principal activity, must be suitable for delivery outside the producer unit.

Ancillary activity: An ancillary activity is a supporting activity undertaken within an enterprise in order to create the conditions within which the principal or secondary activities can be carried out; ancillary activities generally produce services that are commonly found as inputs into almost any kind of productive activity and the value of an individual ancillary activity's output is likely to be small compared with the other activities of the enterprise (e.g. cleaning and maintenance of buildings).

Non-profit institutions serving households: They consist of non-profit institutions which are not predominantly financed and controlled by government and which provide goods or services to households free or at prices that are not economically significant

Operating surplus: The operating surplus measures the surplus or deficit accruing from production before taking account of any interest, rent or similar charges payable on financial or tangible non-produced assets borrowed or rented by the enterprise, or any interest, rent or similar receipts receivable on financial or tangible non-produced assets owned by the enterprise; (note: for unincorporated enterprises owned by households, this component is called "mixed income"). (1993 SNA on-line glossary)

Output: Output consists of those goods or services that are produced within an establishment that become available for use outside that establishment, plus any goods and services produced for own final use. (1993 SNA on-line glossary)

Taxes: Taxes are compulsory, unrequited payments, in cash or in kind, made by institutional units to government units; they are described as unrequited because the government provides nothing in return to the individual unit making the payment, although governments may use the funds raised in taxes to provide goods or services to other units, either individually or collectively, or to the community as a whole. (1993 SNA paragraph 7.48).

Social transfers in kind: Social transfers in kind consist of individual goods and services provided as transfers in kind to individual households by government units (including social security funds) and NPISHs, whether purchased on the market or produced as non-market output by government units or NPISHs; the items included are: (a) social security benefits, reimbursements, (b) other social security benefits in kind, (c) social assistance benefits in kind, and (d) transfers of individual non-market goods or services. (1993 SNA on-line glossary. Para. 8.99)

Subsidies: Subsidies are current unrequited payments that government units, including non-resident government units, make to enterprises on the basis of the levels of their production activities or the quantities or values of the goods or services which they produce, sell or import. They are receivable by resident producers or importers. In the case of resident producers they may be designed to influence their levels of production, the prices at which their outputs are sold or the remuneration of the institutional units engaged in production. Subsidies are equivalent to negative taxes on production in so far as their impact on the operating surplus is in the opposite direction to that of taxes on production. (1993 SNA paragraph 7.71).

Royalties: is the term often used to describe either the regular payments made by the lessees of subsoil assets to the owners of the assets (these payments are treated as rents in the SNA) or the payments made by units using processes or producing products covered by patents (these are treated as purchases of services produced by the owners of the patents in the SNA)".

Taxes on production and imports: Taxes on production and imports consist of taxes payable on goods and services when they are produced, delivered, sold, transferred or otherwise disposed of by their producers plus taxes and duties on imports that become payable when goods enter the economic territory by crossing the frontier or when services are delivered to resident units by non-resident units; they also include other taxes on production, which consist mainly of taxes on the ownership or use of land, buildings or other assets used in production or on the labour employed, or compensation of employees paid. and subsidies on production. (1993 SNA on-line glossary)

Value added – gross: Gross value added is the value of output less the value of intermediate consumption; it is a measure of the contribution to GDP made by an individual producer, industry or sector; gross value added is the source from which the primary incomes of the SNA are generated and is therefore carried forward into the primary distribution of income account. (1993 SNA on-line glossary)

Namibia Department of Water Affairs "Draft Summary of Waster Accounts", 2004

Dinar A. and A. Subramian (1997). Water Pricing Experiences - An International Experience. World Bank Technical Paper No. 386. Washington D.C.

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

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

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

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

References

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

ABS (Australian Bureau of Statistics) 2004. Water Account, Australia 2000-01. ABS Cat. no. 4610.0. Summary at: http://www.abs.gov.au/ausstats/ABS@.nsf/mf/4610.0

International Monetary Fund (2001). *Government Finance Statistical Manual 2001*. ISBN 1-58906-061-X, Washington DC.

NLWRA (National Land and Water resources Audit 2001. Australian Water Resources Assessment 2000. NLWRA, Canberra. http://audit.ea.gov.au/ANRA/water/docs/national/Water_Contents.html

Productivity Commission. 2003. Water Rights Arrangements in Australia and Overseas. Productivity Commission Research Paper. http://www.pc.gov.au/research/crp/waterrights/index.html

Chapter 6 The asset accounts

A. Introduction

6.1. This chapter presents accounts which describe the stocks of an asset at the beginning and at the end of an accounting period and the changes due to human and natural processes that took place during this period. In particular, it focuses on the description of quantitative uses of water resources in order to assess the quantitative depletion of the resource. Qualitative characteristics of the stocks are dealt with in the quality accounts presented in chapter 7. This chapter focuses exclusively with on the accounts in physical units. Because of the social nature of water, being essential to sustain life, there are no standard techniques to assess its value. Market prices do not fully reflect the value of the resource itself and the resource rent is often negative. A discussion on various methods of valuing water is presented in a separate chapter, namely chapter 8.

6.2. This chapter starts with a description of the hydrological cycle which governs water movement from the atmosphere to the earth and its links with water asset accounts (Section B). Water is in continuous movement through the natural processes - contrary to other natural resources such as forest or mineral deposits – and it is important to understand its natural cycle and it is represented in the accounting framework.

6.3. Section C describes asset accounts in detail. In particular, it first describes how the SNA asset boundary has been expanded and presents the SEEAW asset classification; it then describes in details the asset accounts. Section D presents accounts for transboundary water resources, which are water resources that cross, mark or are located on the boundaries between two or more countries. Water accounts could be used for the management of these resources as they facilitate the formulation and monitoring of policies for water allocation among riparian countries.

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

B. The hydrological cycle

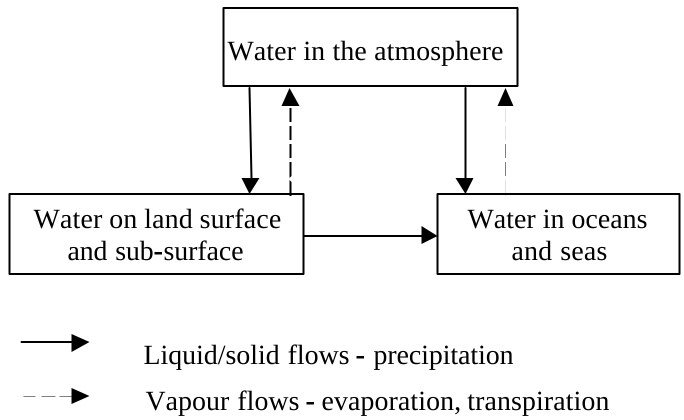
6.5. Water is in continuous movement: because of solar radiation and gravity, water keeps moving from lands and oceans into the atmosphere in the form of vapour and, in turn, to fall back again on land and oceans in the form of precipitation. The succession of these stages is called hydrological cycle. Understanding the hydrological cycle helps defining the water asset boundary and explaining spatial and temporal differences of water distribution. **Error! Reference source not found.** shows the various stages that water goes through during this natural water cycle. The figure shows land, atmosphere and sea as repositories of water. If we focus on water on land surface and sub-surface, the natural input of water is precipitation. Part of this precipitation evaporates back into the atmosphere, part infiltrates into the ground to recharge aquifers, and the rest drains into rivers, lakes, reservoirs and groundwater and eventually reach the sea. This cycle continues as water evaporates from land, oceans and seas to the atmosphere and falls back onto land, oceans and seas in the form of precipitation.

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

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

This means that precipitation either evaporates or transpires through vegetation (evapotranspiration), flows over river or streams (runoff), or is stored in water bodies (changes in storage).

Figure 6.1: Natural water cycle



Source: UNESCO (1989).

6.7. Within this natural water balance, adjustments should be made to reflect modifications to the cycle due to the human activities of abstraction from and returns of water into the environment. Water asset accounts describe this new balance by relating the storages of water – stocks - in 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 account

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

1. Extension of the SNA asset boundary

6.9. The 1993 SNA defines economic assets as entities:

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

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

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

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

2. Asset classification

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

- EA.13 Water Resources (measured in cubic metres)
  - EA.131 Surface water
    - EA.1311 Artificial Reservoirs
    - EA.1312 Lakes
    - EA.1313 Rivers and streams
    - EA 1314 Snow and Ice
    - EA 1315 Glaciers
  - EA 132 Groundwater
  - EA.133 Soil Water

EA.131 Surface water

6.13. Surface water comprises all water which flows over or is stored on the ground surface (UNESCO/WMO International Glossary of Hydrology, 1992). Surface water includes *artificial reservoirs*, which are man-made reservoirs used for storage, regulation and control of water resources; *lakes* which are in general large body of standing water occupying a depression in the earth surface; *rivers and streams* which are bodies of water flowing continuously or periodically in a channel; *snow and ice* which include "temporary[?]" layer of snow and ice on the ground surface; and *glaciers* which are bodies of land ice that consist of recrystallized snow accumulated on the surface of the ground. Snow, ice and glaciers are measured in water equivalent.

EA.132 Groundwater

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

EA.133 Soil water

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

6.16. The SEEA-2003 includes asset classification of water resources only the first three categories of surface water (EA.1311 to EA.113) and groundwater (EA.132). The SEEAW explicitly includes in the classification also snow, ice and glaciers and soil water. As for soil water, snow and ice, the SEEA-2003 acknowledges the importance of these resources mainly in terms of flows as they represent a temporary storage of water and explain some of the seasonal variation in the stock level of reservoirs, lakes and rivers. They hold water during the cold season and release it during warmer months. In addition, the inclusion of soil water in the accounts allows for a clearer representation of the exchanges of water between water resources as soil water represents an intermediate step between the exchanges on the one side between the atmosphere and water on land and subsurface - mainly through precipitation and evaporation - and, on the other, between rivers, lakes and reservoirs through infiltration, runoff etc. However, it became more evident the importance of these resources also in terms of stocks, in particular for soil water. Water in the soil is a very important resource for food production as it sustains rainfed agriculture, pasture, forestry, etc. Most water management tends to focus water in river, lakes etc. neglecting rain and soil water management, even though the management of soil water flows holds significant potential for water savings, increasing water use efficiency and the protection of vital ecosystems.

6.17. 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 sustain river flow in the driest months and contributes to water peaks. For example, the WWDR (2003) reports that without further precipitation, the water store in the Swiss glaciers is estimated to be sufficient to maintain river flows for about five years. Moreover, monitoring glaciers stocks is also important for monitoring climate change. Several countries including Moldova (Tafi and Weber, 2000), Spain (Naredo and Gascó, 1995), New Zealand (2004) and Chile (Meza et al., 1999) have compiled accounts including soil water, snow and ice.

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

Fresh and non-fresh water resources

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

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

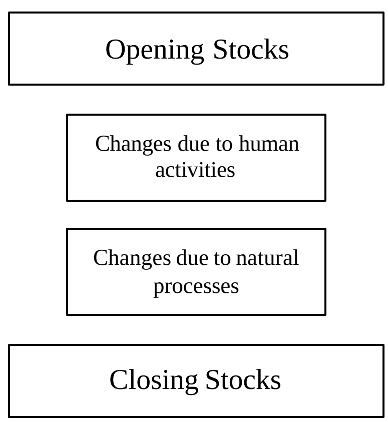
Water in oceans and seas

6.21. The asset classification of water resources excludes water in oceans and seas because the stocks of these resources are enormous compared to any level of abstraction from it. Water in oceans and seas do not incur to depletion: any quantity of water abstracted will not affect the level of the stock. However, sea water may enter the economy either, for example, to be used as cooling water, or, in countries under water stress, be desalinised as opposed to importing water from neighbouring countries. Desalinated water may be a viable and even economic solution to alleviate the problem of water scarcity. Abstraction and desalination of marine water are shown in the supply and use table (chapter 3) as flows of water from the environment to the economy.

3. Asset accounts

6.22. The water asset accounts describe how the stocks of water resources change during a period of time. **Error! Reference source not found.** presents a schematic form of an asset account: in particular, it presents (a) opening and closing stocks which are the stocks level at the beginning and end of the period of time; and distinguished between (b) changes due to human activities, which consist of abstraction and returns of water, and (c) changes due to natural causes which include flows of water between the economy and the environment and transfers of natural resources within the environment. These accounts are particularly relevant because they link water use by the economy (represented by abstraction and returns) to the stocks of water in a country.

Figure 6.2: Schematic representation of an asset account



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

Table 6.1: Asset accounts

Cubic metres

			EA.131 Surface water					EA.132 Groundwater	EA.133 Soil water	Total
			EA.1311 Reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow and Ice	EA.1315 Glaciers			
Opening Stocks										
Changes due to human activities	Abstraction									
	of which sustainable use									
	Returns from the economy									
Changes due to natural processes	Precipitation									
	Inflows from upstream territories									
	Inflows from other resources in the territory	Natural transfers								
		Man-made transfers								
	Evaporation/Actual evapotranspiration									
	Outflows to downstream territories									
	Outflows to the sea									
	Outflows to other resources in the territory	Natural transfers								
		Man-made transfers								
Other volume changes										
Closing Stocks										

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

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

6.26. *Precipitation* consists of volume of atmospheric wet precipitation (rain, snow, hail,...) on the territory of reference during the accounting period. The majority of precipitation would fall on the soil and would thus be recorded in the column of soil water in the asset accounts. Some precipitation would also fall into the other water resources e.g. surface water. It is assumed that water would reach aquifers after having passed through either the soil or surface water (e.g. rivers, lakes, etc.). Thus no precipitation would be shown in the asset accounts for groundwater. The infiltration of precipitation to groundwater is recorded in the accounts as an inflow from other water resources into groundwater. Since soil water is explicitly accounted for, this item records the total volume of precipitation before evapotranspiration takes place.

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

6.28. *Outflows* represent the amount of water that flows out from water resources during the accounting period. Outflows are disaggregated according to the destination of the flow, namely (a) to other water resources, (b) to other territories and (c) to the sea/ocean. Outflows to other territories represent the total volume of water that flows out of the territory of reference during the accounting period. Shared rivers are a typical example of water flowing from one upstream country to a downstream country. Outflows to the sea/oceans represent the volume of water that flows into the sea/oceans. Outflows to other water resources represent water exchanges between water resources within the territory. In particular, they include the flows of water going out of a water body and reaching other water resources within the territory.

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

6.30. *Evaporation/Actual evapotranspiration* is the amount of evaporation and evapotranspiration that occurs in the territory of reference during the accounting period. Note that evaporation refers to the amount of water evaporated from water bodies such as river lakes, artificial reservoir, etc. Evapotranspiration refers to the amount of water that is transferred from the soil to the atmosphere by evaporation and plant transpiration. Evapotranspiration can be "potential" or "actual" depending on the soil and vegetation conditions: potential evapotranspiration refers to the maximum quantity of water capable of being evaporated in a given climate from a continuous stretch of vegetation covering the whole ground and well supplied with water. Actual evapotranspiration, which is reported in the accounts, refer to the amount of water that evaporates from the surface and is transpired by the existing vegetation/plants when the ground is at its natural moisture content that is determined by precipitation.

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

6.32. In **Error! Reference source not found.** the sustainable level of water abstraction can be specified from each water source. This variable is exogenous to the accounts and it is often estimated by the agencies in charge of water management and planning in a country. Its estimation takes into account economic, social and environmental considerations.

6.33. It is often useful to present data relative to "inflows to" and "outflows from" other water resources in a matrix format. This allows for a better understanding of the exchanges of water between resources. Table 6.2 presents such a matrix.

Table 6.2: Matrix of flows between water resources

Destination: ⇨ Origin ⇩	EA.131 Surface water					EA.132 Groundwater	EA.133 Soil water	Outflows to other resources in the territory
	EA.1311 Reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow and Ice	EA.1315 Glaciers			
EA.1311 Reservoirs								
EA.1312 Lakes								
EA.1313 Rivers								
EA.1314 Snow and Ice								
EA.1315 Glaciers								
EA.132 Groundwater								
EA.133 Soil water								
Inflows from other resources in the territory								

4. Definition of stocks for rivers

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

6.35. To keep consistency with the other water resources, the stock level of a river should be measured as the volume of the active riverbed determined on the basis of the geographic profile of the riverbed and the water level. This quantity is usually very small compared to the total stocks of water resources and the annual flows of rivers. However, the river profile and the water depth are important indicators for environmental and economic considerations. The concept of dependable water[11] is an important indicator of long-term annual water development and its calculation depends also on the water depth. The volume of the active riverbed has been used as a measure of stocks for rivers in Spain (Naredo and Gascó, 1995), Chile (Meza et al., 1999) and Moldova (Tafi and Weber, 2000). There might be cases, however, in which the stocks of river may not be meaningful because either the rate of the flow is very high or the profile of riverbed changes constantly because of topographic conditions. In these circumstances, it could be avoided computing the stock of rivers (New Zealand, 2004).

[11] Dependable water is defined as the portion of surface water that can be depended on for annual water development over the long-term, usually 19 out of 20 consecutive years. UNSD Questionnaire 2001 on Environment Statistics – Section on Water.

6.36. Table 6.3 and Table 6.4 show the asset accounts for the Republic of Moldova and the matrix of transfers among the various resources (Tafi and Weber, 2000). In Table 6.3 the stocks of rivers are computed as the volume of the active river beds.

Table 6.3: Asset account for the Republic of Moldova, 1994

Mm^3

	Lakes and reservoirs	Rivers	Groundwater	Soil and vegetation	Total water resource system
Opening stocks	2 743.5	500.0	150 000.0	5 000.0	158 243.5
Abstraction		-2 452.6	-264.5		-2 717.1
Returns		1 763.3	299.1	621.0	2683.4
Returns of lost water (inc. leakages)			218.0		218.0
Returns of wastewater		1 763.3	81.1		1 844.4
Irrigation				621.0	621.0
Precipitation	210.2	168.2		13 635.5	14 013.9
Evapotranspiration	-415.9	-332.8		-12 723.3	-13 472.0
Inflows from other territories		9 000.0	1 100.0		10 100.0
Outflows to other territories		-10 000.0	-1 379.1		-11 379.1
Outflows to the sea					0.0
Net natural internal transfers		2 103.0	264.5	-2 367.5	0.0
Changes in stocks	-205.7	249.1	20.0	-834.3	-770.9
Closing stocks	2 537.8	749.1	150 020.0	4 165.7	157 472.6

Source: Based on Tafi and Weber, 2000.

Table 6.4: Matrix of internal transfers, Republic of Moldova, 1994

Mm^3

Destination: ⇨ / Origin ⇩	Lakes and reservoirs	Rivers	Snow and Ice	Groundwater	Soil and vegetation	B- outflows to other resources
Lakes and reservoirs						0.0
Rivers				20.0		20.0
Groundwater		65.5				65.5
Snow and Ice						0.0
Soil and vegetation		2 057.5		310.0		2 367.5
A- Inflows from other resources		2 123.0		330.0		2 453.0
Net Natural Internal Transfers (= A-B)		2 103.0		264.5	-2367.5	0.0

Source: Tafi and Weber, 2000.

6.37. Some countries, for example, Australia (ABS, 2000) and Namibia (Lange, 1997), measure surface water assets with the volume of surface water that becomes available as, for rivers, it is often more useful to compare the water use with the volume of water that flows in a river during a period of time (represented by the runoff). However, runoff is a measure of flow and not of stock and is part of the changes in stocks for rivers in the asset accounts in **Error! Reference source not found.**. Australia

(ABS, 2000 and 2004) compiles pathway analysis which amount to asset accounts excluding stocks. Table 6.5 shows the water pathways for Victoria, Australia, describing the inflows, changes in quantity of water resources and outflows.

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

GL

		1993-94	1994-95	1995-96	1996-97
Inflows	Precipitation	174 730	133 684	152 561	134 269
	Total	174 730	133 684	152 561	134 269
Anthropogenic changes	Net economic changes	-3 914	-5 481	-4 577	-5 183
	Water used for economic purposes	8 501	9 377	7 878	9 929
	Return flow discharges	4 588	3 896	3 302	4 746
	Net water transfers	n.a.	n.a.	-0.2	0
	Into the measurement region	n.a.	n.a.	0.1	0.1
	From the measurement region	n.a.	n.a.	0.3	0.1
	Total	-3 914	-5 481	-4 576.8	-5 183
Net changes in storage	Changes in storage in lakes and dams	-435	-3 173	1 426	1 015
	Net groundwater recharge	n.a.	n.a.	n.a.	n.a.
	Other volume changes n.e.c.	90 688	45 337	69 718	50 409
	Total	90 253	42 164	71 144	51 424
Outflows	Evapotranspiration	60 243	60 243	60 243	60 243
	Basin outflow (mean annual runoff)[(b)]	19 450	19 450	19 450	19 450
	Total	79 693	79 693	79 693	79 693

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

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

Source: Australian Bureau of Statistics, 2000.

6.38. The water pathways of Table 6.5 is complemented with separate tables on stocks of surface water (measured with Mean Annual Runoff - MAR) and groundwater. Table 6.6 presents surface water assets in Victoria, Australia for the years 1985 and 1998: information on the MAR is presented side by side with the portion allocated for economic and environmental uses.

Table 6.6: Surface water assets, Victoria, Australia

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

Note: (a) Average annual volume allocated for economic activity.
(b) No environmental allocations were made in the 1985 assessment (AWRC 1987a).
(c) MAR — mean annual runoff.
(d) Environmental flows in Victoria are generally made as specified flow regimes, which cannot be readily converted to an annual volume. The volumes listed are specific volumetric allocations.
(e) Reasons for change from 1985 to 1998: hydrological forecasts altered, e.g. reassessment of resources.
(f) Reasons for change from 1985 to 1998: methodological changes, e.g. new estimation techniques and methods derived for measuring water.

Source: Australian Bureau of Statistics, 2000.

6.39. Table 6.7 presents the experience in Namibia (Lange, 1997) in the use of annual runoff as a measure of stock for rivers. It shows stocks for surface and groundwater in Namibia from 1980 to 1993. In this example, surface water has been further disaggregated into perennial and ephemeral surface water: perennial surface water refers to rivers which flow year-round, while ephemeral surface water refers to rivers that only flow after especially long rains. Some of ephemeral surface water is stored in dams and is carried over from previous years, thus its stocks are measured both in terms of annual runoff and annual storage.

Table 6.7: Stocks of groundwater, perennial and ephemeral surface water, Namibia

Millions of cubic metres

	Ground Water	Perennial Surface Water Annual Runoff of Major Rivers					Ephemeral Surface Water	
		Orange	Zambezi	Kwando	Okavango	Kunene	Annual Runoff	Annual Dam Storage
1980	n.a.	3 583	41 633	1 732	5 035	1 561	64	241
1981	n.a.	3 308	23 686	923	5 105	1 980	73	164
1982	n.a.	1 125	23 157	837	3 907	2 868	86	105
1983	n.a.	1 592	25 595	869	9 408	11 156	437	157
1984	n.a.	932	28 555	880	5 375	6 594	481	277
1985	n.a.	2 200	28 996	913	4 629	7 238	367	417
1986	n.a.	2 731	31 916	929	4 239	4 165	215	378
1987	n.a.	21 885	28 988	787	5 393	4 191	775	471
1988	n.a.	10 897	49 953	1 026	5 820	5 085	755	461
1989	n.a.	2 415	19 887	1 064	4 370	4 582	161	335
1990	n.a.	3 534	31 483	795	3 882	3 863	275	303
1991	n.a.	2 800	17 613	661	6 607	7 404	58	184
1992	938	600	34 941	785	3 228	1 840	222	252
1993	n.a.	1 298	24 011	844	2 998	2 516	286	293

Notes: Annual runoff of perennial surface is reported for recording stations. These cannot be summed up since some rivers feed into others. Data are available only for selected aquifers in the Central Area of Namibia in 1992; they are fairly representative of the groundwater stocks in that area in earlier years. Ephemeral surface water estimates are based on data from the major rivers, but not all rivers.

Source: Lange, 1997.

Link with Supply and Use tables

6.40. Asset accounts in physical units are linked with the supply and use tables. In particular, changes due to human activities in the asset accounts, namely abstraction and returns, represent the crossing of the supply and use tables with the asset accounts (see Figure 2.4). The abstraction that appears in the asset accounts in **Error! Reference source not found.** corresponds to the Abstraction from Water Resources by the economy in the physical use table. Similarly, the returns that appear in **Error! Reference source not found.** correspond to the Total Returns to Water Resources in the physical supply table.

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

D. Accounting for transboundary water resources

6.42. Integrated environmental and economic accounting for water resources can be viewed as a tool to manage transboundary water as it provide a transparent information system, which can be used as a basis for informed decision-making. The SEEAW also favours (a) the cooperation and collaboration of all stakeholders for the elaboration of bilateral or multilateral agreements and joint management mechanisms; (b) the exchange of information between riparian parties; and (c) the joint monitoring of water quantity, quality and transboundary impacts. These are all important aspects of international conventions on transboundary water resources.

6.43. *Transboundary waters* include any surface or ground waters which mark, cross or are located on boundaries between two or more States; wherever transboundary waters flow directly into the sea, these transboundary waters end at a straight line across their respective mouths between points on the low-water line of the banks (definition from the Helsinki Convention). With the term “international river basin” we denote here a river basin, which crosses two or more States. Hence an international river basin contains, by definition, some transboundary waters. In addition it may also contain non-transboundary waters in the sense that, although connected to transboundary waters, they do not mark, cross or are located on boundaries between states. This is the case, for example, of a lake, located all within one State, which is connected to a river that crosses another State.

6.44. The two international conventions on transboundary water (The Helsinki Convention, 1996 and UN Convention on the Law of the Non-navigational Uses of International Watercourses, 1997) cover issues - related both to the quality and quantity of transboundary waters - which can be addressed in the various modules of water accounts. In particular, physical water asset accounts can provide information on the major quantitative issues of transboundary water, such as inflows coming from and going to neighbouring countries, and the share of the international water body allocated to a country by treaties and/or agreements.

6.45. Depending on the objectives of the analysis, water asset accounts could be compiled at the national level by presenting detailed information on the origin and destination of the transboundary resources or at (international) river basin level by presenting detailed information on the amount of water that each riparian country abstracts and returns.

6.46. When compiling water asset accounts at the national level, detailed information on the transboundary resources can be included as shown in Table 6.8. Stocks of transboundary water are explicitly identified and the inflows and outflows are further disaggregated according to the origin and destination of the flows. It is useful to report information, if any, on established quotas on abstraction, returns, inflows and outflows. Table 6.8 shows such information in an additional column. This would allow for the monitoring of the compliances to the agreements by comparing, for example, the actual flows with the established quotas, and for the evaluation and negotiation of the current quota’s system.

Table 6.8: Asset account at national level

Cubic metres

	Water Resources[b] (classified according to the asset classification)			Total (1)+(2)
	Legal quotas established by treaties	Transboundary waters (1)	National waters (2)	
Opening Stocks	Quota allocated by treaties			
Abstraction [a]				
Returns [a]				
Precipitation	n.a.			
Inflows from other Water Resources in the territory	n.a.			
Inflows from other Countries[a]:				
Country 1				
…				
Evapotranspiration/Evaporation	n.a.			
Outflows to other Water Resources in the territory	n.a.			
Outflows to other Countries[a]:				
Country 3				
…				
Outflows to the sea	n.a.			
Other Volume changes	n.a.			
Closing Stocks	Quota allocated by treaties			

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

6.47. Water asset accounts could also be compiled for the entire international river basin by identifying the part of the water resources belonging to each riparian country and by allocating the various flows to the countries where they either originate or they take place. It may be useful to adopt a river basin approach for transboundary waters for better management of the resource in terms not only of water allocation among riparian countries to help averting inter-riparian conflicts over water use, but also to protect the environmental health of the basin as a whole (Giordano and Wolf, 2003).

6.48. Table 6.9 shows an asset accounts for an international river basin. The table is based on the assumption that there are only two riparian countries, but the basic structure of the accounts does not change if more area added. The opening and closing stocks of the water resources in the basin are further classified according to the country they belong to. The stocks of transboundary waters are assigned to each riparian country according to the agreements between the countries.

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

	Water Resources (classified according to the asset classification)				Total
	Country 1		Country 2		
	Transboundary waters	National waters	Transboundary waters	National waters	
Opening Stocks	Quota allocated country by treaties		Quota allocated by treaties		
Abstraction [(a)]					
By Country 1					
By Country 2					
Returns[(a)]					
By Country 1					
By Country 2					
Precipitation					
Inflows from other resources in the country					
Inflows from other countries[(a)]:					
Country 1					
Country 2					
Evapotranspiration/Evaporation					
Outflows to other resources in the country					
Outflows to other Countries[(a)]:					
Country 1					
Country 2					
Outflows to the sea					
Other Volume changes					
Closing Stocks	Quota allocated by treaties		Quota allocated by treaties		

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

6.49. Abstraction and returns are further disaggregated according to the country abstracting and returning water. In principle a country can abstract and return water only from its part of the asset. However, there may be cases that a country abstracts more than the part of the stock, which is assigned by treaties. In this case, there is a transfer of water from one country to the other. As in Table 6.8 established quotas for abstractions and returns merely in physical terms can be included in the tables in a separate column to monitor the compliance to the treaties.

E. Derived Indicators

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

Indicators on water resources in the environment

6.51. Indicators on the status of water resources in the environment can be used to assess and monitor water resources in a territory and compare them with those of other territories. These indicators allow for the evaluation of some natural characteristics - climatic, geographic and topographic – of a region. It is important to look at these indicators in addition to those on pressure by human activities in order to link water demand with water supply from the environment. Box 6.1 presents some indicators commonly used for the assessment of the status of water resources in the environment. Note that these indicators do not provide information on the qualitative status of water resources, which are discussed in Chapter 7.

Box 6.1: Selected indicators on water resources in the environment

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

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

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

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

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

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

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

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

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

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

Source: Reported by UNESCO et al. 2003 and computed by FAO/Aquastat.

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

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

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

Indicators on the pressure exerted by human activities

6.62. The previous set of indicators describes the structural characteristics of the water resources in a territory by looking at water generated internally and externally and linking it to the land surface and population size. However, it does not provide a direct indication of the pressure exerted by the economy on water resources. Table 6.11 presents some of the indicators that can be derived from the asset accounts and that are commonly used to link abstraction and returns to water resources in the environment. These indicators show, in quantitative terms, the extent to which water resources are being exploited or used to meet country's water demands.

Table 6.11: Selected indicators on the pressure exerted by human activities

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

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

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

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

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

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

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

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

F. Data sources and methods

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

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

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

GLOSSARY

Abstraction: Amount of water removed from fresh and non-fresh water resources either permanently or temporarily in a given period of time for consumption and production activities. Water used for hydroelectricity generation can be considered as part of water abstraction. Total water abstraction can be broken down according to the type of source (i.e. Freshwater Resources and Non-freshwater Resources) and the type of use. EDG

Actual evapotranspiration: amount of water that evaporates from the surface and is transpired by the existing vegetation/plants when the ground is at its natural moisture content that is determined by precipitation. (EDG)

Artificial Reservoirs: Man-made reservoirs used for storage, regulation and control of water resources. (Electronic Discussion Group on terms and definitions used in water accounting, 2003) EDG

Brackish Water: Water having salinity between that of fresh and marine water. (EPA http://www.epa.gov/owow/estuaries/monitor/glossary.html) EDG

Direct use benefits: Benefits derived from the use of environmental assets as sources of materials, energy or space for input into human activities. (SEEA-2003 7.36)

Evapotranspiration: Quantity of water transferred from the soil to the atmosphere by evaporation and plant transpiration. (UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992) EDG

Fresh water resources: Naturally occurring water having a low concentration of salt, or generally accepted as suitable for abstraction and treatment to produce potable water (UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992) EDG

Lake: Generally large body of standing water occupying a depression in the earth surface. (Termdat "Terminology of water Management: Flood Protection". Working copy 2002)

Glaciers: bodies of land ice that consist of recrystallized snow accumulated on the surface of the ground" (Langbein W.B. and K. T. Iseri, General Introduction of Hydrologic Definitions", Geological Survey Water-Supply Paper 1541-A, United States Geological Survey.)

Glaciers: An accumulation of ice of atmospheric origin generally moving slowly on land over a long period. (UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992)

Groundwater: Subsurface water occupying the saturated zone. (UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992)

Groundwater Recharge: Amount of water added from outside to the zone of saturation of an aquifer during a given period of time. Recharge of an aquifer is the sum of natural and artificial recharge (EDG)

Inflow: Amount of water that flows into a stream, lake reservoir, container, basin, aquifer system, etc. UNESCO/WMO International Dictionary of Hydrology, 2nd edition, 1992. and Termdat "Terminology of water Management: Flood Protection". Working copy 2002. EDG

Option benefits: Benefits derived from the continued existence of elements of the environment that may one day provide benefits for those currently living. (SEEA-2003 paragraph 7.37)

Outflow: Flow of water out of a stream, lake, reservoir, container, basin, aquifer system, etc. (UNESCO/WMO International Dictionary of Hydrology, 2nd edition, 1992. Termdat "Terminology of water Management: Flood Protection". Working copy 2002) EDG

Potential Evapotranspiration: Maximum quantity of water capable of being evaporated in a given climate from a continuous stretch of vegetation covering the whole ground and well supplied with water. It thus includes evaporation from the soil and transpiration from the vegetation of a specified region in a given time interval, expressed as depth. UNESCO/WMO International (Glossary of Hydrology, 2nd edition, 1992.) (EDG)

Precipitation: Total volume of atmospheric wet precipitation (rain, snow, hail, ...) on a territory in a given period of time. EDG

Rivers and streams: Body of water flowing continuously or periodically in a channel. (Termdat "Terminology of water Management: Flood Protection". Working copy 2002)

Runoff: The part of precipitation in a given country/territory and period of time, that appears as stream flow.

Soil water: Water suspended in the uppermost belt of soil, or in the zone of aeration near the ground surface, that can be discharged in to the atmosphere by evapotranspiration. (UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992.) (EDG)

Surface Water: Water which flows over or is stored on the ground surface. (UNESCO/WMO International Glossary of Hydrology, 2nd edition, 1992)

Total Water Returns: Water that is returned into the environment during a given period of time after use. Total returns can be classified according to the receiving media (i.e. fresh and non-fresh water resources) and to the type of water (e.g. treated water, cooling water, etc.). EDG

Transboundary waters: means any surface or ground waters which mark, cross or are located on boundaries between two or more States; wherever transboundary waters flow directly into the sea, these transboundary waters end at a straight line across their respective mouths between points on the low-water line of the banks. (Helsinki Convention 1992)

REFERENCES

Australian Bureau of Statistics (2000). *Water Accounts for Australia, 1993-94 to 1996-97*, Catalogue No. 4610.0, Canberra: Australian Bureau of Statistics.

Australian Bureau of Statistics (2004). *Water Accounts for Australia, 2000-01*, Catalogue No. 4610.0, Canberra: Australian Bureau of Statistics.

Food and Agricultural Organization of the United Nations (1978). *Systematic index of international water resources treaties, declarations, acts, and cases by basin*. Volume I. Legislative study 15, Rome: FAO.

Food and Agricultural Organization of the United Nations (1984). *Systematic index of international water resources treaties, declarations, acts, and cases by basin*. Volume II. Legislative study 34, Rome: FAO.

Food and Agricultural Organization of the United Nations, Aquastat (2001). Statistics on Water Resources By Country In Fao's Aquastat Programme. Working Paper No. 25. Joint ECE/Eurostat Work Session on Methodological Issues of Environment Statistics (Ottawa, Canada, 1-4 October 2001)

Giordano, M.A. and A.T. Wolf. (2003). Sharing waters: Post-Rio international water management. *Natural Resources Forum* 27: 163-171.

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

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

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

Meza, F.R., Jiliberto, F. Maldini, A. Magri, M. Alvarez-Arenas, M. García, S. Valenzuela and L. Losarcos (1999). *Cuentas ambientales del Recurso Agua en Chile*. Documento de trabajo No. 11, Serie Economía Ambiental, Comisión Nacional del Medio Ambiente, Santiago, Chile.

Naredo, J.M. and J.M. Gascó (1995). *Las Cuentas del Agua en España*. Unpublished report for Ministerio de Obras Públicas, Transportes y Medio Ambiente, Madrid, Spain.

Redaud, J.M. (1998). *Indicators to measure the impact of agriculture on water use: pricing and cost of water services*. In Sustainable management of Water in Agriculture (1998) OECD Proceedings. ISBN 9264160647

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

Soulard, F., R. Lebrun, L. Kemp and A. Elliott, 2002, The Development of the Canadian Water Accounts: The Climatic Water Balance, paper presented at the Canadian Water Resources Association 2002 annual meeting, Winnipeg, Canada.

Statistics New Zealand (2004). *Water: Physical Stock Accounts for the June years 1995 to 2001 – Inaugural report*. Available on line at: http://www.stats.govt.nz/environment/default.htm.

Tafi, J and J. L. Weber (2000). Inland Water Accounts of the Republic of Moldova, Preliminary Results of Resource Accounts in Raw Quantities, 1994 and 1998, Eurostat, TACIS Project MD92FR01.

UNEP, Oregon State University and FAO (2202). *Atlas of International Freshwater Agreements*. ISBN: 92 807 2232 8

United Nations Education, Scientific and Cultural Organization and World Meteorological Organization (1992). *International Glossary of Hydrology, Second Edition*.

United Nations Education, Scientific and Cultural Organization et al. (2003). World Water Development Report.

United Nations (2001). *Indicators of Sustainable Development: Guidelines and Methodologies – 2001*

Chapter 7 Quality accounts [NEW VERSION - TO BE EDITED]

A. Scope of water quality accounting

7.1. Water quality designates the physical, chemical, biological and aesthetic properties of water that determine its suitability for use and its ability to maintain the health and integrity of aquatic ecosystems which provide a series of services. Many of these properties are controlled or influenced by constituents that are dissolved, suspended or just carried in water. More widely, "quality" captures the aptitudes of the ecosystems and water to fulfil their natural functions and human uses. Hence, from the accounting perspective, the different water bodies should be regarded both as ecosystems which biological status is dictated by the physical and chemical characteristics of water and their container and also as repository of water proper that can be used for direct economic purposes.

7.2. Quality is a property of a water body or of water that has no dimension. Hence, it has to be quantified with respect to the size of the water body in the view to relate their stock and fluxes with economical issues that are expressed in amounts of expenditures. The aim of water accounting is to compute a "quantity of quality" of the different water resources and to express it in units suitable for further comparison with expenditures. A very important outcome is the possibility to derive representative indicators from the accounting procedure precisely because the quantitative assessment that is required by the accounting framework.

7.3. Accounting quality of water is a major issue since a] the quality of water used as resource is a key component of the possibility of mobilisation, because the regulations that may forbid the use of polluted water (that could not anyway be processed economically and reliably) and b] because many ecosystems services (human health, fisheries, leisure, final purification of wastes, etc.) would be jeopardized by poor quality of aquatic ecosystems. Hence, accounting quality is a much wider challenge that just considering the suitability of water to be processed for distribution or industrial use.

7.4. Consequently, quality accounts consider both perspectives. The aquatic ecosystems should be accounted considering their potential to fulfil their functions and provide services, considering the impact resulting from the uses of water and emissions of pollutants at least. The water resource proper is on its side accounted as a good which quality relates to the uses and the economy of its provision.

7.5. Considering the procedure from the ecosystem perspective, quality is attached to a fix reach of river which is flown through by moving water. In other words, quality on this reach reflects the distribution of states observed in water when passing in this reach. This is consistent with the uses of water since abstraction is made all along the pumping period (with some exceptions) at a certain point situated on a precise reach. These remarks apply all the more to groundwater and lakes that are more stable water bodies. If the quality accounts are carried out using GIS facilities to accurately locate the different elements of water bodies, an efficient linkage can be done between ecosystem oriented accounts and use oriented accounts. In the case of rivers, the use oriented accounts address a subset of the ecosystem oriented accounts defined by the presence of any abstraction facility. Deploying the river ecosystem oriented accounts with the proper quality assessment provides a by-product that can be directly input to the supply and uses account just correcting the inputs by the volume abstracted instead of river representative unit.

7.6. For the time being, the establishing of comprehensive relationships between water quality, in the broad acceptation mentioned above, and economy has not yet been carried out. However, the quality status of aquatic systems can be accounted in a way that the relationships with expenditures related to prevention (e.g. wastewater treatment) and restoration could be carried out. The qualitative assessment of water used as resource has not been yet considered with the goal to producing accounts and relating these accounts with the economy of water uses. This point is discussed later in the chapter emphasising that a) relationships are only indirect and partial and that b) the valuation of ecosystems and ecosystems services are not yet backed by sound methodologies.

B. Assessing and reporting quality of aquatic systems

1. Common principles

7.7. Natural waters exhibit a wide variety of chemical (e.g., nitrate, dissolved oxygen, etc.), physical (e.g., temperature, velocity, etc.) and biological (e.g., bacteria, phytoplankton, fish, etc.) characteristics that result from natural processes and anthropogenic activities. These characteristics determine the structure and richness of aquatic ecosystems and the different uses of water that can be made considering its composition and their changes along time, seasonal and inter-annual on the one hand and the techniques for water preparation and distribution that are currently available under affordable cost on the other hand.

7.8. In this chapter the wording “water quality” applies to both water and to the water body that contains it. Since water quality expresses the lesser or greater suitability of water to be used for certain purposes (preparing potable water, irrigation, etc.) or to maintain ecological functions of the water body, it is both a multi-dimensional and partly subjective characteristic of water bodies. It is multi-dimensional because each use and function has different requirements. It is partly subjective because an equal debasement in composition is judged more or less important *vs.* identical uses in different countries. This is reflected in the different methods for assessing water quality and in their application rules that are exemplified in next sections.

7.9. As a result, the quality judgment of any water is relative to the target of the assessment. Water suitable for fish life may be unsuited for human bathing; water suited for drinking water preparation may be rejected for some industrial purposes. Consequently, quality assessment is not the exact counterpart of resource assessment that is related to simple and unique measure expressed in objective unit (volume). By contrast, quality assessment is expressed in qualitative terms of suitable / unsuitable or excellent / good / fair / mean / bad for example. This is reflected in most country assessment methods that designed set of standards for each different use.

7.10. The qualitative judgement placed on each assessed water or water body status reflects two distinct problematic supported by different assessment methods. The binary judgement suitable / non suitable equally worded as compliant / non compliant or good / bad relates to a normative acceptation of water quality. This is usually the case when legal background supports the assessment, and this is usually, but not exclusively, the case when considering water uses.

7.11. A more detailed approach aims at assessing how far the current status is from a target status, supposed to mimic its unspoiled state or fully suitable conditions. The judgement is expressed with more terms and often represented by standard colours ranging from best to worst quality along blue, green, yellow, orange and red (sometimes black). For instance, the European Water Framework

Directive defines five ecological quality classes qualified as "high", "good", "moderate", "poor" and "bad" that must be represented with the colour convention mentioned above. Each class is defined according to the worst scoring in one among three types of classification: biological quality, hydro-morphological quality, and physicochemical quality. This approach, which natural extend is to a continuous index within a certain range is the most often applied to natural bodies of water under scientific and operational judgement.

2. Water quality criteria

7.12. Natural non-perturbed waters may be unsuitable for certain uses and therefore considered as having "bad quality" albeit they are not impacted by human activities. This remarks lead to two important conclusions that are:

- If quality assessment if carried out by comparing current status to natural conditions or potential the judgement may be different from that provided by comparing the status to absolute reference. This alternative is much linked to the assessment rules and set of criteria that are country depending.
- Quality is not a simple equation relating receiving waters and pollution discharges. This is because a) most important substances for quality assessment are naturally present in natural waters, their concentration being modified by emissions and b) important quality criteria relate to the effect of emissions that is monitored by components not presents in emissions.

7.13. The suitability of water to each use or function is generally defined by a series of criteria that apply to the components of the water system. These components are called "water quality variable", "characteristic", "component", "determinand" and "parameter". A "criterion" (Train, 1979) for water quality is the linking between a determinand and one threshold value (e.g. the determinand "nitrate" should have a concentration below 10mg N l^{-1}). All can be associated with reference value or literal description. The neologism "determinand" built from "determinant" was suggested by many experts with the acceptation "what helps determining", thus pinpointing the fact that water quality is not measured but determined by a series of characteristics. Following suggestions by the EEA(Kristensen and Bogestrand, 1996), the word "determinand" is used in this chapter. It is wise to avoid the wording "pollutant" for designating a determinand used to assess quality, even though its concentration may result from pollution. This last word is restricted to designate the inputs that are emitted directly or indirectly to water bodies, generally from human activities.

7.14. The difference in vocabulary captures the fact that the relationship between emissions and quality is indirect and non-linear, despite certain. For example, river quality is much determined by the content in dissolved oxygen that results from 1) temperature and agitation, 2) degradation of organic matters, essentially measured as BOD (biological oxygen demand) and 3) in-situ production of oxygen by aquatic vegetal photosynthesis. The causes 2) and 3) are closely related to emissions; respectively because the organic matters contained in wastewater and as a result of eutrophication processes in relation with nutrients (N, P) from urban, industrial and agricultural sources. These causes act nevertheless in opposite ways with respect to oxygen content on water, notwithstanding for diurnal cycles and kilometric distance between source and impact that induces a lag between emission and the related expression in water quality.

7.15. With some minor differences, all water quality assessment methods comprise reference values resulting from scientific assessment or normative values provided by legislation to which monitored values of determinands are compared. The biggest differences lay in the number of determinands considered to assess quality for a certain function, the number of thresholds provided for each determinand (from one to several) and the rules that are applied to aggregate the results of comparisons between each observation and the available thresholds in a certain case. A discussion on the rules that drive the way the water quality accounts are further calculated takes place in the next section, because they define the reporting of water quality assessment. The final reporting of water quality is the fruit of the selection of relevant determinands, sets of threshold values and calculation rules that reflect at the end the purpose of the assessment and defines its greater or lesser possibility to impact these results into further calculations.

7.16. The ranges of threshold values found in different publications and regulations may vary quite widely, because different concerns are expressed, that depend on local conditions when ecosystems protection is considered. Therefore it is of primarily importance to consider a] what are the targets of the quality assessment system and b] which groups of determinands are addressed in the assessment procedure to qualify the quality of water with respect to certain uses.

7.17. The choice of determinands is the outcome of a scientific, practical, economical and political compromise. Some important determinands cannot be reliably and affordably monitored because they have special behaviour (e.g.; liquid - sediment quick exchange) or because no routine determination method exist. This later reason is especially the case for pesticides, of which a few dozens can be accurately quantified among several hundreds of active substances hat are marketed. Same problem occurs considering biological toxins (with special mention to cyanotoxins) and endocrine disruptors. A special mention has to be made about large numbers of chemicals, for example toxic hydrocarbons derivatives that are hardly soluble in water and that pose considerable problems for making reliable samples.

7.18. To illustrate this, the determinands used by Canada, France and South Africa have been entered in a database and processed (Canadian Council of Ministers of the Environment, 2001b; Canadian Council of Ministers of the Environment, 2001a; Canadian Council of Ministers of the Environment, 2003), (Oudin and Maupas, 1999a), (Department of Water Affairs and Forestry, 1996a, 1996b, 1996c, 1996d, 1996e, 1996f and 1996g), summarized in (Department of Water Affairs and Forestry, 1996h)

Table 7.1: Number of determinands per functions of water and water ecosystems considered in different water quality assessment systems

Function addressed	Total Codes	CANADA	FRANCE	SOUTH AFRICA
Biological potential	264	115	125	24
Filed watering, irrigation	122	37	58	27
Fish farming	76	NA	41	35
Industrial water preparation	11	NA	NA	11
Leisure, recreation and aquatic sports	29	10	7	12
Livestock watering	168	69	58	41
Tap water preparation	259	82	135	42

7.19. The above table shows large differences between the example countries in the number of determinands considered for each function. The total number of different determinands is 277, but the number of common determinands is quite low. Calculating the number of determinands common to the three countries and the ones met in only one country per chemical group is reported in the next table.

Table 7.2: Number of determinands per chemical group considered in different water quality assessment systems

Determinand group	Common determinands	Specific to Canada	Specific to France	Specific to South Africa	Total number of determinands
Biological information		1	1	2	5
Environmental determinands	6	1	1	1	10
Gases dissolved	1		2	1	5
Metals (and metalloids)	9	3	2	1	24
Nutrients	1		1	1	5
Organic matters determinands			4	1	7
Other				1	1
Pathogenic germs	2	1		3	8
Pesticides	4	22	23	6	68
Radioactivity		26			26
Salinity determinands	4		1	3	14
Toxics (non metal, non pesticides)	2	36	38	3	104
	6	**36**	**39**	**6**	**277**

Common determinands are those used by the three countries in their guidelines. Specific to XX counts the determinands used by this single country XX in its guidelines. Determinands that are common to two countries over three are not counted in this example table. The total number of determinands reflects determinands used by a single country at least.

7.20. The large endemicity of determinands exemplified in Table 7.2 reflects primarily different concepts and understandings of local problems. The large difference in pesticides lists reflects as well different agricultural practices. By contrast, low endemicity and few commons determinants compared to the total of possible determinands reflect slightly different perspectives. This is the case for metals; a bulk of quite identical metals is used by two countries between the three possible combinations. These differences just demonstrate that quality issues are to be dealt with at the assessment (result of processing) and concern (function addressed) levels.

7.21. Quality of groundwater resources assessment requires specific determinands and adapted assessment rules. However, considering beneficial uses, they are close to those used for surface waters. The main difference is that, with exceptions in some karstic environments, groundwater does not constitute a habitat for aquatic life. However, for many parameters they should meet similar requirements because of the possible transfers of water between the different water bodies (through springs, infiltration...).

7.22. Australian groundwater (ABS (Australian Bureau of Statistics), 2004), for instance, have been classified according to their salinity, measured by the total dissolved solids. Four classes have been defined: “fresh” (salinity<500 mg/l), “marginal” (500<salinity<1 500), “brackish” (1 500<salinity <5 000) and “saline” (salinity>5 000 mg/l). These categories correspond to potential limitations for economic uses: “Fresh” quality is recommended for human drinking, “marginal” quality can be used for irrigation and, at the end of the range, some industrial processes are able to use very saline water, including sea water (the salinity of which is about 35 000 mg/l).

7.23. The quality of the final product (tap water, industrial water, etc.) is not discussed here. Is reflects legal standards that must be met in any circumstance. The important cause in relation with expenditures is the quality of raw water used for the production of distribution water. This is part of most assessment systems. The surveillance is however carried out at permitted sites by organisations that do not necessarily exchange their data with environmental surveillance programmes.

3. Water quality assessment and reporting

7.24. The assessment proper and the subsequent reporting of water quality depend on the rules that are applied to a set of observations carried out on the determinands listed in the guidelines adopted by each country. These rules are defined to achieve the provision of certain message and were not established to ensure further use of results. Even though the first step always consists in comparing the observed value to the threshold, the way of assessing the final quality may vary from country to country to large extend. The different philosophies must be considered with the view of the accountability of results.

7.25. The major difference between the different methods lays in the way the results of the application of each criterion to the observed values are combined together. Two approaches exist: the "rule of the worst", that is the most widely represented and a weighted calculation of results. Both approaches provide a judgement of water quality that can be expressed as a binary response, a quality class or a continuous value within a given range and can be adapted to carry out quality accountings.

Application of the "rule of the worst"

7.26. The French SEQ approach (Oudin and Maupas, 1999a; Oudin and Maupas, 1999b) is a sophisticated water quality assessment system based on the "rule of the worst". Each function is analysed through a series of "perturbations[12]" that group determinands having comparable impact. This way of grouping is more focused on uses than the chemical grouping used in Table 7.2, albeit some groups may coincide. The final quality judgement is the result of the worst index given by at least 1 criterion in any perturbation involved in the function during the whole assessment period. This rule may be smoothed considering the 90%ile instead of the worst value. The final reporting is made as class or by the 0-100 continuous index. The threshold values and index calculation were designed to ensure that the same quality index computed with respect to different water body functions would show the same degree of impact, and hence suggest the same nuisance. Moreover, the 5 possible classes apportion evenly the 0-100 range thus making the outcomes quite simple to compare. This specific feature is used in designing quality indices, detailed in the ending sections of this chapter. This method is very suitable for calculating WQA because classes (used for final reporting) are fully consistent across the different classification.

7.27. The "rule of the worst" is quite justified when dealing with toxics and aquatic life buts tends to hide seasonal variations and classifies identically a single trespassing and permanently bad quality water. Despite the intrinsic multidimensionality of water quality issues, many classification schemes suggest to assess the "overall quality" as the worst results of all function focused quality assessments. This method, defining quality as "the worst of the worst", is questionable from management point of view since it hides all progresses in water quality resulting from measure programmes. Moreover, the improvement of monitoring programmes often results in apparent worsening of quality indexes, by mechanical effect (more measurements of more determinands increase the probability to monitor extreme values). Specific indices have been developed to tackle this issue under the Water Quality Accounting (WQA) methodology.

[12] The French wording is "altération" that has no practical translation in English under this acceptation.

7.28. For practical reporting reasons and uncertainty attached to quality issues, quality is often reported as classes, most often represented by conventional colours (blue, the best to red /black the worst). The worst class obtained in any of the three classifications determines the global class, exemplifying the rule "of the worst". The three classifications are themselves characterized by ranges for several parameters. For instance, the high, good and moderate classes against physicochemical quality are determined by the rules reported in Table 7.3.

Table 7.3: Physicochemical classification: elements for the ecological quality classes of rivers

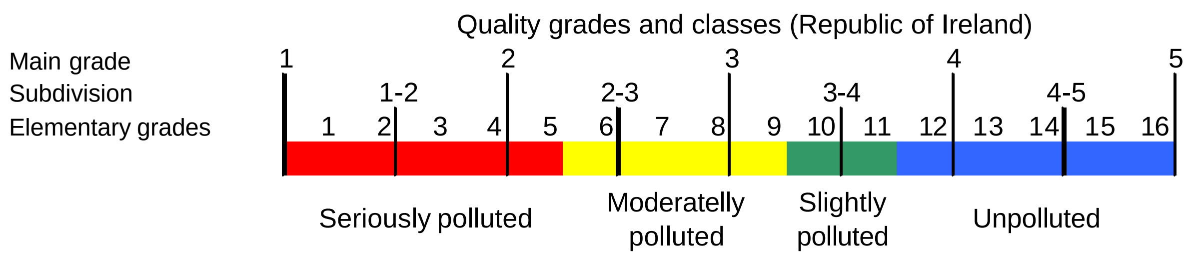
Element	**High status**	**Good status**	**Moderate status**
General conditions	The values of the physicochemical elements correspond totally or nearly totally to undisturbed conditions. Nutrient concentrations remain within the range normally associated with undisturbed conditions. Levels of salinity, pH, oxygen balance, acid neutralising capacity and temperature do not show signs of anthropogenic disturbance and remain within the range normally associated with undisturbed conditions.	Temperature, oxygen balance, pH, acid neutralising capacity and salinity do not reach levels outside the range established so as to ensure the functioning of the type specific ecosystem and the achievement of the values specified above for the biological quality elements. Nutrient concentrations do not exceed the levels established so as to ensure the functioning of the ecosystem and the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific synthetic pollutants	Concentrations close to zero and at least below the limits of detection of the most advanced analytical techniques in general use.	Concentrations not in excess of the standards set in accordance with the procedure detailed in section 1.2.6 without prejudice to Directive 91/414/EC and Directive 98/8/EC.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Specific non-synthetic pollutants	Concentrations remain within the range normally associated with undisturbed conditions.	Concentrations not in excess of the standards set in accordance with the procedure detailed in section 1.2.6 without prejudice to Directive 91/414/EC and Directive 98/8/EC.	Conditions consistent with the achievement of the values specified above for the biological quality elements.

Source: Directive of the European Parliament and of the Council 2000/60/EC, 22.12.2000 Official Journal of the European Union.

7.29. This table presents the requirements that any European water body should meet to fulfil compliance objectives. It illustrates a legal approach of water quality since judgement is expressed in a binary mode (complies / does not comply) that is not sufficient for environmental assessment or for designing a measure programme. Analytical purposes, especially trend assessment require more details, expressed as distance to target, that may result from adjustment of the same compliance assessment rules and threshold values. The criteria are quite complex and mix-up comparison with reference conditions and legal values. The rules expressed are close to those enforced in South Africa where many criteria refer to local undisturbed conditions, hence depending on the sound assessment of reference conditions.;

7.30. A third example of classification reporting is given by the Irish reporting scheme(McGarrigle, 2001) that is based on a continuous grade (1-16) from which quality classes are derived, as shown in Figure 7.1. The different grades are related to the most likely pollution intensity. The reporting as grades gives more precise results when a global index is calculated. It is important to note that, by contrast with the French SEQ, the width of classes in odd, the "green" class extending on two grades whereas the red and blue extend each on 5 grades.

Figure 7.1: Correspondence between quality grades and quality classes in the quality system used in the Republic of Ireland



7.31. The differences between the systems based on the “rule of the worst” lay into threshold values and assessment rules that vary among countries (European Topic Centre- Inland waters, 2000).

Application of a weighting rule

7.32. The Canadian federal system (CCME) (Canadian Council of Ministers of the Environment, 2001a) has designed a quite different method of judgement, which is not necessarily the one used by individual states. The principle is based on the weighting of three factors of trespassing values at each site. It takes into account the number of determinands not meeting their criterion (“scope” S = number of failed determinands / total number of determinands monitored), the frequency of trespassing during the assessment period (“frequency” F = number of failed tests / total number of tests).

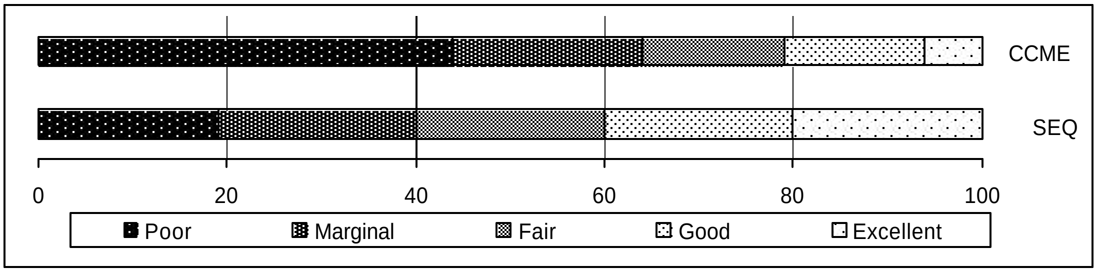
7.33. The third factor expresses the distance between the threshold and the observed value (“excursion” E = [observed value / target value]-1) despite the presence of a single threshold in the guidelines. This last value is inverted to take into account the direction of the test (should the target be low (contaminant) or high (oxygen)) and normalised so that the sum of all excursions fall in the range 0-100. Taking into account the distance between observation and target also exists in the SEQ approach, for example, since 4 thresholds are provided for most determinands, but factors F and S are not incorporated because of the "rule of the worst".

7.34. The final index is the length of the 3D vector [s,f,e] normalised to 0-100 by dividing its final length by 1.732 ($3^{1/2}$). For presentation reasons, the length 0 is given the index 100 (best quality). By construction, the index is capable of being run for different functions of water. To some extend, it can cope with slightly different sets of determinands, but should apply to annual series, otherwise the F factor could not be assessed. The authors recommend that datasets having at least 4 values per year should be used. The final index is therefore calculated as:

$$CCMEindex = 100 - \frac{\sqrt{S^2 + F^2 + E^2}}{1.732},$$

The range of assessments extends over 5 classes, as in other systems, but the attached values are quite different: Excellent (100-95); Good (94-80); Fair (79-65); marginal (64-45) and poor (44-0). The difference in grade scales vs. qualification is illustrated in next Figure 7.2.

Figure 7.2: Comparison of grading between France and Canada



This figure exemplifies how the differences in calculation methods reflect in grading. The meaning of classes is almost identical but the numeric values of class limits are very different. Hence, data conversion should be carried out before comparing assessments and accounts made from SEQ and CCME assessments for example.

7.35. Concluding, this specific index presents many positive aspects for annual assessments in which is it is likely to provide a more nuanced assessment than the ones based on "worst case" philosophy applied at the annual level. The use of the excursion variable counteracts positively with the unique threshold reported in the guidelines. Concluding, the results provided by the use of this index provides cannot be compared directly with ones provided by other methods not because the scales are different but more fundamentally because annual integration and annual worst case do not measure the same thing.

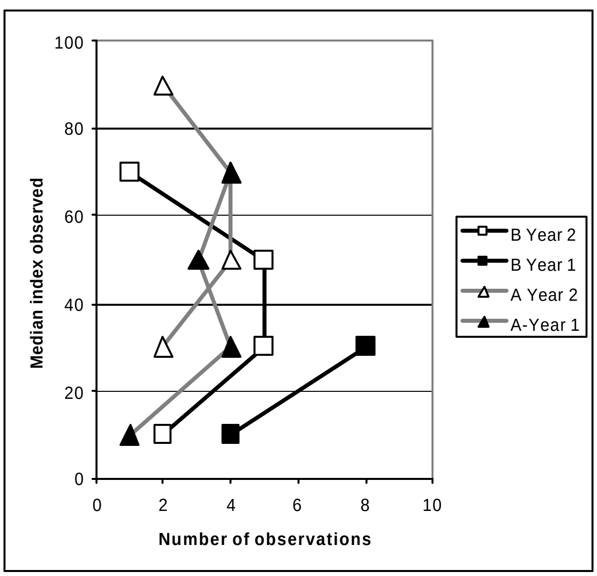
Suggestion for selecting the appropriate assessment method

7.36. Each assessment method and rule has pros and cons. Even though no implicit or explicit judgement on the different rules is expressed, the selection of an assessment method is by far not neutral in the outcomes of the accounting procedure. To exemplify the range of differences that may occur, different applications of the "rule of the worst" have been applied to a forged series of observations. The hypothesis is that point A represents a large river system that slowly improves between year 1 and year 2 because many pollution sources are involved in its water quality. By contrast, point B represents a smaller system where the dilution of a single emission in the major cause of degradation. This source has been purified between year 1 and year 2, but the receiving capacity is not enough to insure permanent good quality. The figure and the tables are commented to show the differences in assessment and the way of selecting the adequate method for accounting.

Table 7.4: Forged example of quality assessment data

Sample rank	A-Year 1	A Year 2	B Year 1	B Year 2	Quality class	A-Year 1	A Year 2	B Year 1	B Year 2
	water quality index (SEQ referring)					Number of observation in class			
1	9	30	6	13	Very bad: 5	1		4	2
2	28	35	11	14	Bad: 4	4	2	8	5
3	34	44	15	21	Acceptable: 3	3	4		5
4	38	45	17	25	Good: 2	4	4		1
5	39	47	21	28	Excellent: 1		2		
6	55	48	22	35		Results obtained as classes			
7	58	70	22	36	Average class	3	2	4	4
8	59	72	22	44	90%ile class	4	4	5	5
9	61	73	23	44	100%ile class	5	4	5	5
10	61	78	26	45		Results obtained as indexes			
11	63	83	26	55	Index from classes	47	60	23	38
12	76	92	29	60	Index from indexes	48	60	20	35
					90%ile	28	35	12	15
					100%ile	9	30	6	13
Remark: the indexes have supposedly been done by assessing each sample against the guidelines, individual index calculated and sorted by increasing order. Hence the worst case applies to rank 1 and 90%ile ~to rank 2. Calculation of 90%ile in the rightmost columns is the result of adjustment of values that show potential slight difference between true adjustment en simple setting aside of the worst value.									

Figure 7.3: Comparison of assessment rules for two different sets of data



The figure represents the number of samples falling into a class, according to the quality index computed on each sample. The quality classes range from 5 (index 0-20) to 1 (index 80-100) according to SEQ system. Point B shows significant improvement of quality for 5 samples during year 2. The "rule of the shows improvement only in point B, whereas the major change occurred at point A that gained 67% in index ([38-23]/23)against 27%. Surprisingly, the 90%ile rule, supposedly to be more sensitive by discarding outliers shows not any difference in results.

The changes in indexes either computed as average index or reconstructed index from class are quite undisturbed by the calculation method and show significant differences between years.

7.37. The differences in results resulting from the application of assessment rules reflect the different targets that are aimed at. The "rule of the worst" possibly adjusted by using the 90%ile value reflects the impact of worst condition of the ecosystem. The resulting quality grade is possibly quite related to the actual expenditures that are sized to most demanding conditions, generally as occurring 20 or 10 times per century. The production of water quality accounts based on severe quality assessment is therefore not contradictory with the target of comparing the status with protection expenditures,

7.38. However, the accounts made by this way cannot provide the correct assessment of progresses that result from investments and operational costs. The efficiency of expenditures relates more to the gradual changes that are recorded by aggregating the observations. The aggregated assessment may results from a) integrated quality assessment as provided by the CCME method or by aggregating assessment based on the "rule of the worst" applied to each sample. This way is complementary to the recommendation and it is strongly suggested to carry out both calculations.

7.39. By contrast, the accounts of water uses are less sensitive to extreme conditions. Water is used or prepared all year long, and the production expenditures reflect the sum of constraints the producer has had to face. To compare more accurately the actual expenditures related to water uses with respect to the issues related to the quality of resource, an aggregated account based on the different quality met along the year seems preferable. This aggregation can be done as well on natural waters since the quality assessment is restricted to the waters currently in use for water preparation.

C. Principles of water quality accounting applied to natural water systems

1. Rationales and fundamental methodology

7.40. The goal of accounting is to assess the quantity of resource being more or less suitable for water related functions. Resource accounts (see Chapter 6) address the available volumes and WQA quantifies the suitability of these quality assessments in a practicable way. It could be envisaged to attach water quality information to each elementary volume used. In practice, this would be unmanageable and would not properly address resource protection and improvement issues.

7.41. The main theoretical problem to tackle is that asset accounts use volume, that is an accounting unit whereas quality is reported as index or class, that have the dimension of a ratio, which is not an accountable unit: volumes can be added and subtracted, quality classes cannot. The accounts must show the opening and closing stocks together with the changes in stocks during the accounting period for each quality class. Table 7.5 recalls the general structure for quality accounts as presented in the SEEA, based on quality assessment reported as classes. The only logical response to the impossibility to account quality is to account instead an asset apportioned by quality, thus making it necessary to define a relevant asset to this end.

Table 7.5: Quality accounts reporting table

	Quality classes				
	Quality 1	Quality 2	Quality 3	Quality n	Total (Rows)
Opening stocks					
Changes in stocks					
Closing stocks					
Total (Columns)					Check (TC=TR)

Remark: the total by line is the total of SRU disregarding the apportionment by quality grade. The total by column has but a checking goal. The true sum is [opening stocks] + [change in stocks] = [closing stocks]. This method is general enough to cope with change in total SRU related to strong change in annual run-off. If long-term average of run-off is used to compute SRU, then [opening stocks] = [closing stocks].

Source: SEEA 2003.

7.42. The general principles depicted by SEEA apply to any water resource. Still waters as lakes, reservoirs and groundwater are obvious cases where stocks are large *vs*. the seasonal change in stocks, with the exception of arid countries where reservoirs may be refilled only 10 times per century. The major problem with these objects is that the water stock is often unknown or irrelevant, as discussed in the "assets accounts" chapter 6. Quality of groundwater is however frequently monitored, which is not the case for the majority of lakes and reservoirs. By contrast, rivers have little stock, their volume being renewed several times a year. The correct accounting unit for rivers has required a rather complex approach to capture the run-off and the length that are the major characteristics of rivers.

7.43. Accounts being comprehensive by definition, quality accounting was designed to follow-up the quality changes of water resources on a representative and comprehensive way, i.e., considering their absolute and relative size. The underlying objective is to judge the efficiency of the measures taken in order to protect or improve the state of water bodies. First of all, matching WQA and emission accounts is expected to achieve this goal. Second, the comparison on changes in "stocks of quality" is expected to provide better assessment of effectiveness of protective and restoration measures, including the related capital and running costs, some of which are not included in the emission account. For practical reasons (especially since measures and expenses are recorded at the administrative level), WQA should ideally be computed at both levels of river basin and administrative units and reported on a relevant time basis, as discussed in §7.38 to 7.40 above.

7.44. A specific measuring unit has been introduced to weight the relative and absolute size of running water bodies: the "standardized river-kilometre" (Heldal and Østdahl, 1984) which unit is L^4T^{-1}. Further developments suggested replacing this name by UMEC (Unité de Mesure des Eaux Courantes, (Margat, 1996)), translated in English by *standard river unit* (SRU) after the suggestion by Eurostat (EEA, 2001a). An SRU, which is worth 1 $km.m^{-3}$, represents a 1 km long watercourse with a 1 m^{-3} outflow as well as a 0.5 km long watercourse with a 2 m^{-3} outflow. This unit allows the aggregation of stretches of watercourses that are of different size because it is analogous to a momentum, assuming that water has a specific mass of 1000 kg m^{-3}. In this case, the dimension units become MLT^{-1} that has a more understandable meaning.

7.45. The calculation method by individual reach provides all elements for analysing the changes in stocks at the elementary level that may be important for assessing the effectiveness of measures programmes. It solves at well the difficult issue of mixing water masses of different qualities (see Weber, 1986, p366), because it provides the elements to accounts by river size class.

7.46. The question of the reference run-off value to consider for calculating the SRU has no unique response. It is important to mention in calculations which reference is taken otherwise comparisons could not be made: the eventual choice depends on a compromise between the purpose of the accounting and available data. A generalised procedure would probably use interannual average (module) because this data is the only one that can be estimated from scarce information. This is the recommendation made by the first developers of the methodology (Margat, in Weber, 1986, p 359). The reasons are very fundamental: only river volumes are accountable without double accounting. These river volumes are estimated by the average run-off, whereas using total run-off would lead to multiple accounting because the same volume is observed in several points, with different qualities.

7.47. With the introduction of SRU, all required elements to carry out WQA on rivers with concern to river water are met. The next logical steps are required to produce the expected results:

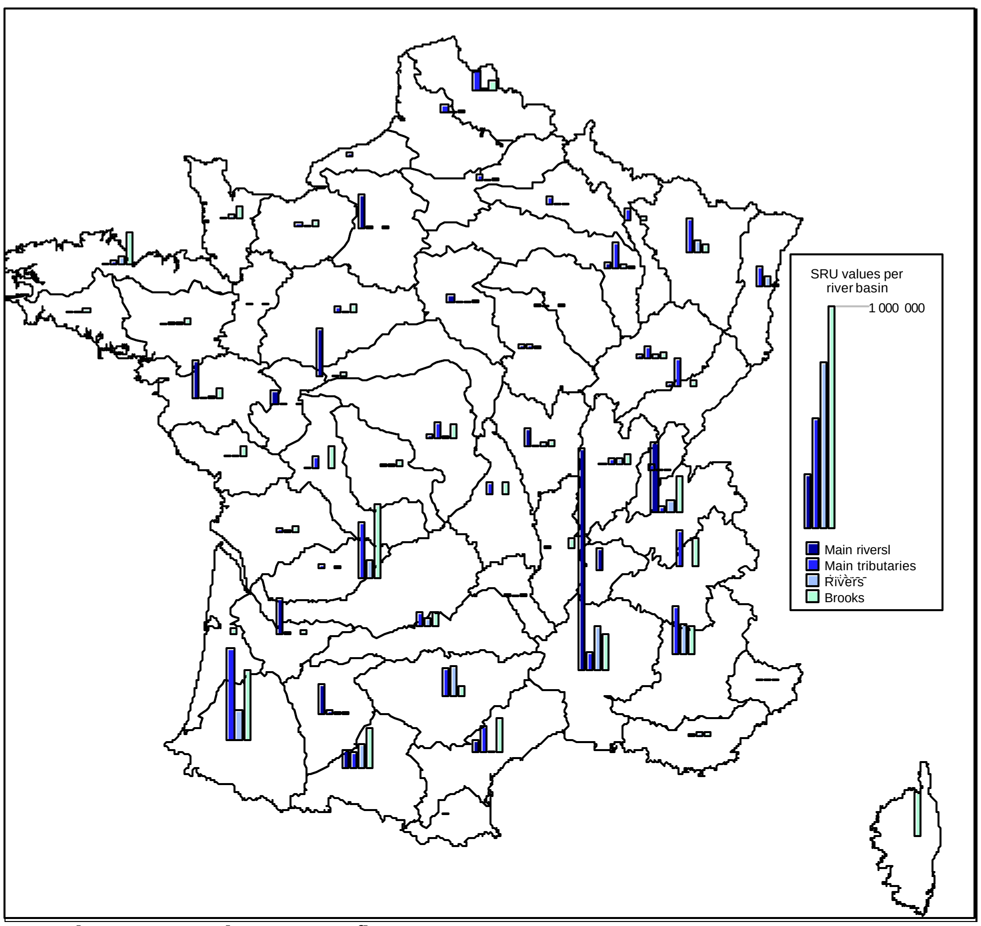
- Defining the accounting catchments (or areas) in which the catchment aggregates (Table 7.5) shall be produced, along with the river system size classes to be accounted,
- Assessing quality indexes or classes along water courses (see section A and B),
- Defining and evaluating run-off values references along watercourses and their length

and compute the SRU values for every reach of the river systems, the reference being in turn driven by the accounting period and the quality assessment choices,

- Sorting out the reaches per quality and sum the corresponding SRU to populate the stock table.

7.48. The minimum size of rivers to be considered impacts the final quantity of SRU in a catchment. Because the lack of adequate data, the marginal contribution of smallest rivers is unknown. The calculations carried out by Ifen during the methodological development phase and based on provisional map demonstrate the high importance of small rivers. For instance, the French water system, calculated with a simplified methodology from a 1:1,400,000 map, comprises on average 10,800 kilo SRU (kSRU) for its ~76,000 km of main courses. The French water system is disaggregated into 55 catchment areas, constituting as many accounting catchments, and the watercourses mentioned above were distributed into 4 size classes as shown in Figure 7.4.

Figure 7.4: Indicative SRU values per watercourse size class of the 55 French accounting catchments



* Based on interannual average outflows

Source: Ifen - The accounts of the quality of the watercourses –August 1999.

Table 7.6: Total SRU of rivers by size class (France) at the 1:1.4 million scale

	Largest rivers	Rivers	Small rivers	Smallest rivers	Together
Length (km) per class	5157	19342	12552	39296	76347
kSRU per class	2879	3120	1513	3365	10877
%	26%	29%	14%	31%	100%

Source: Ifen - The accounts of the quality of the watercourses –August 1999.

7.49. The values in the Table 7.6 are a truncated sample of French rivers in France, because the total length is by 500,000 km. A very good regression can be calculated between the cumulated length of river and cumulated SRU from Table 7.6, thus allowing a rough estimate of the potential changes in total SRU for different hypothesis of total river length. This estimate is reported in the next table.

Table 7.7: Extrapolated SRU of French rivers according to total length calculated

Cumulated length (km)	5157	24499	37051	76347	150000	250000	500000
Cumulated kSRU (observed)	2879	5999	7512	10877	NA	NA	NA
Cumulated kSRU (extrapolated)	*2800*	*6100*	*7400*	*10600*	*14800*	*19000*	*26700*

7.50. The table above shows that the scale has great importance: considering all rivers existing at the 1:50,000 scale would increase by 2.5 the total SRU registered at the 1:1,400,000 scale. Hence, the scale of producing the accounts is of major importance in comparing final results for rivers.

7.51. Fundamentally, the introduction of the SRU depicts a population of reaches of different sizes which altogether constitute the river systems. The monitoring stations sample this population without any concern about the representativeness of reaches. Since water quality at any reach is extremely depending on quality upstream and often well described by quality downstream, extrapolating quality indexes between monitoring stations is a lawful option. This method provides at the end an **exhaustive sampling of the reach population**. This view of the basic methodology behind the river accounting procedure allows a] the use of simplified methods that capture the same information and b] the production of indicators derived from the accounting methodology. This exhaustive sampling may have gaps in some parts (a certain river has not been monitored that year for example). The calculation methods should allows filling such gaps by replacing the missing data by the average distribution, at the end of processing (this is the meaning of the column "not studied" in Table 7.11).

7.52. The basic methodology (Ifen and Beture-Cerec, 2003) uses detailed quality monitoring data, assesses quality indexes, builds linear maps of quality and run-off (than can be substituted by drained area proxies if run-off data is not available) and computes accounts table either by catchment or by administrative unit. It requires a structured river geographical system in which each reach can be populated with run-off and quality values from extrapolation modules fuelled by monitoring data. This methodology could be applied in any country where water quality is regularly monitored on an adequate set of sites, even not representative, since the extrapolation procedure overcomes representativeness issues. In particular for European countries an appropriate use of extended EuroWaternet dataflow would allow establishing regular water quality accounts. This methodology is currently (2005) under implementation at the EEA. The basic methodology most prominent feature is the apportionment of accounts per catchment as well as per administrative unit.

7.53. For the assessment of groundwater quality, as the flow is very low, the resources can directly be measured in volume (m^3), which is practised by the Australian Bureau of Statistics. 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 (expressed in cubic metres) also increased between the two years.

Table 7.8: 1985 and 1998 accounts of the groundwater quality in Victorian provinces (Australia)(in million m^3)

	Fresh	Marginal	Brackish	Saline	Total
1985	477.5	339.2	123.3	32.3	972.3
1998 (incomplete)	(39.1)	(566.6)	(141.1)	(n.a.)	(746.8)

Source: Water Account for Australia – 1993-94 to 1996-97 - Australian Bureau of Statistics, May 2000. More recent data not available.

2. Adjustment of the accounting methodology to process incomplete data

7.54. The ideal situation was not met during the previous years when the development of river quality accounts took place. According to available data, different practical methodologies can be used to achieve calculations despite the target should be implementing the basic methodology with well organised data sets. The French Institute for the Environment (Ifen), has successively developed a simplified methodology along with the validation of the basic methodology on a limited part of the French territory where calculable river GIS and comprehensive data sets were available, the Rhin-Meuse water agency (Délégation de bassin Rhin-Meuse, 2003). The limitations in data may come from different source, each requiring specific analysis. The assessment of variant has been successfully carried out in other European countries (England and Wales (EEA, 2001b), Ireland (EEA, 2001c) and Slovenia (report not published)) in parallel with France (op. cit.) with different types of data sets.

7.55. Different gaps in data that may appear and be combined together. These gaps are the lack of calculable river system, the provision of quality data as statistics per river size groups or as classes instead of index and, in the most complex case, as maps of quality classes. Moreover, run-off data may be less or more lacking or be replaced by productivity ratios that apply to catchment or areas. The two next tables suggest adequate processing of the different situations that can be met to produce usable accounts despite data lacking.

Table 7.9: Decision table to compute SRU in different data gaps combinations.

Run-off data availability (1 to 3)	A: A calculable map is available	B: No calculable map is available	C: Not any map is available
1: Run-off data available at gauging stations	Basic methodology; outcome is SRU per reach.	Simplified methodology: outcome is SRU per catchment and river size class	Abandon project.
2: Only run-off productivity data available	Applying basic methodology with restricted data, outcome is proxy SRU per reach.	Applying simplified methodology with restricted data, outcome is proxy SRU per catchment, possibly all size classes mixed-up	Abandon project
3: Only catchment area data available	Only proxy SRU per catchment are achievable	Only proxy SRU per catchment are achievable	Abandon project

Table 7.10: Decision table to compute WQA in different data gaps combinations.

Quality data availability (4 to 7)	**D: SRU per reach available**	**E: proxy SRU per catchment / river size class available**	**F: Only proxy SRU per catchment available**
4: Quality data at stations	Basic methodology: extrapolate quality per reach	* basic methodology if A3, ** compute quality statistics per catchment and river size class	May be impossible is stations location not available, otherwise is E4, case **
5: Quality classes at stations	Convert quality class into index, process as D4	Convert quality class into index, process as E4	May be impossible is stations location not available, otherwise is E5
6: Classes per river segments (linear quality maps)	Simplified methodology (see Ifen publications for details), produces proxy WQA per pseudo-reach (maybe reach)	Simplified methodology (see Ifen publications for details), produces proxy WQA per catchment and river size class	Simplified methodology (see Ifen publications for details), produces proxy WQA per catchment only
7: Statistics on quality per catchment	Special case, that is unlikely to be met (see § 7.60 below)	Derive methodology from simplify methodology, compute proxy WQA per catchment	Derive methodology from simplify methodology, compute proxy WQA per catchment

7.56. The different combinations of data gaps are presented in the two orientation tables (Table 7.9 and Table 7.10 above). They consider separately the calculation of SRU and the subsequent allocation of quality indexes to the SRU values. The differentiation is made necessary by the fact that different run-off data (with possible differences in gaps) are required to compute SRU proper and extrapolate quality indexes. If the case is met, the decision path in the second table may have different column entry than in the first of the two tables.

7.57. The best documented cases of WQA production in data gap context is the development of the "simplified accounts" in France and the trial implementation in England and Wales, Ireland and Slovenia (op. cit.). In the French case the available data was restricted to linear maps of quality classes (not indexes) and no structured river system GIS was available (Crouzet, Germain *et al.*, 1999). In this case, it was nevertheless possible to carry out WQA, thanks to assumptions regarding SRU calculation. Data situation was B1 (main rivers) and B2 (other rivers) on the one hand and E6 for quality data. For the time being the only full country WQA for France have been carried out using this simplified method, because the river GIS had too many errors preventing use of the full method.

7.58. A frequent issue is the need to transform quality classes into calculable index since classes cannot be calculated. The transformation hypothesis is that the indexes are evenly distributed within a class reported on the map or a t a station. Hence, any class data is replaced by the median index of the class. If only classes are available, they must first be converted into grades. In that case, each class value is given an estimated grade equal to the median grade of the class. In the example of Figure 7.1, the "red" class would be given grade 3, the "yellow" class would be given the grade 7.5 and so on. The use of such estimated quality grades derived from quality classes is less accurate than using the original grades, in the same way as calculating a sum from rounded values is less accurate than rounding the final sum. For example, if SEQ derived classes are used, the final distribution of indexes will lay in the range [10-90] instead of [0-100], the total loss of information reaching eventually a whole class!

7.59. An expected mixed case is when the major river system is calculated using the basic methodology over the whole rivers size class with a GIS that covers only a portion of the size classes. For example, the GIS under development for the sake of the extended WISE (Water Information System for Europe) is planned at the 1:250,000. Hence, many rivers that flow totally inside a single elementary catchment will not have associated geometry and will fall into case Bx and E/F7 whereas larger rivers will fall into A1/D4. This mixed procedure is totally in line with the fundamentals of water quality accounts, as exposed in §7.52.

D. Derived indicators

7.60. The main outcome of the calculations is the populating the Table 7.5 with opening and closing stocks. The details on the changes in stocks are more or less accurate depending on the completeness of the methodology used. The basic methodology is capable of tracing changes at the reach level whereas calculations fuelled with less data could only provide aggregated changes at the river size class or just at the catchment level.

Table 7.11: Apportionments of stocks with respect to oxidable matters by catchment (Rhin-Meuse water agency)

Basin	Order	Quality classes in km.m3/s A	B	C	D	E	F	Not studied	Sum
08	1	0	0	3	0	0	0	0	**3**
08	2	0	31	8	0	0	0	0	**40**
08	3	0	29	19	4	0	0	0	**53**
08	5	0	130	200	0	0	0	0	**330**
08	6	0	0	0	0	0	0	0	**0**
08	Sum	0	191	231	4	0	0	0	**426**
Sum	1	13	158	125	18	6	0		320
Sum	2	3	96	320	6	6	0		431
Sum	3	58	119	211	12	12	0		412
Sum	4	127	234	373	10	6	0		749
Sum	5	168	1 570	456	306	2	0		2 503
Sum	6	0	1 837	1 389	0	0	0		3 227
Global sum		**369**	**4 015**	**2 877**	**352**	**32**	**0**		**7 644**

Applying the basic methodology provides detailed stock tables that are presented by elementary catchment and river size class (upper part: basin code 08 and size classes from 1 to 6) and then aggregated at highest entity level (lower part) that comprises two accounting catchments..

Hydrologic reference: long-term annual average. Source: (Ifen and Beture-Cerec, 2003).

7.61. The stock tables are the direct accounting outcomes, and these tables and underlying data can provide aggregated indicators that prolong the scope of the accounting procedure. The three main issues that are expected to be addressed by a representative quality assessment are covered by the corresponding indexes that were developed:

- **Issue one**: What is the current overall status? Is it possible to aggregate all SRU sorted by quality into few, even unique figure? The proposed index is an *averaged quality grade* named RQGI (River Quality Global Index) that ranges between 0 (worst) and 10 (best) to discriminate from the basic indexes ranging between 0-100. It can be split in five even intervals that are homogeneous with the 5 quality classes of any system, inter alia, the SEQ system, for consistency.
- **Issue two:** What are the characteristics underlying this status? Does the aggregated RQGI express a general contamination or is it resulting from hotspots for example? The *pattern index* responds to this question.
- **Issue three:** What are the components of the current status? Does nitrate related quality weights more than phosphate related quality in the final status assessment for example? The *predominance indicator* responds to this question.

7.62. All indicators are computed following simple aggregation methods that take into account the method applied to carry out SRU calculation. In the event the simplified method is used, a special adjustment is made to avoid bias that could result from odd classes. The detail of methods is reported and discussed in (Crouzet, Germain *et al.*, 1999; EEA, 2001a).

1. The RQGI indicator

7.63. The River Quality Generalised Index (RQGI) is the weighted average quality index of the system considered normalised to a 0-10 continuous scale. It applies to a river size class within a catchment as well as to all rivers size classes of a whole country. The weight used is the quantity of

SRU having a certain quality grade. The calculation system applies in the basic case (each reach is populated) or in the simplified case (a river stretch may have several grades). This later case may happen even in the case when monitoring data is available and river system GIS is not broken down in reaches. This was for example the situation in Ireland during the trial application. In this case, the SRU value attached to the stretch is broken down according to the proportion of the stretch described by the monitoring points.

7.64. Conversion to the 5 quality classes of the Water Framework Directive is possible. To distinguish expression of the results in classes, the term GQA (Generalised Quality Assessment) is used instead of RQGI the reports as grades. Two equations are presented, the second having a correction in the case the quality is expressed as classes and if several classes share the same river stretch (see §7.56 and following)

General case:

$$RQGI = \frac{10}{n} \times \frac{\sum_{j=1}^{C} \sum_{i=1}^{n} S_j \times G_j}{\sum_{j=1}^{C} S_j}$$

Adjustment:

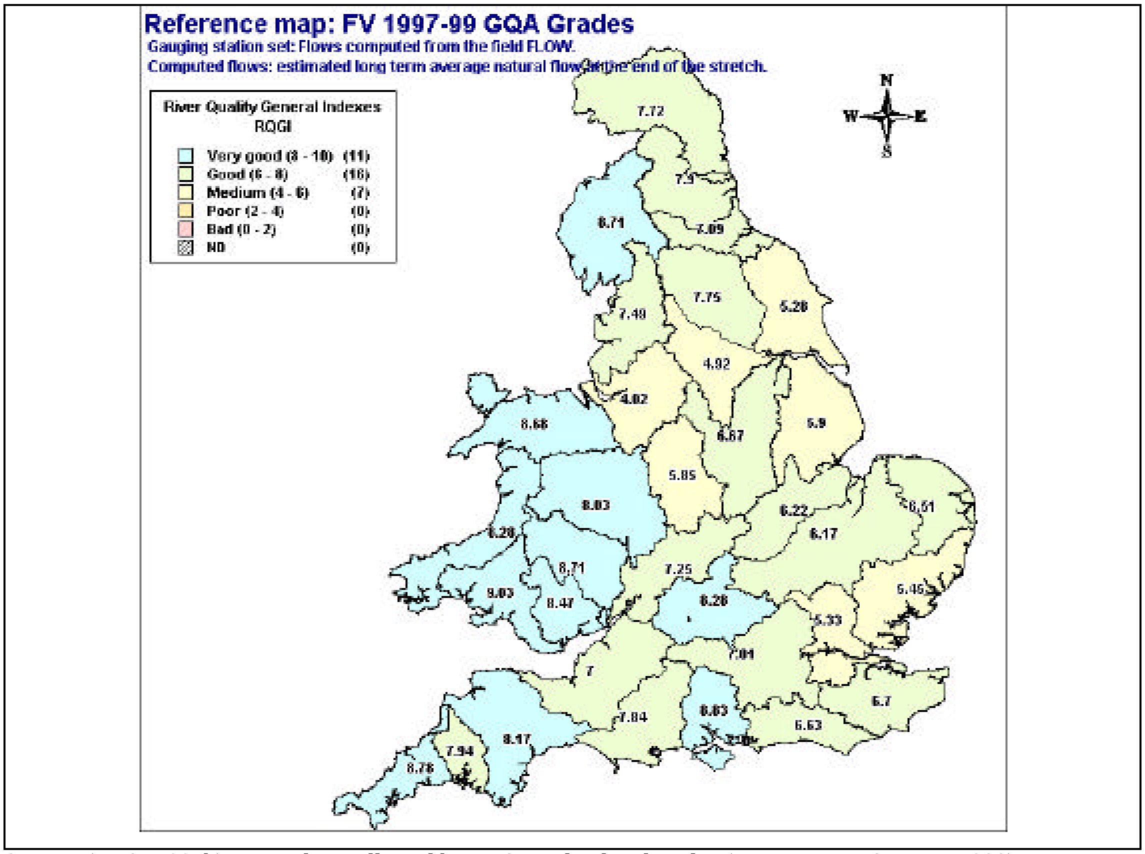
$$RQGI = \frac{10}{n} \times \frac{\sum_{j=1}^{C} \sum_{i=1}^{n} S_j \times I_i \times {}^{li}\!/_{Lj}}{\sum_{j=1}^{C} S_j}$$

Where S_j is the quantity of SRU of reach / stretch j, G_j /I_i are respectively the quality index (grade) or class or reach j or ith portion of stretch j, l_i the length on stretch j with quality grade i, n is the range of quality grades of the assessment system, L_j is the total length of stretch j. This equation allows processing any initial quality grade scaling.

7.65. The correct weighting factor for quality has been long discussed. In the equations above, it is considered that the index value contains its own weight. Hence, the index is the quality weight. In the average class number is sought for, it used to populate the variable I_i. This method keeps the average class number and provides identical results if subsequently transformed from index computation.

7.66. By construction, the RQGI indicator can be calculated for any grouping: river class within a catchment, all rivers within a NUTs unit, etc. Since data can be aggregated at any level, Ifen used RQGI to report the overall quality of French rivers in 2000 as an aggregated note of 5.3, RQGI ranging from more than 8 to less than 2 depending on region and river courses size class (Juin, 2002, p 21) When historical data is available, progresses can be demonstrated by comparison, such as the example taken from pilot application in England and Wales (EEA, 2001b). Between 1990 and 1997/1999 the overall index for all the reviewed catchments improved from 6.50/10 in 1990 up to 7.47/10 in 19997/1999, which situation by catchment is shown on Figure 7.5.

Figure 7.5: Global river quality index in England and Wales 1997/1999



Source: (EEA, 2001b), using data collected by EPA England and Wales (Environment Agency, 1998)

2. The pattern indicator

7.67. The RQGI does not capture the diversity of situations within a catchment. The relative proportion of "good quality" and "bad quality" that is averaged into a single figure can however be synthesised as a "quality pattern" indicator. It is a combined indicator that merges the proportion of SRU having good quality with the proportion of SRU having bad quality in ad hoc proportion reflecting that in any catchment the majority of water bodies are expected to have a good quality status; the proportion of water bodies showing bad quality should be as small as possible. Similarly to the RQGI, the pattern indicator can be calculated for any aggregate, for example per river size class within each catchment or for all rivers in a country. The indicator is built thanks to a table presenting 3 groups of good and 3 groups of bad quality. The values defining the cells in the table are chosen to allow any category to be represented.

7.68. The calculation of the pattern is not immediate since it requires defining a combination rule and a set of rules to quantify the combination rules. A tentative table crossing the three categories of "good quality" and "bad quality" is presented below. The adjectives defining the proportions of "good" and "bad" are different to emphasise that the respective threshold values are be different, reflecting the potential requirements for quality. For example, the presence of enough good quality sources is necessary for drinking water making, for fish spawning, etc. Remedial action may be focused on bad quality classes and highly depends on the structure of impacted water resources. The first stage consists in defining the combination rule that is exemplified in Table 7.12.

Table 7.12: Combination rule for quality patterns definition and assessment

Proportion of bad quality	**Proportion of good quality**		
	High	**Medium**	**Low**
Negligible	Good status (A)	Acceptable, with good quality rivers (B)	Mediocre everywhere (C)
Significant	Some black spots, surrounded by good quality waters (B)	Transition, risks of degradation(C)	Mediocre, with localised polluted points. (D)
Excessive	Important black spots, high risk of degradation (D)	Catchment highly polluted (D)	Overall pollution, unacceptable. (E)

Legend: the cells are shaded according to combination of columns and rows entries. The lighter the shading, the better the overall status of the catchment is. The 9 combinations are clustered into 5 final patterns indicated by letters "A" to "E". This classification is provisional.

7.69. The precise definition of each proportion requires two sets of hypothesis that apply to the aggregate to be analysed:

- The threshold values of the RQGI that makes a a result being qualified good" or "bad". For example, RQGI greater or equal to 6.0 was assumed "good", whereas the RQGI less or equal to 4.0 was assumed "bad". This is equivalent to the assessment made in the French pilot study where SEQ-classes 1 and 2 on the one hand, 4 and 5 ("HC") on the other were respectively considered as "good" and "bad".
- The proportion of SRU falling into the three quality categories defined above that are considered as respectively high / negligible, medium / significant and low / excessive. For example, more than 60% of the sum of SRU having a RQGI greater or equal to 6.0 is a "high proportion of good quality", whereas 10% or more of the sum of SRU having a RQGI less than 4.0 are considered as "excessive proportion of bad quality".

7.70. The values used in comparative reporting carried out during trial implementation (op. cit.) are reported in Table 7.13.. The implementation software provides all facilities to tune all the requested values. They should be assessed in application to other catchment and quality guidelines situations.

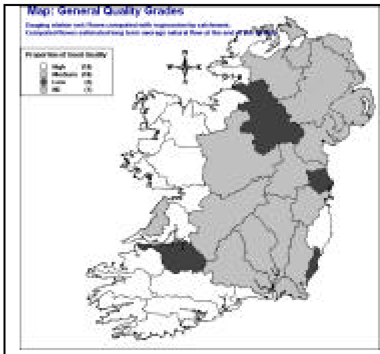
Table 7.13: Combination rule for quality patterns definition and assessment

Good quality definition ("G")	Any stretch with RQGI >=6.0, is "Good" ("G")		
Bad quality definition	Any stretch with RQGI <=4.0 id bad ("B")		
Good quality distribution	High:>=60% of total SRU "G"	Medium: otherwise	Low : <=30% of total SRU "G"
Bad quality distribution	Negligible: <=5% of total SRU "B"	Significant : otherwise	Excessive >= 10% SRU "B"

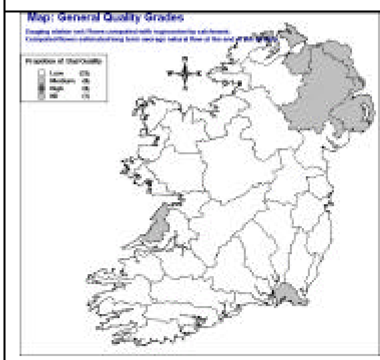
"G" and "B" are for 'good' and 'bad', as previously defined.

7.71. The final reporting is done by mapping and by tables. The best presentation is with three maps respectively presenting the distribution of good quality, the distribution of bad quality and the combined index. Conventionally, the groups are presented in white for the best and dark for the worst. Therefore, low proportion of good is dark and low proportion of bad is clear. The example refers to Ireland, comparing the results for the assessment of biological quality of rivers in 1990.

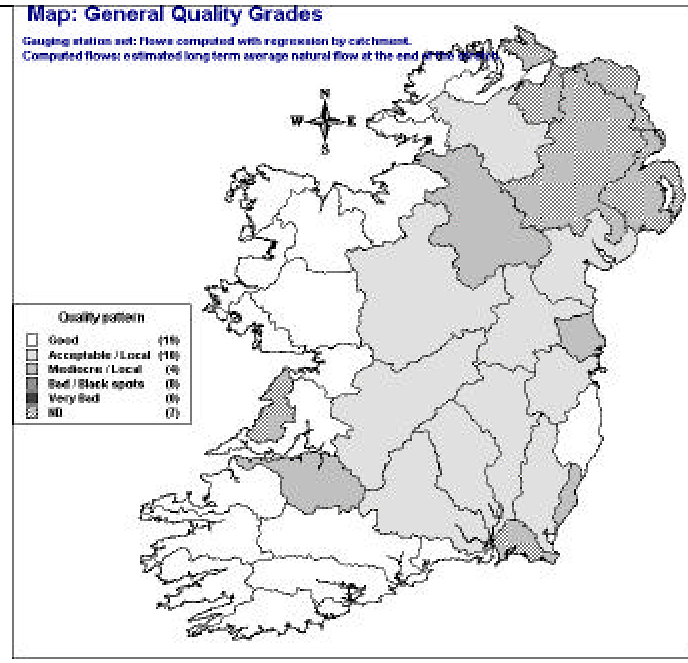
Figure 7.6: Pattern indicator (Irish river basins, 1990)



Good quality distribution



Bad quality distribution



Combined patterns

Comments: The Irish situation shows contrasted situation. West and South West catchments show both high rate of good and low rates of bad quality; they are undoubtedly in good state. By contrast, a catchment North of the mouth of the Shannon river west of the city of Ennis presents both medium good and significant bad quality. Four catchments show low proportion of good and low proportion of bad, suggesting local "hot spots" pollution sources the last map reflects the final assessment

Source: (EEA, 2001c, Data provided by Irish EPA),

3. The predominance indicator

7.72. The predominance indicator expressed the relative contribution of function oriented or determinand oriented (perturbation [c.f. §7.26] or determinand group) to the final RQGI. It captures the pollution impact and completes the pattern that captures the spatial distribution of quality. Practically two quality stock results built using different quality assessments are compared on the same aggregates (catchment, river groups, etc.) instead of comparing different years. Calculation of this index is possible provided a quality assessment system breaking down quality index according to functions or perturbations (such as SEQ) is used. The quality index computed for each function should represent represents the same nuisance. Taking a school notation example, a good note in history and in mathematics rewards a comparable level of instruction despite topics are different.

7.73. The outputs are presented as maps or tables reporting the differences in stocks between situations, after agreeing on the magnitude of change that is considered significant. A strong difference is when a 20% change is observed, in the case of using SEQ index (this should be adjusted when the scale is irregular, such as in the Canadian guidelines). The ad hoc value can be adjusted considering the distributions of differences and the targeted precision of the assessment. A tabulated example shows the distribution of relative issues related to organic matters (which source is urban sewage and industrial wastes) vs. nitrate issues (mainly related to agricultural nitrogen losses). The statistic is aggregated by accounting catchment, as presented in Figure 7.4.

7.74. This indicator may as well help expressing distance to target. A reference calculation has to be done replacing monitored water quality by water quality objective and use it as reference value against which actual status is reported.

Table 7.14: Preponderance of organic matters *vs.* Nitrate in French river quality (1994)

River class size	Number of accounting catchments where organic matters determine water quality	Number of accounting catchments where nitrate determines water quality	Average raw differences (in classes)	Average raw differences (in classes) weighted by SRU
Largest rivers	17/30 (57%)	13/30 (43%)	-0,41	-0,57
Rivers	30/51 (59%)	21/51 (41%)	-0,27	-0,52
Small rivers	34/50 (68%)	16/50 (32%)	-0,39	-0,45
Smallest rivers	37/54 (69%)	17/54 (31%)	-040	-0,29
Together	40/55 (73%)	15/55 (27%)	-0,35	-0,45

Remark: the figures are number of catchment falling in the case / total of catchments in the size class. Some size classes do not appear in all catchments. Source: (Translated from Crouzet, Germain et al., 1999, p48)

E. Application example

7.75. The first application was carried out in France, taking stock of water quality maps released by the "national network for water data (RNDE)". Ifen sized this opportunity, with the financial and intellectual support of Eurostat to develop and apply river water accounts methodology derived from the general methodology drafted under the auspices of the French commission on national accounts (Weber, 1986).

7.76. The water quality maps issued by RNDE were built against several perturbations. The *'organic matter perturbation'*, considers the following parameters: dissolved oxygen, BOD_5 (biochemical oxygen demand at 5 days), COD (chemical oxygen demand) and ammonium (ions NH_4^+). Other perturbations were also used eutrophication and nitrate. All data were reported as 5 quality classes, according to the SEQ, as river segments possibly hosting different qualities. Despite the data source is unique, some differences could be observed between maps, because the reported watercourses differed and the final stock had to be adjusted to reach the same SRU total. The description of stocks according to quality was available for two years for a reasonably comparable assessment (dealing with "overall quality") and the quality accounts show that there had been an improvement between the two years:

there are more and more SRU in good quality classes (1 and 2) and less and less in bad quality classes (4 and 5).

Table 7.15: 1992 and 1994 accounts of the French watercourses quality (organic matter indicator - in kSRU)

	1992 state					*Changes by quality class*					1994 state				
Quality class *	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
Largest rivers	5	1253	891	510	177	3	*336*	*9*	*-183*	*-165*	8	1583	893	358	12
Rivers	309	1228	1194	336	50	16	*464*	*-275*	*-182*	*-22*	325	1691	919	154	288
Small rivers	260	615	451	128	47	44	*130*	*-129*	*-17*	*-28*	306	749	322	110	188
Smallest rivers	860	1464	690	243	95	-44	*176*	*228*	*15*	*-23*	810	1295	917	258	72

Note: The figures in the middle column (in italics) do not in all cases match precisely the calculated difference between the 1992 and 1994 states of the rivers in question. This is because of difficulties in comparing certain groups of watercourses in some watershed basins between the two points in time.

* Quality classes are named 1 to 5 from best to worst.

Source: (Crouzet, Germain *et al.*, 1999)

7.77. Other applications have been carried out with the aim to validate the methodology, check the relevance of the derived indicators and assess the different situations that may impact further implementation. They have been mentioned in sections above. A project to match economic data (namely expenditures) and physical accounts was started by Ifen and resulted in the development and validation of the basic methodology on the Rhin-Meuse water agency area, as exposed in previous section. The extension to the whole French territory was jeopardized by the many defects identified in the French GIS database which presented many lacks in the connectivity of rivers. This project has been postponed until the database is repaired and has not been restarted in 2005.

7.78. However, this project resulted in a comprehensive development that has been carried out with financial assistance of Eurostat, resulting in a new calculation module into the NOPOLU *Système 2* software platform[13] under supervision of the Ifen (Ifen and Beture-Cerec, 2003). The basic methodology proved capable of computing the internal transfers resulting in stock change that require detailed calculations and providing any aggregation of results at catchment or administrative.

7.79. The EEA plans to implement the basic methodology, based on the current EuroWaternet which is a network, designed at the EU level, aiming at collecting harmonised data at different locations all around Europe. Combined with the European delimitation of catchment areas and the hydrographical map of the different watercourses that is currently being constructed jointly by 4 European bodies (JRC, Eurostat, DC environment and the EEA), this data constitutes the basis to characterise stretches of rivers with quality classes or grades. The actual implementation will be carried out from 2005 onwards, starting with volunteer countries.

F. Implementation procedure

7.80. Water quality accounting through basic methodology is a standardised way to produce reliable information from current monitoring systems. Everywhere river GIS featured with small reaches (in the

[13] Nopolu is software developed by Beture-Cerec consulting company. : http://www.beture-cerec.com/, St Quentin en Yvelines agency. Mention given for full information of readers.

range few hundred metres to few kilometre) and connectivity is available, the implementation is straightforward; It requires positioning quality and run-off monitoring stations to process their data.

7.81. Where these facilities do not exist, the wisest way is to build an operational GIS for rivers and catchments because it is a valuable investment that has a wide spectrum of uses, especially regarding the resources accounts and the other natural capital accounts (land cover, land use and ecosystems at least). The cost of operational system can be much reduced by using the free SRTM elevation data and modern GIS software. The major obstacle can be the will to build a very detailed GIS oriented to topographic accuracy at large scale (e.g. 1:10,000 to 1:25,000) instead of an operational system oriented to functional accuracy at lower scale (e.g. 1:100,000 or 1:250,000) that are sufficient for achieving all mentioned targets.

7.82. If none of the previous options is available, simplified approaches, as described in Table 7.9 and Table 7.10 should be considered. In all circumstances, there is a series of steps, presented below as a check-list that is intended to ensure the proper development of the quality accounting procedure. The needed elements are:

- The precise identification of the water body class to account: river system, lakes and reservoirs, groundwater leading to the ad hoc data collection on the physical features to be accounted (e.g. what are the minimum size of rivers to include, what are the minimum size of lakes to include? Should smaller objects be considered as statistical objects or discarded?),
- The precise scope of the quality accounting, namely ecosystem oriented account or only beneficial use oriented accounts. Since water as primary resource quality accounts are a subset of ecosystem oriented accounts, they can be derived from the latter accounts if water bodies elements well positioned and accounts carried out using basic methodology,
- The objectives of the reporting. Is it indicator production only or should detailed tables be produced to match expenditures? Can only catchment be processed or should administrative units be reported as well?
- Accurate information on the quality assessment methods in use in the country and available data (e.g. does the assessment method provides classes indexes, even of odd ranges, annual or seasonal results, is raw data available to re-assess quality or are only final results available? Etc.), and the scope of the assessment method,
- In all circumstance, and preferably if resource oriented accounts are envisaged, all relevant information on the quality of abstracted water, at the point of abstraction. This information may constitute (check accurately) a complement to ecosystem surveillance monitoring data,
- Information on run-off for rivers, replenishment and turn-over for lakes and groundwater. The minimum values for rivers are monthly averages, possibly yearly averages for basic methodology application. Otherwise, the use of debased methodologies is necessary and requires specific adjustments,
- A calculable GIS that includes connected river reaches, position and volumes or lakes and reservoirs, area and capacity of groundwater. Otherwise, what are the achievable calculation to envisage (see Table 7.9 and Table 7.10 for details and consult publications),
- The organisation of data and the availability of ad hoc software, hardware and expert availability to carry out calculations and production of outcomes. The quantity of resource to allocate depends widely on the available information. Indicative values are that the application of the simplified method, starting from scratch (no ad hoc software) require 3

month of senior expert and 5 month of junior expert, including development of the calculation software under MS Access® and MapInfo®. If the basic method can be run on ad hoc GIS with data managed for example with the NOPOLU *Système 2* platform, routine production of comprehensive accounts falls to 10 days per year (senior + junior expert), the initial customisation may require on week to one month of senior expert depending on the quality of data. The use of incomplete data is quite resource consuming because little automation of tasks is possible, thus leading to many errors that require replaying the procedure.

REFERENCES

ABS (Australian Bureau of Statistics), 2004. *Water accounts Australia 2000-01. n° 4610.0*. Canberra. ABS. 137 pages.

Canadian Council of Ministers of the Environment, 2001a. “Canadian water quality quidelines for the protection of aquatic life: CCME Water Quality Index 1.0, technical report”. in *Canadian environmental quality guidelines, 1999*. (Edited by Canadian Coucil of Ministers of the Environment). Winnipeg. 13 p.

Canadian Council of Ministers of the Environment, 2001b. “Canadian water quality quidelines for the protection of aquatic life: CCME Water Quality Index 1.0, User's Manual”. in *Canadian environmental quality guidelines, 1999*. (Edited by Canadian Coucil of Ministers of the Environment). Winnipeg. 5 p.

Canadian Council of Ministers of the Environment, 2003. “Summary of Existing Canadian Environmental Quality Guidelines”. in *Canadian environmental quality guidelines, 1999*. (Edited by Canadian Coucil of Ministers of the Environment). Winnipeg. 12 p.

Crouzet, P., Germain, C. and Le Gall, G., 1999. *Les Comptes de la qualité des cours d'eau. Mise en oeuvre d'une méthode simplifiée de calcul. Développements en cours*. *Etudes et Travaux n° 25*. Orléans. Institut français de l'environnement. 70 pages.

Délégation de bassin Rhin-Meuse, 2003. “Réalisation d'un test de validation de l'outil de linéarisation de la qualité physico-chimique des cours d'eau”. (*writen by Jean-Pierre Wagner and Céline Spitz, ordered by* 'DIREN Lorraine'), 76 pages.

Department of Water Affairs and Forestry, 1996a. *South African Water Quality Guidelines.Volume 1: Domestic Use*. Edition 2. Pretoria. 196 pages.

Department of Water Affairs and Forestry, 1996b. *South African Water Quality Guidelines.Volume 2: Recreational Use*. Edition 2. Pretoria. 89 pages.

Department of Water Affairs and Forestry, 1996c. *South African Water Quality Guidelines.Volume 3: Industrial Use*. Edition 2. Pretoria. 122 pages.

Department of Water Affairs and Forestry, 1996d. *South African Water Quality Guidelines.Volume 4: Agricultural Use: Irrigation*. Edition 2. Pretoria. 194 pages.

Department of Water Affairs and Forestry, 1996e. *South African Water Quality Guidelines.Volume 5: Agricultural Use: Livestock Watering*. Edition 2. Pretoria. 163 pages.

Department of Water Affairs and Forestry, 1996f. *South African Water Quality Guidelines.Volume 6: Agricultural Water Use: Aquaculture*. Edition 2. Pretoria. 185 pages.

Department of Water Affairs and Forestry, 1996g. *South African Water Quality Guidelines.Volume 7: Aquatic Ecosystems.* Edition 2. Pretoria. 161 pages.

Department of Water Affairs and Forestry, 1996h. *South African Water Quality Guidelines.Volume 8: Field Guide.* Edition 1. Pretoria. 68 pages.

EEA, 2001a. "Reporting river quality using the Water Quality Accounts methodology. Application within the Eurowaternet process". (*report type: Draft, writen by Philippe Crouzet*) Copenhagen, 24 pages, availability: limit.

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

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

Environment Agency, 1998. *The State of the Environment of England and Wales: Fresh Waters.* London. The Stationery Office. 214 pages.

European Topic Centre- Inland waters, 2000. "Comparative Analysis of River Quality Classification Schemes in Europe". (*report type: Final (english version), writen by Steve Nixon, Anne Gendebien et al., n° PO25/97/3, ordered by* 'European Environment Agency') Medmenham, 72 pages, (5 annexes), availability: limit.

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

Ifen and Beture-Cerec, 2003. "Study report: Water quality accounts calculation module". (*report type: Final, writen by Philippe Crouzet, Guillaume le Gall et al., n° Grant agreement 200141200031, ordered by* 'Eurostat') Orléans, 20 pages, availability: Total.

Juin, D. *(Ed.)* 2002. *L'environnement en France.* Paris et Orléans, La Découverte et Institut français de l'environnement. 602 pages.

Kristensen, P. and Bogestrand, J., 1996. *Surface water quality monitoring. Topic Report. Inland Waters n° 2/1996.* Copenhagen. European Environment Agency. 106 + annexes pages.

Margat, J., 1996. *Les ressources en eau. Conception, évaluation, cartographie, comptabilité.*Vol. 28: *Manuels et méthodes* Orléans. Editions BRGM, FAO. 148 pages.

McGarrigle, M., 2001. Personal communication. (Visit to Irish EPA).

Oudin, L.-C. and Maupas, D., 1999a. *Système d'évaluation de la qualité des eaux des cours d'eau, SEQ-eau. Version 1,* 2 vols.Vol. 1: *Les études des agences de l'eau n° 64.* Paris. Office International de l'eau. (Annexe A 282 pp., Annexe B 223 pp.), 259 pages.

Oudin, L.-C. and Maupas, D., 1999b. *Système d'évaluation de la qualité des eaux des cours d'eau, SEQ-eau. Version 1. Annexes et Grilles,* 2 vols.Vol. 2: *Les études des agences de l'eau n° 64.* Paris. Office International de l'eau. 305 pages.

Train, R. E., 1979. *Quality Criteria for water.* London. Castle House Publications Ltd. 256 pages.

Weber, J.-L. *(Ed.)* 1986. *Les comptes du patrimoine naturel.* Paris, INSEE. Collections de l'INSEE (Série C) **n° 137-138**. 552 pages.

Chapter 8 Implementing the accounts

A. Introduction

8.1. The objective is this chapter is to provide insights on how to start with the implementation of a water accounting programme. Section B describes water accounts in the context of a more general information system on water. Water accounts provide a framework to analyse the interaction between the environment and the economy. This information is the basis for the formulation of policies to reduce water stress and pressure caused by the economy, to link the physical and monetary statistics in a consistent manner, to evaluate the impact of water policies on the environment and the economy etc. However, there can be policy concerns which cannot be addressed by an accounting system when, for example, the spatial and temporal reference needed for decision making is too detailed than that used in the accounts.

8.2. Section C presents key elements for the establishment of a national programme on water accounts. Section E provides an example of how basic information on water is collected and estimated. Section F presents the links between water accounting and international questionnaires on water. In particular, the UNSD/UNEP and Eurostat/OECD Questionnaire will be considered. This section shows how much of the accounting tables could be compiled by using data from those Questionnaires.

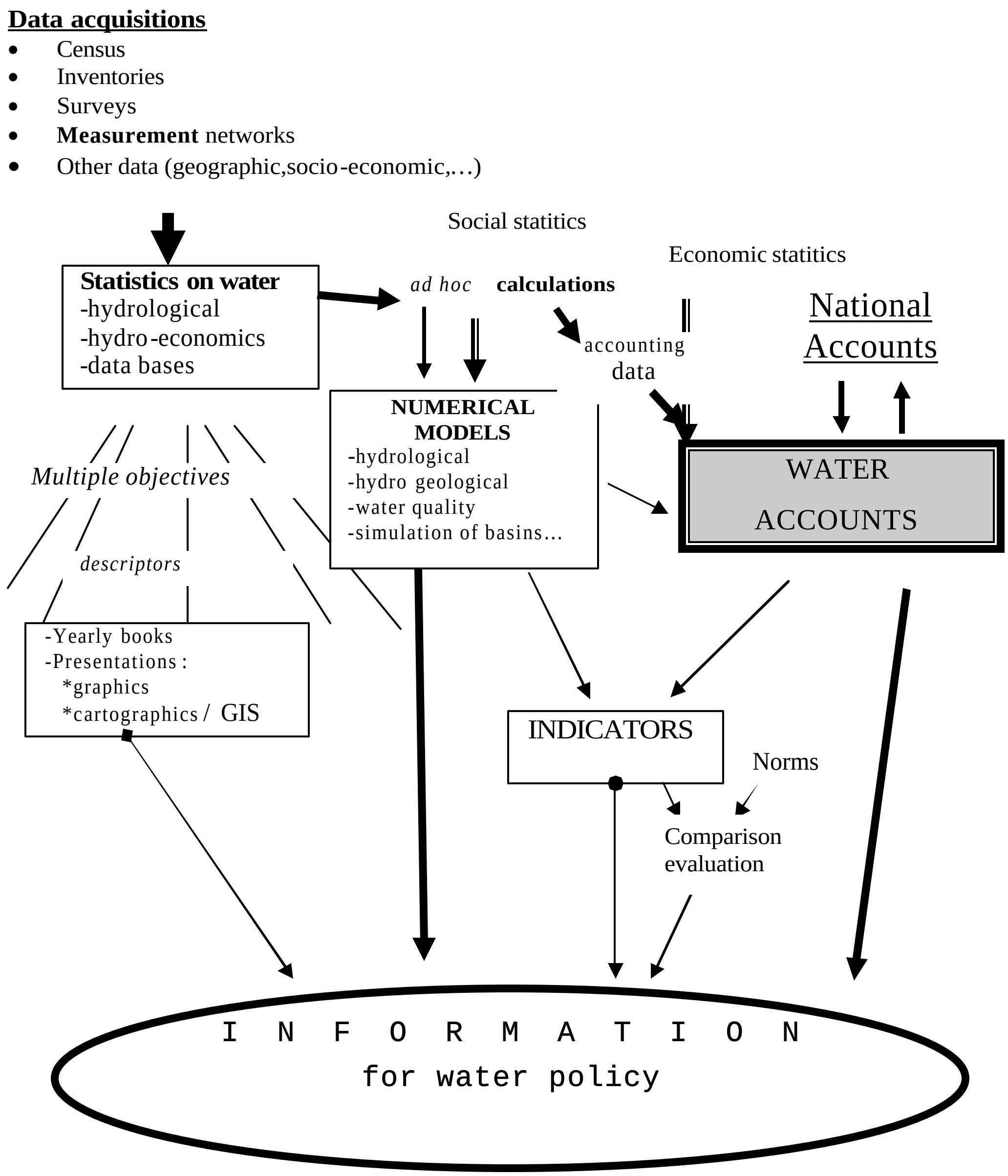
B. Water accounts as part of a more general information system on water

8.3. The SEEAW integrates hydrological and economic information on water according to the framework of the SNA. In order to start the implementation of water accounts, it is important to understand how the information system represented by the SEEAW relates to other available information on water in a country. This would help not to identify potential data sources, but also understand the steps necessary to manipulate available data in order to be used in the accounting framework.

8.4. Figure 8.1 shows the various stages for the production of information on water for policy making from basic data represented by hydrological, economic and social statistics, to a more organized integrated framework – represented by models and water accounts - and indicators which all provide synthetic information for decision makers at different scales of space and time (for example with models : hourly for economic decision during flood events and monthly for agro-economic decision linked to management of water stocks with flow forecasts under uncertainty; and with water account : annually for policy monitoring and change).

8.5. *Statistics on water* include information on water resources in the environment and often also some information related to water use by the economy. This information is often the result of direct measurements for example, through field measurements, which can be collected through censuses, surveys etc. or the result of indirect estimation, for example through the result of modelling or simple use of estimated parameters. Statistics on water are often scattered in various institutions which collect these data for a variety of purposes. The main producers of water statistics are meteorological and hydrological institutes, agencies responsible for the management of water resources and for the abstraction and distribution of water, government agencies in charge of controlling or providing water supply related services, etc.

Figure 8.1: Structure of information on water for policy



8.6. *Water accounts* can be viewed as an information system which organizes into a coherent and systematic manner environment, social and economic statistics relevant to water according to the framework of national accounts. This is obtained by ensuring that (a) the data in the framework refer to the same spatial and temporal reference, (b) the classifications and definitions are the same for economic and hydrological information, and (c) the hydrological (e.g. water balance and basic hydraulic laws) and economic (e.g. SNA accounting identities) concepts are not violated.

8.7. Since basic information on water does not always have the same spatial and temporal reference also in relationship to economic statistics, it is often necessary to manipulate basic data before using them in the accounting framework. However, since water accounts are consistent with basic hydrological concepts, the manipulation required usually involve aggregation of basic data (for example, local basic data on precipitation are recorded by meteorological institutes on a daily or monthly basis, while the accounts are compiled for longer periods of time and for a given territory, thus requiring weighted spatial interpolation and integration).

8.8. *Indicators* are synthetic measures of complex (multifaceted and multidimensional) phenomena which assist in the description of a phenomenon, the evaluation of its changes over time and the assessment of comparative studies. Indicators are particularly useful for policy makers as they provide a common instrument of communication with users, specialists, and decision-makers. A number of indicators, as presented throughout this handbook, can be derived from the accounts and are used for policy purposes. The advantages of using indicators derived from the accounting system is that they are fully consistent with each other and they not only reveal trends, but allow for consistent in-depth analysis on the causes of particular trends (by analysing the information system behind these indicators) and for consistent formulation of policies (by scenario modelling based on the information system).

8.9. *Information for water policy* comes from different sources, data bases and system of information including water accounts. Water accounts provide an information system for the analysis of the interactions between the economy and the environment. Although the accounts cannot always be compiled at the level of disaggregation or spatial and temporal reference detail necessary for certain policy questions, the consistency of the basic hydrological, economic and social statistics with the accounting framework - especially when accounts are calculated at the level of water management which is the basin level (generally according to a sound national territory pattern of 6 to 10 main adjacent river basins) - provide the basis for making integrated decisions at local level and ensuring that these are in-line, or at least do not conflict with, the achievement of broader national objectives which include social, economic and environmental goals. In addition, this consistency of basic information with the accounting framework reduces the monitoring burden at local and national level.

C. Elements of a national programme in water accounts

8.10. Before embarking in a national programme of integrated environmental, social and economic accounting for water resources, there should be a clear perception of the status of national accounting in the country, of the objectives and priorities of environmental and economic policy, and of data availability, especially on environmental and socio-economic conditions. The assessment of statistical capacities, environmental conditions and political priorities facilitates the formulation of a work plan and effective coordination of data gathering by different agencies.

8.11. The accounting framework is typically adjusted to address specific environmental and economic concerns in a country. The flexible building-block structure of the SEEA and SEEAW allows for the selection and modification of the modules of the accounts so as to suit the conditions and priority concerns of a particular country. A strong link between the accounts and their ability to responds to policy concerns in a country is one of the fundamental elements for the sustainability of the accounting programme.

8.12. Elements of an implementing strategy could include training, pilot, benchmark and regular compilations, as well as special studies. Ideally, a national programme of water accounting should be nationally driven within the institution(s) in charge of water management with a long term perspective for three main reasons: the statistics may often require a long time to be developed; the analysis of some environmental effects requires long time-series and the process must be sustainable with clear short term benefits.

8.13. Although each country may start an implementation programme in water accounting through different mechanism, some common steps can be identified. They include:

(a) A preliminary assessment of the water policy concerns in the country;

(b) The organization of meetings with water managers, data providers, policy makers (and potential donors) with the objectives of describing and explaining the accounting framework, how it could be adapted to respond to the country's policy concerns and defining the data requirement (in terms of the assessment of data availability and the identification data sources);

(c) The establishment of a formal institutional arrangement between agencies and institutions and the establishment of a steering committee responsible for the project;

(d) implementation phase of a pilot compilation, at the appropriate level (national or pilot basin);

(e) Organization of a workshop to review the results of the pilot compilation and identify data gaps and decide on future steps towards a regular compilation of the accounts.

1. Preliminary assessment of the water policy concerns in the country

8.14. One of the strengths of water accounts is the ability to respond to policy questions related to water. The link with the policy uses of water accounts is fundamental for a successful implementation of the accounts. Generally, if the compilation of the accounts remains a pure numerical exercise, the risk is that the costs of implementing the accounts outweigh the benefits derived from them and, therefore, there would no incentives in the continuation of the accounting programme in the long run.

8.15. Understanding the policy concern in a country would also assist in the choice of which accounting module is more relevant. For example, in countries facing water scarcity, information on water resources and on water use by the economy and its link with information on water in the environment are fundamental to design policies aimed at conserving water. In these cases, supply and use tables and asset accounts are often the modules compiled as a first priority. On the other side, resource rich countries may face problems with water pollution. In these cases, emission accounts and quality accounts may be considered a priority.

2. Organization of meetings with stakeholders

8.16. The organization of meetings with water managers, data providers, policy makers and potential donors would have the objectives of (a) describing the accounting framework, (b) deciding how to adapt it to respond to the country's policy concerns, and (c) making an assessment of data availability and data sources.

8.17. It is important that all the parties involved in the compilation of the accounts understand the importance of such a framework for decision making as well as understanding the benefits that each institution would derive from the compilation of such an integrated and comprehensive data system.

8.18. Adapting the SEEAW framework to the country's specific policy concerns involve several decision: which module of the accounts are relevant and should be compiled as a priority; which spatial and temporal reference to use for the accounts.

Which modules of the accounts to compile

8.19. The modular approach of the SEEAW allows for the compilation of selected modules of the accounts according to the country's priorities: supply and use tables in physical or monetary units, emission accounts, asset accounts, etc. The compilation of a larger set of accounts could be done in benchmark compilations which could be carried out for longer interval of time than the regular compilations. For example, if regular compilations are carried out annually, benchmark compilations could be done every 5 to 10 years.

8.20. The choice of which module of the accounts to compile regularly depends heavily on the policy relevance of the specific module in the country and the ability to gather/collect relevant data on a regular basis.

Spatial reference

8.21. The choice of territory of reference depends heavily on the objectives of the accounts, the possibility to reconcile the spatial reference of hydrological, monetary and physical data on water, and the ability to clearly define the conditions at the border lines (potential flow exchanges between territories).

8.22. The most appropriate territory for water management is a river basin, preferably as a whole, or otherwise partially or even as a group of adjacent river basins. The choice of whether subdivide or expand a river basin depends also the ability to gather economic data which are generally available for an administrative region. For example, if the river basin is very small and covers only part of an administrative region, there may be problems in obtaining data on water use, discharges, expenditures etc. and it may become necessary to expand the area to adjacent river basins. Unfortunately, even in this case, territory limits will generally be different of those of an entire administrative region.

8.23. In case of a very large territory or a territory with rather diverse water resources or water utilizations, the division of the accounting area into smaller region, for instance a sub-basin, or divided in regional social-political entities, can help to make the analysis more useful and accurate. The different water accounts must then, with the support of GIS tools, be aggregated in order to have water accounts for the entire region. Subdividing an area for the compilation of water accounts increases the data requirements for the compilation of the accounts (more detailed data, calculation of the water exchanges between the different subdivisions which will cancel each other out during the construction of the accounts for the entire territory, etc.)

Temporal reference

8.24. The compilation of water accounts involves the choice of the temporal coverage of the accounts and the frequency of their compilation. For example, accounts could be compiled for a year on a yearly basis or every two years. For those areas where there is a strong seasonality which affects both the availability of water resources and their uses (for example, in some countries warm and dry months corresponds to a decrease in the water resources and an increase demand due to tourism during the summer period), quarterly accounts would allow for a better understanding and monitoring of water policies. However, these accounts are more data demanding and their implementation is often more difficult.

8.25. As mentioned before, the temporal reference of economic and hydrological data is different as the first refer to an accounting year which generally, but not necessarily, corresponds to a civil year that is from 1 January to 31 December. The second correspond to the hydrological year which is a continuous 12-month period selected in such a way that overall changes in storage are minimal (so that carryover is reduced to a minimum and so is the uncertainty in the assessment of the stocks of "soil water”). It is fundamental that, when compiling water accounts, the temporal reference of economic and hydrological data is the same.

8.26. While the accounting year is more appropriate for the formulation and evaluation of macro-economic policy, the hydrological year provides more meaningful comparisons of hydrological data. If there is a substantial difference between the accounting and hydrological year, the choice of one versus the other depends on the main objectives of the compilation of the accounts. In these circumstances it is advisable to devise a reconciliation mechanism of the temporal reference of hydrological with economic data and vice versa.

8.27. The choice of the frequency of the compilation of the accounts depends on a number of factors including the ability to respond to the country’s policy concerns and to gather relevant data.

Assessment of data availability and data sources

8.28. The assessment of data availability and data sources for the compilation of the accounts is particularly important to understand the feasibility of the accounting project. This assessment also set the basis for the establishment of coordination mechanism among relevant agencies (institutional arrangements at different levels: national, region, basin…) for the compilation of the accounts.

3. Establishment of an institutional arrangement

8.29. Water accounts require an interdisciplinary work for a number of reasons the most important of which is related to the fact that data necessary for the compilation of the accounts are generally scattered among various institutions. It is fundamental, therefore, that data producers and users are collaborating in this exercise though some form of institutional arrangement where responsibilities for each party are clearly defined.

8.30. Public information on water resources and water uses is generally under the responsibility of the Ministry in charge of monitoring the water policy implementation. Within this intuitional framework hydrological data are often elaborated by specific institutions such as an institute or branch of hydrology and hydraulics, sometimes a meteorological institute, a geological institute. This institute may elaborate part of the water management programme, more particularly as regards the management of the water resource.

8.31. Data on water quality are often the responsibility of a specific governmental agency dedicated to environment: environmental protection agency, pollution control authority, agency for the environment and the energy, etc. The agency generally gathers data on the status of the water system from scattered monitoring points. It decides on the procedure of measurement, on the network of the monitoring points, which can themselves be looked after by other governmental entities (e.g. municipalities, administrative services for water supply, etc.) acting as focal points of the agency. The agency reports on the quality of the water system to the government and to the public. Its work is sometimes complemented by the work of health departments.

8.32. There could also be specific agencies dedicated to water only: water supply utilities, offices for irrigations, rivers authorities, water boards, water agencies, etc. These agencies can be national, local or work at the level of a river basin. Their specialization is of course an advantage. However, instructions should be given at the national level to ensure comparability of the data collected locally. When these agencies are relatively independent and confronted to different concerns, for instance different types of pollution, they may establish different set of data, preventing from an aggregation of these data.

8.33. Statistical offices often provide monetary information on enterprises operating in the water sector (business surveys), on purchase of water by other industries, on households' consumption of water, etc. If responsible for such surveys, they may also collect physical data about water: volumes of water consumed by industries, households, volumes of water abstracted and returned. Statistical offices are most often responsible for the compilation of national accounts.

8.34. The challenge is to make all these institutions work together. As environmental accounts have been conceived as satellite accounts to national accounts to ensure the coherence with them, a recommendation could be to elaborate them within the national accounts department. However, due to the existence and responsibility of the national institution in charge of water or of a water directorate within the ministry for environment, water accounts can also be compiled within this institution or department, at the appropriate spatial level, with the help of a national accountant assigned to it. Each country has its own policy as regards the building of satellite accounts: concentrate them with the national accounts or decentralise them within the relevant ministry at the basin or national level, with a structured involvement of all concerned institutions by water (there are generally more than ten at the central level).

8.35. Thus, more important than the institutional location of the water accounts is the establishment of the institutional arrangement - a formal agreement between parties in which all agencies involved in the compilation of the accounts agree to contribute and in which manner.

8.36. It is often a good practice to establish a small technical committee responsible for monitoring the implementation of the water accounts.

4. Implementation of a pilot compilation

8.37. Generally a programme of water accounting is initiated by a pilot project. The objective of the pilot project would be to explore the need for and capabilities of conducting water accounting in the country. The pilot compilation is generally based on existing statistics. Considerable data gaps can be expected at the start of the programme requiring estimates that should be replaced by more reliable data in later compilations.

8.38. However weak in terms of data, a pilot compilation serves important purposes: (a) it represents an important training phase in which national staff familiarize with the concepts and methods of integrated accounting; (b) it assists in setting up coordination mechanisms of data collection in the country and guides future data development; and (c) it provides directions for a course of action for future work after the assessment of data gaps, reliability, and compilation methodology, which is generally done at the end of the pilot phase.

8.39. It is suggested that the pilot compilation be carried out as an interdisciplinary work from the beginning in which the institution(s) responsible for the compilation of national accounts (generally, the statistical office), providers of physical data on water resources, and other in-line Ministries/Institutions play key roles.

8.40. A pilot compilation could be done for a sub-region with the objective of extending the methodology to the rest of the country (starting, for example, from accounts for a river basin). This was the case of a pilot project in water accounting in Morocco where the pilot project focused on the compilation of water accounts on one sub-river basin using existing data (see)

Box 8.1: Pilot project in the Oum-Er-Bia river basin, Morocco

The project was launched during a preliminary mission of UNSD and DSD in Morocco in June 2003. An institutional set-up was agreed at the national level for the future institutionalization of the water accounts in Morocco. The approach of the project is new as it involves carrying out water accounts first at the riverbasin level and then aggregating the accounts over the nine river basins of Morocco. The information at the national level will then be presented in a satellite system of the System of National Accounts. The Oum-Er-Bia river basin was chosen as the pilot as it presents problems of water scarcity, flooding, water quality - as a result of wastewater from sugar and leather manufacturing; and exports of water to other basins. As part of the project a workshop was jointly organized by the Government of Morocco and the Department of Economic and Social Affairs, Division for Sustainable Development and Statistics Division (Afourer, Morocco, 13-15 January 2004). The Workshop, which gathered 60 technical decision makers from all major organisations concerned in water within this basin, discussed problems encountered in and the preliminary results of the implementation of water accounts in the Oum-Er-Bia river basin. The workshop agreed that water accounting is an important cross-sectoral tool for integrated water management at the river basin level. The preliminary experience of the compilation of the accounts has shown the feasibility of the approach. It was recommended that the water accounts be implemented in all river basins of Morocco. The difficulty of harmonizing economic and environmental data in a common framework at the river-basin level was recognized. As a solution, it was proposed to compile physical water accounts at the river-basin level, monetary accounts at the regional level and then reconcile the two accounts.

5. Organization of a workshop to review the results of the pilot compilation

8.41. Generally after the pilot compilation of the accounts, it is a good practice to review the results during a workshop in order to identify data gaps, review problems encountered in the pilot compilation and decide how to overcome them. The workshop would also have the objective to prepare a feasibility study (technical, financial, institutional etc.) of water accounts in view to establish, with a medium-term perspective and after additional training and supports as appropriate, a regular accounting programme within the normal work programme of each institution

D. Example of direct and indirect data in the compilation of physical accounts

8.42. An important phase in the implementation of the accounts is the validation of data. The accounting framework with its inherent checks and balances, allows for the identification of inconsistencies and errors in the data. In these cases, the compiler of the accounts has to go back to the original data source to verify that the information available is correct (there may be a misunderstanding of the concepts actually needed in the accounts - e.g. potential vs. actual evapotranspiration, or simply there may be a transcription error). In the validation process, it would be useful to have margin of errors (represented by confidence intervals) associated with each figure so as to determine which information is potentially less-reliable.

8.43. In addition to having information on the margin of error of the data, it is useful to identify which information in the accounting tables is generally obtained from other data in the table - that is data which are calculated either as a proportion (or other calculation), a residual or as a summation of tables entries. The term ‘indirect data’ is used here to refer to those figures in the tables, while the term ‘direct data’ refers to the figures obtained independently from other accounting entries.

8.44. In the physical asset accounts, for example, most of row totals are indirect data as they are obtained as a sum of the row entries. The only exception is for precipitation where data are generally available for (a) total precipitation a territory and (b) the part of it which falls directly into surface water (by type of water body). Thus, data for precipitation on the soil is obtained from the accounting tables as a difference between (a) and (b) Table 8.1 shows an example of 'direct' and 'indirect' data entries of an asset accounts. Similar tables can be built for the other accounting tables.

Table 8.1: Direct and indirect data for asset accounts.

			EA.131 Surface water							
			EA.1311 Reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow and Ice	EA.1315 Glaciers	EA.132 Groundwater	EA.133 Soil water	Total
Opening Stocks			Direct	Direct	Direct	Direct	Direct	Direct	Direct	Indirect
Changes due to human activities	Abstraction		Indirect	Indirect	Indirect	Indirect	Indirect	Indirect	Indirect	Indirect
	Returns		Indirect	Indirect	Indirect	N/A	N/A	Indirect	Indirect	Indirect
Changes due to natural processes	Precipitation		Direct	Direct	Direct	Direct	Direct	N/A	Indirect	Direct
	Inflows from upstream territories		Direct	Direct	Direct	N/A	N/A	Direct	N/A	Indirect
	Inflows from other resources in the territory:	Natural transfers	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Indirect
		Man-made transfers	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Indirect
	Evaporation/Actual evapotranspiration		Direct	Direct	Direct	Direct	Direct	N/A		Indirect
	Outflows to downstream territories		N/A	N/A	Direct	N/A	N/A	Direct	N/A	Indirect
	Outflows to the sea		N/A	N/A	Direct	N/A	N/A	Direct	N/A	Indirect
	Outflows to other resources in the territory:	Natural transfers	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Indirect
		Man-made transfers	Direct	Direct	Direct	Direct	Direct	Direct	Direct	Indirect
Other changes in volume										
Closing Stocks			Direct	Direct	Direct	Direct	Direct	Indirect	Direct	Indirect

Direct data

Indirect data

Not applicable

E. Links with International Questionnaires on Water Resources

8.45. Statistics on water are collected at international level by several Questionnaires. This section presents the links between the information needed to compile water accounts with that collected by the UNSD/UNEP and the OECD/Eurostat Questionnaires and shows overlaps and data gaps between the questionnaires and the accounts.

8.46. The OECD/Eurostat and UNSD/UNEP Questionnaires cover several sections on various natural resources. One of these sections is dedicated to water resources. The two Questionnaires cover different regions of the world: the OECD/Eurostat questionnaire covers OECD countries and the UNSD/UNEP Questionnaire covers non-OECD countries. The information collected by the two questionnaires is very similar. The UNSD/UNEP Questionnaire is however much smaller in size and less demanding in terms of detail. Both questionnaires collect information on the following:

- water resources,
- water withdrawal,
- water use,
- wastewater treatment,
- production and disposal of sewage sludge,
- discharge of wastewater into the environment.

8.47. The information collected through the section of water of the OECD/Eurostat and UNSD/UNEP Questionnaires can be used for the compilation of simplified accounting tables (in physical units). Each table (asset account, supply and use table, etc.) is presented with highlighted those cells that can be filled with data collected by the Questionnaires. This table presentation helps to identify which additional information is needed for the compilation of the accounts.

8.48. Some differences in the terminology and definitions are still present but this does not constitute an impediment in the use of the information collected by the Questionnaires in the accounting framework. Despite these minor differences, the correspondence of the definitions is clear. The glossary which accompanies this handbook is based on an extensive review of existing terms and definitions taken from international questionnaires on water resources, international glossaries of hydrology. It was discussed electronically with hydrologists, statisticians, accountants and other experts in the field.

8.49. Information collected through the questionnaires on "water resources" helps in filling the asset account. Attention should be paid, however, in the coverage/definition of water resources: the asset SEEAW classification of water resources includes both fresh and brackish water, while the information on water resources collected through the questionnaires covers only fresh water and brackish waters are considered together with marine water. The accounts can be compiled according to the quality of water (in this case quality is defined in terms of salinity content) depending of each country specificities and policy concerns. Table 8.2 presents the asset account table only for fresh water resources.

8.50. Another difference is the definition of abstraction which in the questionnaires is recorded net of artificial recharges into aquifers while in the accounts these flows are reported separately.

Table 8.2: Link between water asset accounts and Questionnaires

			EA.131 Surface water					EA.132 Groundwater	EA.133 Soil water	Total
			EA.1311 Reservoirs	EA.1312 Lakes	EA.1313 Rivers	EA.1314 Snow and Ice	EA.1315 Glaciers			
Opening Stocks										
Changes due to human activities	Abstraction		UU					UU		
	Returns					X	X	OE		
Changes due to natural processes	Precipitation							X		UU, OE
	Inflows from upstream territories					X	X		X	UU, OE
	Inflows from other resources in the territory:	Natural transfers								
		Man-made transfers								
	Evaporation/Actual evapotranspiration							X		UU, OE
	Outflows to downstream territories		X	X		X	X		X	OE UU OE
	Outflows to the sea		X	X		X	X		X	
	Outflows to other resources in the territory:	Natural transfers								
		Man-made transfers								
Other changes in volume										
Closing Stocks										

UU means entry from the UNSD/UNEP Questionnaire

OE means entry from the OECD/Eurostat Questionnaire

8.51. Table 8.3 shows the physical use table. Some differences in the definition of water reuse (in the accounts it include reuse of treated or untreated wastewater while in the UNSD/UNEP Questionnaire it includes only the reuse of treated wastewater) and in the terminology (the accounts refers to ISIC 41 the distribution of water while the questionnaire refers to 'public water supply' which however does not depend on the government ownership of the distribution industry).

Table 8.3: Link between physical use table and the Questionnaires

	ISIC					Households	Rest of the World	Total
	ISIC 41	ISIC 01-05	ISIC 15-37	ISIC 40	OTHER			
Total Abstraction:								
from Water resources:								
Surface water	UU,OE	UU,OE	UU,OE	UU,OE	UU,OE	UU,OE		
Groundwater	UU,OE	UU,OE	UU,OE	UU,OE	UU,OE	UU,OE		
Soil water								
from Other sources (e.g. sea water)	OE	OE	OE	OE	OE			UU
Use of water received from other economic units							UU	UU*
Of which wastewater (reused water)	OE	OE	OE	OE				UU,OE**
Of which from ISIC 41	UU	UU,OE	UU,OE	UU,OE	UU,OE	UU,OE		UU
Total use of water								

UU* corresponds to "Other supply" in the UNSD/UNEP Questionnaire

UU,OE** corresponds to "Total reuse of freshwater" in the UNSD/UNEP Questionnaire.

Table 8.4: Link between physical supply table and the Questionnaires

	ISIC								Households	Rest of the World	Total
	ISIC 41	ISIC 01-05	ISIC 10.-14	ISIC 15-37	ISIC 40	ISIC 45	OTHER	Total ISIC			
Supply of water to other economic units	UU										
Of which wastewater		UU*	UU*	UU*	UU*	UU*	UU*	OE	UU*,OE	UU	OE
Total returns		UU*	UU*	UU*	UU*	UU*	UU*	OE	UU*,OE		UU**,OE
To Water Resources											OE
Surface Water											
Groundwater											
Soil water											
To other sources											OE
Total supply of water											

8.52. UU* corresponds to information on generation of wastewater by economic activity (independently whether the wastewater is discharged or not into the environment) are collected by the UNSD/UNEP Questionnaire

8.53. UU** corresponds to information on "water returned without use" and water losses during transport which are subcategories of total returns in the accounting tables.

8.54. Some variables collected in the questionnaires such as percentage of national resident population connected to different types of treatment plants are part of the supplementary information. There are other variables which do not appear directly in the water accounts, but they are used for the assessment of this information: for example, the breakdown of wastewater treatment between primary, secondary and tertiary may help in the determination of the costs of the overall treatment.

References

Babillot P. (1995) - Compte de l'eau sur le bassin de la haute Loire (IFEN, juil., 126 p. Orléans).

Babillot P. et Margat J. (1996) - Ressources et utilisations de l'eau du bassin de la Loire. Essai de comptabilité régionale de l'eau (Colloque de la Soc. Hydrot. De France "La Loire", Juin, Tours, Publ. La Houille Blanche 6/7, pp. 41-46).

Babillot P. et Margat J. (1998) - La comptabilité nationale de l'eau en France : instrument d'analyse et de gestion patrimoniale (Soc. Hydrot. Fr., 25e journées de l'hydraulique "L'école française de l'eau du Service du développement mondial", Chambéry, 15-17 sept., 6 p., Paris).

Bauer A. et Costi A. (1993) - Élaboration de comptes pilotes de l'eau dans le bassin du fleuve Brantas, Indonésie (Inst. Pour une Politique Européenne de l'Environnement / DDCSTE, fév., 211 p. Paris).

Bauer A. et *al.* (1993) - Comptes de l'eau, guide méthodologique (Inst. Pour une Politique Européenne de l'Environnement / DDCSTE, sept., 217 p. Paris).

Chéné J.M. et Boutayeb N. (1991) – "Decision-aid tool for strategic management of water reserves. Application to the Moulouya river basin in Morocco", International symposium on management strategies of water resources, ISKI, Istambul, November 1991.

Falcitelli F. (1996) - Accounting System for inland Water Flow : a Methodological Proposal (Publ. In " Contabilità Ambientale ", Istat, Annali di Statistica, Anno 125, Ser. X, Vol. 13, Roma).

FAO/Margat J., Vallée D. (2003) - " Review of world water resources by country " (Ed. F.A.O. Wateur Reports 23, 110 p., Rome, avril 2003).

Fiering M.B., Harrington J.J., De Lucia R.J. (1971) - Water resources System Analysis (Policy research and coordination branch, Resource paper n° 3, 47 p., Ottawa, Canada).

Grobecker C. (1993) - Compte des eaux continentales (Inst. Français de l'Environnement, Notes de méthode, n° 2, Déc., 30 p., Orléans).

McLeman W. (2000) - Water Accounts for Australia, 1993-94 to 1996-1997 (ABS, Catalogue N° 4610.0, Australian Bureau of Statistics).

Margat J. (1984) – Compte des eaux continentales (Quantité). Essai d'application à un groupe de bassins de Basse-Normandie (Calvados), (C.I.C.P.N. / Minist. Environnement, Doc. BRGM 84 SGN 357 EAU, Févr., 228 p + Annexe Orléans).

Margat J. (1986) – Le compte des eaux continentales. Chap. 5 de l'ouvrage collectif "Les comptes du patrimoine naturel", pp. 281-414. Ed. INSEE, les collections de l'INSEE n° 535-536, Sér. D n° 137-138, 552 p., Paris.

Margat J. (1996) – Les ressources en eau, Ed. BRGM et FAO, Sér. Manuels et Méthodes n° 28, 146 p., Orléans, Rome ? Chap. 5 : "Comptabilité des ressources et des utilisations d'eau".

Meza F. (PUC), Jiliberto R. (TAU), Maldini F. (ECONAT) et *al.* (1999) – Cuentas Ambientales del Recurso Agua en Chile (Documento de Trabajo N° 11, Serie Economia Ambiental, Pontificia Universidad Catolica de Chile, Facultad de Agronomia y ciencias Forestales, Departemento de Recursos Naturales).

Naredo J.M., Gasco J.M. (1994) – Spanish Water Accounts (Spanish Minist. Of Publics Works, Transport et the Environment, Summary Report, 25 p. + Annexes, Madrid).

OCDE (COMOLET A., WEBER J.L.) (1990) – Comptabilité des ressources naturelles, étude pilote sur les eaux continentales. OCDE, Com. De l'Environnement, Groupe sur l'état de l'environnement, doc. ENV/SE (90), août, 25 p., Paris.

OECD (1994) – Natural Resource Accounts : Taking Stock in OECD Countries. OECD Environment Monographs N. 84, Paris.

OECD/Weber J.L. (2000) – Links with naturel resource accounts and related indicators : the case of water resource and use accounts (OECD, spécial session on material flow accounting, 24 oct. 2000, Paris).

Tafi J. (DASS, Moldova) et Weber J.L. (IFEN France) (2000) – Inland Water Accounts of the Republic of Moldova – Preliminary Results of resource Accounts in Raw Quantities, 1994 et 1998, draft technical report for Eurostat, DASS et IFEN, July).

Weber J.L./INSEE (1984) – L'articulation des comptes du patrimoine naturel et de la comptabilité économique nationale. L'exemple du compte des eaux continentales. (Conf. Statisticiens europ., réun. informelle probl. méthodol. génér. Statistiques de l'environnement. Paris, 16-19 Av. Doc. Trav. N° 6, 35 p., Paris).

Weber J.L. (1986) – Articulation des comptes nationaux et des données physiques : comptes satellites de l'environnement et comptes du patrimoine naturel. 11 p. in Études de Comptabilité nationale – ARCHAMBAULT E. et ARKHIPOFF O. (éds) – Economica – Paris (Actes du Colloque de comptabilité nationale, Paris 3-5 Déc. 84).

Chapter 9 Examples of policy uses and applications of water accounts [NEW VERSION - TO BE EDITED]

A. Introduction

9.1. Global freshwater resources are under pressure from ever-increasing demand for human activities, contamination from pollution, increasing incidence of water-related disease, loss and degradation of freshwater ecosystems, and global climatic change that affects water supply and demand. As the limits of domestic water resources are reached, countries are increasingly dependent on shared international water resources, raising the potential for conflict. These concerns affect both industrialized countries with highly developed water and sanitation infrastructure as well as developing countries where many people still do not have access to basic services. Social disruption, premature death and lost productivity from water-related illness impose a heavy cost on developing countries. Under these growing pressures, water management has become increasingly difficult.

9.2. The Australian Bureau of Statistics notes that most water statistics focus on hydrology and water quality, but have not paid much attention to economic and social aspects (Vardon and Peavey, 2004). However, some critical policy questions require linking data about water with economic data, for example:

- the consequences for water resources of economic growth, and patterns of household consumption and international trade
- the social and economic impacts of water policy measures such as regulation, water pricing, and property rights
- the contribution of specific economic activities to pressure on water resources and options for reducing pressure

Water accounts provide a unique tool for improved water management because they integrate data about both the environmental and economic aspects of water supply and use.

9.3. The ability to address jointly the environmental, economic, and social aspects of water policy is central to Integrated Water Resources Management (IWRM), a widely accepted approach to water management adopted by Agenda 21, the EU Water Framework Directive (Directive 2000/60) and the 2003 Third World Water Forum in Tokyo. IWRM has also been identified as one of the immediate actions countries should take for achieving the Millennium Development Goals, which has been widely adopted as the framework for development (MPTFWS, 2003).

9.4. Integrated water resources management is based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good, whose quantity and quality determine the nature of its utilization.

9.5. Water accounting has a unique contribution to make to IWRM because it is the only approach that integrates economic accounts with accounts for water use and supply in a framework that supports quantitative analysis. Water managers often have information about water use by broad groups of end-users, but this data cannot be easily used for economic analysis because the classification of end-users rarely corresponds to the classification of economic activities used for the national accounts. The water accounts, in contrast to other water databases, links water data (use, supply, resources, discharge of pollutants, etc.) directly to economic accounts. They achieve this by sharing structure, definitions and classifications with SNA; water suppliers and end-users are classified by the same system used for the economic accounts, the ISIC.

9.6. The first part of this chapter focuses on the policy uses of water accounts with examples drawn from countries that have compiled water accounts. The water accounts, like other environmental accounts and the economic accounts, provide 1) indicators and descriptive statistics for monitoring and evaluation, and 2) detailed statistics for policy analysis.

9.7. Part B describes the most common indicators used to evaluate the current patterns of water use and supply, and pollution. It begins with macro-level indicators that provide 'warning' signs of a trend that may be unsustainable or socially undesirable, often at the national level. It then progresses to more detailed indicators and statistics from the water accounts that shed light on sources of pressure on water resources, opportunities for reducing the pressure, and contribution of economic incentives (such as pricing) to the problem and possible solutions. These indicators can be compiled directly from the water accounts without requiring much technical expertise

9.8. This information sets the stage for analysis of more complex water policy issues, mostly based on economic models that incorporate the water accounts. Rather than attempting a comprehensive review, Part C seeks to demonstrate the use of water accounts for several critical policy issues such as projecting future water demands or estimating the impact of water pricing reform. Generally, these applications require cooperation between statisticians and economists and other specialists with expertise in various analytical techniques.

9.9. The comprehensive framework for water accounting presented in this Manual has not yet been fully implemented by any country. Virtually all countries begin with physical supply and use tables for water and emissions, viewing these tables as the most important for improved water management. Countries add monetary accounts for water and accounts for pollution depending on the policy concerns and data availability. Asset accounts may be partly developed, depending on data availability, but there has been relatively little compilation and use of these accounts so far. Most examples of policy applications utilize accounts for the supply and use of water and generation of pollution described in Chapters 3 and 4.

9.10. Although the water accounts are usually compiled at the national level for an accounting period of one year, this is often not so useful for water managers because water availability and use often vary among regions, and from one season to the next within a year. Section D addresses this problem by describing the development of water accounting on a regional basis—often for river basins or the 'accounting catchment' defined earlier in the manual. Several countries now compile water accounts on a regional basis (e.g., Australia, France, Netherlands, Sweden). The possibility of introducing more flexible temporal dimensions is also discussed.

9.11. IWRM is based on the concept that water resources (rivers, groundwater, lakes, wetlands, etc.) are linked to each other, to human activities and to other resources such as forests and land use. Improved water management requires taking into account all related resources. Section E describes some of the links between water accounts and other resource accounts in the SEEA that would be useful for IWRM and a more comprehensive approach to sustainable development.

9.12. The Annex addresses more thoroughly the link between indicators that can be derived from the water accounts and sets of indicators and index numbers developed by international organizations, such as the Millennium Development Goals, UN Commission on Sustainable Development (Sustainable Development Indicators) and OECD (Environmental Indicators).

B. Indicators for water management

9.13. The first step toward improved water management is usually to obtain a good understanding of current patterns of use, supply and pressure. Descriptive statistics and indicators from the accounts provide the following kind of information:

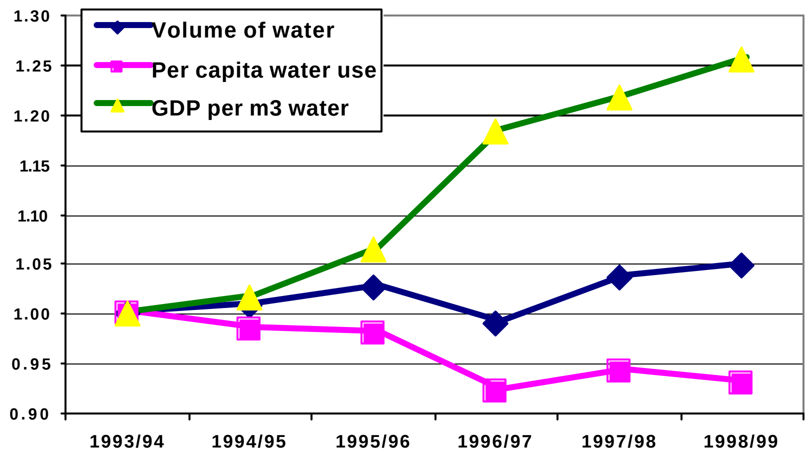
- *Sources of pressure on water resources*: how much does each sector contribute to particular environmental problems, such as overexploitation of groundwater or water pollution?
- *State of the water resources:* what is the quality status of the different water bodies and what is the proportion of water resource under threat of degradation or on the way to recovery? Are measures effective and appropriate?
- *Opportunities for improving water productivity*: Is water being allocated to the highest value users? What opportunities exist to increase water efficiency and productivity? How extensive are losses?
- *Appropriate pricing policies:* Are water providers achieving full cost recovery? Is pricing equitable across different users? Do pricing policies provide incentives for water conservation and pollution prevention, or do they encourage excessive use of water resources?

This section discusses how the water accounts contribute to each one of these areas of information. The indicators presented have all been introduced and defined in Chapters 3-5; notes to each table and figure identify the relevant chapter.

1. Sources of pressure on water resources

9.14. Simple time trends of total water use and pollution reveal changing pressure on water resources and indicators of ‘decoupling,’ that is, separating economic growth from increased use of resources. For example, in Botswana, per capita water use and water productivity (measured by GDP per cubic meter of water used) both declined from 1993 to 1998, so that the volume of total water use increased only 5% (Figure 9.2) even though GDP grew more than 25%. For a water scarce country, this is a positive trend. Statistics Netherlands constructed a similar set of indicators for wastewater and water pollutants (nutrients and metals) over the period 1996 to 2001 (van der Veeren at al., 2004): even though GDP has grown considerably, the Netherlands managed to reduce the volume of water pollutants substantially (Figure 9.1). Of course, to assess the pressure on water, either as a source or a sink, these trends must be evaluated against water availability in specific places and seasons. Most countries have not integrated this step with their water accounts, an issue taken up later in this part of the chapter.

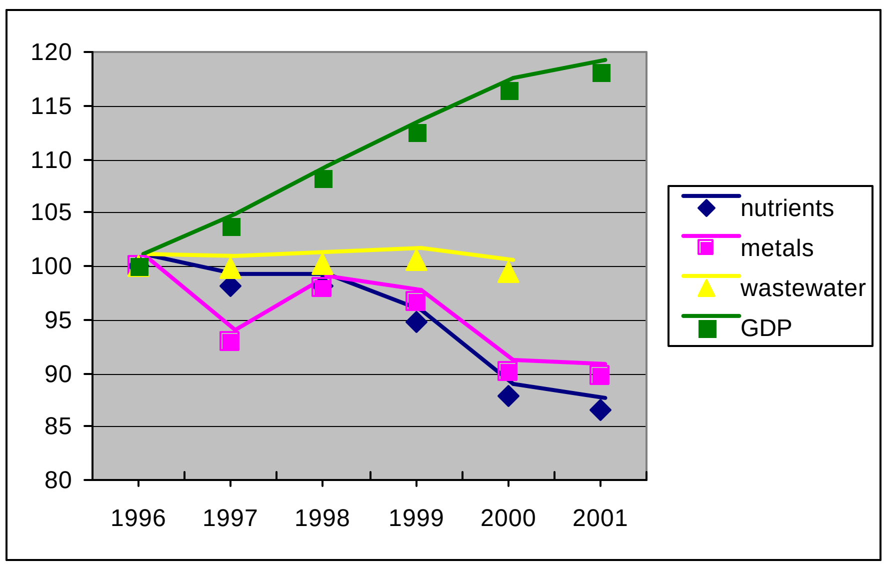
Figure 9.1: Index of water use, population and GDP in Botswana, 1993 to 1998 (1993 = 1.00)



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

Source: Based on Lange et al., 2003

Figure 9.2: Index of growth of GDP, wastewater, and emissions of nutrients and metals in the Netherlands, 1996 to 2001 (1996 = 1.00)



Note : These indicators can be derived from the physical supply and use table and the emissions table described in Chapters 3 and 4

Source: Figure 25, van der Veeren et al. (2004)

9.15. Even at the macroeconomic level, the water accounts typically make further distinctions based on characteristics of water to provide a more thorough and useful assessment of trends; some of the most common characteristics include

- Volume of water used disaggregated by purpose such as cooling, industrial process, cleaning, etc. This is useful for identifying the potential for water conservation and improvements in water efficiency. In Denmark, for example, 79% of water was used for cooling (Table 9.1, Statistics Denmark, 1999).

- Volume of water provided by water utilities through 'mains' compared to self-extracted and reuse of water. Nearly half of Australia's water use in 2000-01 was abstracted directly by end-users, with the remaining provided through water mains or by reuse of water (Table 9.2). This distinction is important because in some countries there are significant differences among these sources in terms of water regulations, the capacity for monitoring may differ, and investment strategies for the future are affected by the source of water.
- Volume of water by natural source. Overexploitation of groundwater, for example, may be a critical issue in some countries so water managers need accounts that identify trends in groundwater abstraction and the users of groundwater. Similarly, it may be very useful to identify use of water from shared international water resources when allocations from such resources are restricted.
- Similar measures can be compiled for wastewater (e.g., shares that are treated and untreated) and pollution.
- Status of water bodies by catchment and size class, leading to apportioning causes between point, non-point, domestic, and other sources. Identifying the roles of different sources allows identification of sound investment in corrective measures.

Table 9.1: Water use by purpose in Denmark, 1994

	1000 m^3	Percent
Tap water	434,400	6%
Cooling	5,356,157	79%
Production processes	58,276	1%
Added to products	3,996	*
Other purposes	885,896	13%
Total	6,738,725	100%

*less than 1%

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

Source: Adapted from Table 5.1.1, Statistics Denmark, 1999

Table 9.2: Water use by source in Australia in 2000-01

	GL (10^9 litres)	Percent of total water use
Self-extraction, excluding amount by water utilities for delivery through mains	11,608	47%
Mains' water	12,784	51%
Reuse	527	2%
Total	24,919	100%

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

Source: Table 2.9, ABS, 2004

Comparing environmental and socio-economic performance of industries

9.16. The economy-wide indicators discussed above provide an overview of the relationship between economic development and water use, but information about water use at the industry level is required to understand the trend and prioritise actions. Environmental-economic profiles are constructed to compare the environmental performance of industries, or individual companies within an industry, among each other and over time. These profiles include indicators that compare the environmental burden imposed by an industry to the economic contribution it makes. For a simple water profile, an industry's environmental burden is represented by its share of water use and/or pollution generated, and its economic contribution is represented by its share of value-added. Water profiles may be used for "benchmarking" industry performance in order to promote water efficiency and water conservation.

9.17. In Australia, for example, Agriculture accounts for 67% of total water use, but less than 2% of GDP (Table 9.3), indicating that its burden on water is greater than its economic contribution—but how much greater in comparison to other industries? Water productivity combines the two elements, economic contribution and environmental burden, into a single number by dividing industry value-added by water use (see Chapter 3 for a precise definition and derivation of this indicator).

9.18. Water productivity is the most widely used indicator from the water accounts for cross-sector comparisons; it is often the first indicator, and sometimes the only indicator, compiled. Water productivity provides a first approximation of the potential gains and losses from a reallocation of water—an issue taken up in more detail in Section C. Water productivity is also interpreted as a rough approximation of the socio-economic benefits generated by allocating water to a particular industry (and is sometimes mistakenly confused with water value - see Chapter 8 for a discussion of this distinction). Australia's water accounts reveal that water productivity in agriculture (A$0.58 of VA/$m^3$ of water) is orders of magnitude less than services (Other industries, A$487.65).

Table 9.3: Water profile and water productivity in Australia, 2000-2001

	Water consumption (ML)	Percent distribution of water consumption	Percent of Industry Gross Value-added	A$ VA/m3 water consumption
Agriculture, total	16,660,381	66.9%	1.8%	0.58
Livestock	5,568,474	22.4%	0.3%	0.27
Dairy farming	2,834,418	11.4%	0.3%	0.53
Vegetables	555,711	2.2%	0.3%	3.27
Fruit	802,632	3.2%	0.3%	1.98
Grapes	729,137	2.9%	0.3%	1.86
Sugar	1,310,671	5.3%	0.1%	0.22
Cotton	2,908,178	11.7%	0.2%	0.42
Rice	1,951,160	7.8%	0.1%	0.18
Forestry & fishing	26,924	0.1%	0.3%	57.42
Mining	400,622	1.6%	6.3%	84.81
Manufacturing	866,061	3.5%	13.6%	84.70
Electricity and gas supply	1,687,778	6.8%	2.1%	6.59
Water supply	1,793,953	7.2%	0.8%	2.35
Other industries	832,100	3.3%	75.2%	487.65
Households	2,181,447	8.8%	Na	Na
Environment	459,393	1.8%	Na	Na
Total	**24,908,659**	**100.0%**	**100.0%**	

Na: not applicable

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

Source: Based on ABS, 2004, Tables 1.3 & 5.11

9.19. It is quite useful to compile a times series of environmental-economic profiles over time, such as the water productivity time series for Namibia in Table 9.6. Water profiles can also be much more extensive, as shown in the example for two industries in Sweden (Figure 9.3) using 14 measures of performance: three measures of economic contribution (production, value-added, hours worked), one non-water environmental factor (energy use), and 10 factors related to water use and wastewater treatment.

Table 9.4: Water profile for Namibia, 1997 to 2001

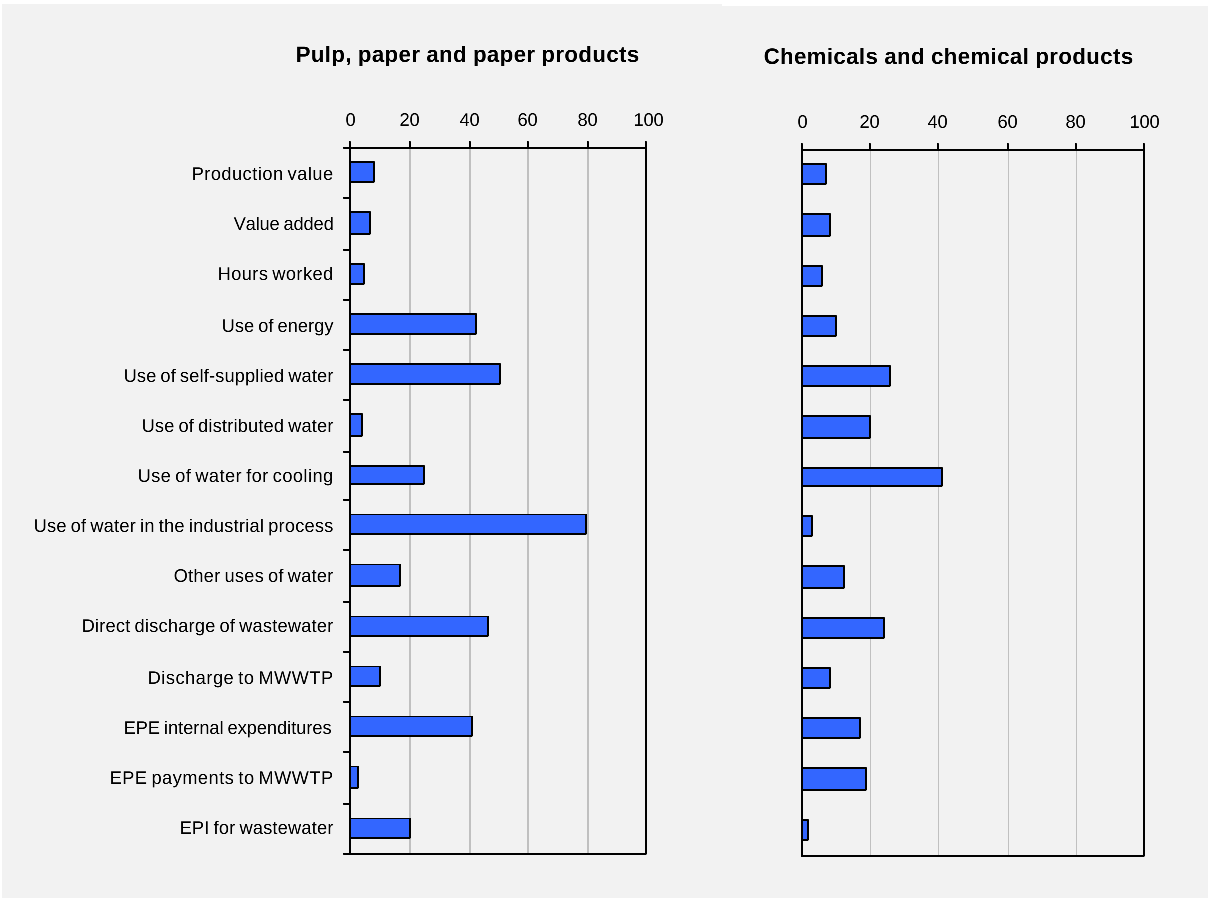
(Namibia $ of value-added per m^3 of water use, constant 1995 prices)

	1997-98	1998-99	1999-2000	2000-01	2001-02
Agriculture	5.5	5.6	5.5	5.2	4.5
Commercial Crops	0.8	0.8	0.7	0.8	1.0
Commercial Livestock	18.5	18.6	19.2	22.2	20.9
Traditional agriculture	7.5	8.4	8.1	6.2	4.6
Fishing	14,352.5	1,573.9	936.2	983.3	991.3
Mining	130.3	132.9	172.1	174.4	167.0
Manufacturing	227.7	205.9	228.5	223.9	226.6
Services	547.7	535.9	582.7	590.2	575.3
Government	211.1	211.8	236.7	216.6	234.2

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

Source: Based on DWA, 2005 and Lange forthcoming 2006

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



Notes: The values are percentages of the total for manufacturing enterprises recorded against each variable.

The indicators for this profile are obtained from the physical supply and use table (Chapter 3), the emission accounts (Chapter 4), and the tables for environmental protection expenditures and investment (Chapter 5)

EPE = Environmental protection expenditure; EPI = Environmental protection investment

Source: Statistics Sweden, 1999.

9.20. For effective water management, one must understand the reasons for large differences in water use and pollution emissions from different industries. A country's water use or pollution depends on several factors: size and structure of the economy, technology, and population. Size is indicated by total GDP, structure by each industry's share of GDP, and technology by water intensity of each sector (see chapter 5 for more detailed discussion of the derivation of water intensity indicators).

9.21. Table 9.5 shows the distribution of water use by industry in Namibia and the water intensity of each industry. In 2001-2002, Commercial crop farming accounted for 43% of total water use and had a "water intensity" of 327, that is, Commercial crops require 327 litres of water to generate a dollar of output. Within the agricultural sector, water intensities vary a great deal; commercial livestock farming has water intensity of only 18 litres per dollar of output. As in most countries, Agriculture is the most water-intensive sector; all other sectors are an order of magnitude or more lower in water intensity.

Even a small increase in Agricultural production would have a substantial impact on water use because of its relatively high water intensity, whereas, the same increase in Service sector production, or even Mining and Manufacturing, would have a much smaller impact on water use.

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

	Percent of water use	Water intensity (direct): Litres/N$output	Total domestic water requirements: litres/N$ output
Commercial crops	42.5%	326.56	350.7
Commercial animal products	9.0%	17.55	35.7
Traditional agriculture	23.1%	117.7	156.8
Fishing	0.2%	0.04	21.8
Mining	2.5%	0.96	16.9
Meat processing	0.5%	1.29	31.5
Fish processing	0.3%	0.72	18.6
Grain milling	0.1%	0.26	33.6
Beverages and other food processing	0.4%	0.42	27.4
Other manufacturing	1.4%	0.68	1.24
Electricity	*	0.17	16.3
Water	*	0.19	18.4
Construction	0.1%	0.10	31.9
Trade; repairs	0.7%	0.38	22.0
Hotels and restaurants	0.6%	1.26	21.7
Transport	0.2%	0.14	23.7
Communication	0.0%	0.05	15.9
Finance and insurance	0.2%	0.24	22.3
Business services	0.1%	0.11	18.2
Other private services	1.1%	1.95	31.8
Government services	5.0%	1.67	24.3
Households	11.9%	Na	Na
Total	100.0%	Na	Na

Note: Total domestic requirements are calculated from the physical supply and use table (Chapter 3) coupled with an input-output table. They do not include water embodied in imports.

*less than 0.1%

Na: not applicable

Source: Based on DWA, 2005 and Lange forthcoming 2006

9.22. Water productivity could be increased within an industry by introducing more water efficient technology or changing the product mix from lower-value to higher-value products; water productivity can also be increased by reallocation of water from high- to low-water-intensive industries. For a water scarce country, a fundamental message from such analysis is:

- sustainable economic growth may be limited if based on water-intensive sectors, or,
- measures must be introduced to reduce water intensity if economic growth is to be based on water-intensive sectors like Agriculture

This does not mean, of course, that agriculture-led development is not feasible; rather, it indicates that development must be based on the higher-value, less water-intensive agricultural subsectors, accompanied by incentives to increase water efficiency and conservation.

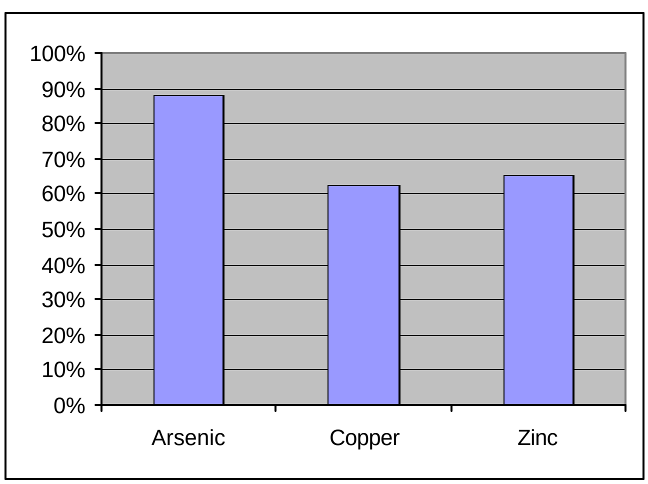
9.23. The assessment of water intensity tells water managers why water use or pollution is so high, but it is also important to understand the *driving forces*, that is, the forces that determine the level and structure of industry production. For example, Australian households used 1800 GL directly in 1994-95, but they consume many goods and services, which require water to produce. When all the water - direct + indirect - required to meet household demand is taken into account, total water use rises almost nine-fold to 16,172 GL (Lenzen and Foran, 2001).

9.24. This principle of measuring the 'upstream' water requirements can be applied to each product or category of final demand using hybrid input-output tables, which are input-output tables augmented by water accounts (described in Chapters 5 and 6). The hybrid input-output tables can be used to calculate the Total water requirement per unit of industry output can be compared to the direct requirement (water intensity). In the previous example for Namibia, total domestic water requirements (shown in column 3 of Table 9.5) are considerably higher than direct water requirements in most instances. This important indicator is on the border of water statistics and more complex policy analysis and will be taken up again, in relation to trade, in the next section.

International transport of water and pollution

9.25. For countries sharing international water resources, actions by one country often affect others, and water management in one country may require accounting for the volume and quality of water flows from other countries. For example, the rivers in the Netherlands have their origin in other countries and carry pollutants emitted by upstream countries. Table 9.4 shows the significance of this problem for the Netherlands: most of the arsenic (88%), copper (62%) and zinc (65%) has its origins abroad and is 'imported' into the Netherlands. In such cases, even the most stringent national policy for pollution control may have only a limited impact on the load of pollutants in a river at the country level. For shared international water resources, only a regional approach to water and pollution policy will be effective.

Figure 9.4: Percentage of metal emissions to rivers in the Netherlands originating abroad in 2000



Note: These indicators can be obtained from the supply and use table for emissions (Chapter 4).

Source: Adapted from Figure 20 van der Veeren et al. (2004)

2. Potential for increasing effective supply and improving water productivity

9.26. Water supply and water productivity are not determined solely by natural conditions and driving forces. The way that water is managed affects the amount of water that can be utilized by end-users and the productivity of water. The effective supply of water can be increased by:

- *Increasing water efficiency by individual users*. Domestic water requirements can be met with very different volumes depending on consumer behavior and technology: shower *vs* bath, toilet flush volumes, improved technology of washing devices, pressure washers, temporized taps, etc. In industrial processes, changes in technology, sometimes very simple, may simultaneously reduce both water use and pollution as well as provide recyclable water. A simple and effective example is the dry recovery of animal droppings in the stall areas of slaughterhouses.
- *Reducing system losses*. Losses can result from leakages due to poor infrastructure maintenance and other causes such as illegal connections, faulty water meters, and so on. In many industrialized countries, losses are fairly low. In Australia, for example, losses as a percent of total supply range from a low of 3% in ACT to 17 % in Victoria (ABS, 2004). In developing countries, losses can be much higher. Among the 29 municipalities in Namibia's water accounts, 3 had losses between 11-15% of supply in 2001; 12 towns, accounting for 21% of municipal water supply, had losses of 20-39%; and the rest has losses 40% or greater (Lange, 2005).
- *Increasing reuse of water* and use of return flows by directing water to storage or other uses and minimizing pollution and salinity of return flows. Reuse of water has been identified as one of the most cost-effective ways to provide water, and has been increasing steadily in water scarce countries (ABS, 2004).

3. Water pricing and incentives for water conservation

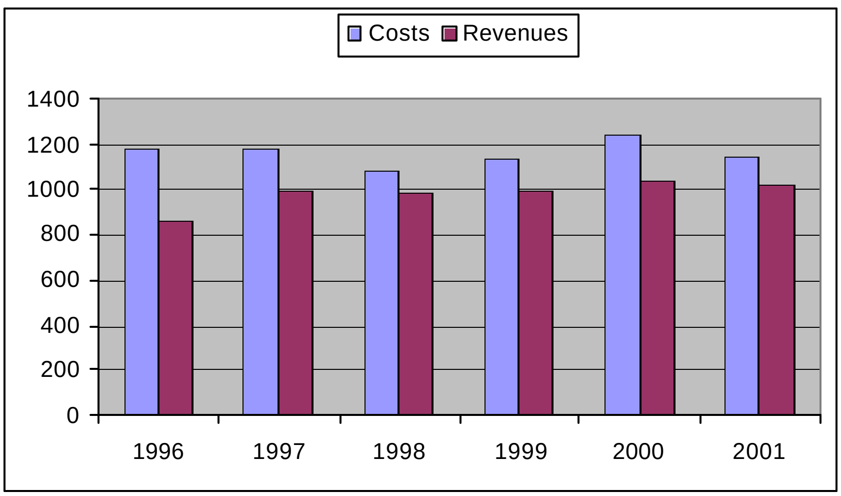
9.27. Water pricing is important for financial sustainability - a system must be able to recover its costs - and also for environmental sustainability because of the incentives pricing provides for resource utilization. Except for the minimum amount of water necessary for human survival, people will generally use less water the higher its price. Conversely, where water prices are low, there is little incentive for conservation. It is not unusual for water scarce countries to subsidize the use of water, even for low-value production in commercial agriculture.

9.28. Accounts that would reveal cost recovery - the cost of supply and water tariffs - are not compiled in many countries, or are compiled for only part of water use, mainly because of a lack of data. For water supplied by utilities through water mains, it is usually possible to compile accounts for the average cost of supply, but little data is available for self-abstraction (e.g., Statistics Sweden, 2003). On the pricing side, municipalities may apply a single price for combined water and wastewater services, making it difficult to estimate the charge for each service.

9.29. In countries with full-cost recovery (which may be defined differently in each country), the average price should equal the average cost of supply, although it is unlikely to match precisely in any given year, and sometimes researchers use this shorthand method to estimate implicit unit price and supply cost (Chapter 5). However, many countries, especially developing countries, do not have full-cost recovery pricing, so the price and supply cost will differ (see Chapter 5). Furthermore, even with full-cost recovery, unit supply costs may vary significantly within a country due to differences in regional water resource availability. For example, Namibia's bulk water supply is based on a system of nearly 200 water schemes and unit supply costs range from a low of N$0.27/m3 to more than N$500.00/m3 (Lange, 2004). Prices will vary by customer where water fees are a combination of fixed fees plus variable fees based on the volume and/or type of customer.

9.30. Once supply costs and price have been calculated, the implicit subsidy by sector can be calculated. A similar set of indicators can be compiled for wastewater treatment as well. Similar calculations can be made for wastewater treatment supply costs and pricing. In the case of the Netherlands, full cost recovery has been achieved for drinking water, but not for wastewater ()

Figure 9.5: Costs and revenues for wastewater treatment services in the Netherlands, 1996 to 2001 (in million euros)



Note: Data are compiled only for households and companies connected to municipal sewer systems.

These figures can be compiled from the monetary supply and use tables presented in Chapter 5

Source: Figure 34, van der Veeren et al., 2004

4. Sustainability: comparing water resources and water use

9.31. In assessing sustainability of water use, the volume of water use must be compared to the renewable supply of water, based on an assessment of stocks or estimated renewable supply. However, few countries compile water stock and resource accounts that are as comprehensive as their water SUTs. In some countries, water quality is a greater concern than water volume, so stocks that measure volume may not be a high priority. In other countries, water managers recognize the importance of stock accounts, but do not have comprehensive data, particularly for groundwater stocks. An example is provided for Namibia in Table 9.6. Water authorities acknowledge that the national-level figures for water availability shown in the table are mainly useful for building public awareness, but that national figures may hide relative surpluses and shortages among sub-national regions. Water management requires similar figures at a more spatially disaggregated level within water management areas.

Table 9.6: Water use in 2001 compared to estimated availability of water resources in Namibia

	Estimated long term available water resources* (Mm3 per annum)	Water use, 2001 (Mm3)
Dams on ephemeral rivers	100	85
Perennial rivers	170	90
Groundwater	159	106
Other (recycled)	8	1
Total	**437**	**282**

*Based on currently installed capacity

These figures are obtained from water asset accounts (Chapter 6) and physical supply and use tables (Chapter 3)

Source: Department of Water Affairs, 2005

C. Water management and policy analysis

9.32. Under IWRM, decision-makers no longer rely primarily on conventional supply-oriented approaches to water management. Rather, water management analyzes the benefits of current allocations of water, anticipates future water demands, and evaluates different policy options for meeting those demands. Options include increasing the effective supply of water from efficiency improvements, wastewater reuse, demand management, and other measures. Policy analysis using the water accounts can address a very broad range of issues. Some of the most critical policy issues for water managers include:

- What are the likely future water demands under alternative economic development scenarios and are they sustainable? How do changes in agricultural, energy, forestry and other policies affect water supply and use?
- What is the impact of trade on water use and pollution?
- What are the opportunities for, costs and benefits of water demand management and other water conservation measures? Can economic growth be ‘decoupled’ from growth in water use?
- What would be the social and economic impact of pricing reform for water and wastewater?
- What are the costs and benefits of treating different sources of water pollution?
- What is the highest value allocation of water among countries sharing an international river or lake?
- How will external phenomena, like climate change affect water resources and how can the economy best prepare for these impacts?

9.33. The water accounts provide detailed information that can be used to analyze pressure on water resources, formulate long-term water management strategies and design effective policies for implementing a given strategy, such as appropriate water pricing and effluent taxes. These applications typically require linking the water accounts described in Chapters 3-5 to economic models, and integrating the input-output (IO) table with water accounts is an essential step in building many of these models (See Box 9.1). The consistency between national accounts and water accounts allows the easy incorporation of water accounts in many different kinds of economic models.

9.34. The number and range of potential policy applications of water accounts are vast and it is not possible to provide a comprehensive review in this chapter; rather, a selection of examples based on water accounts is provided. These examples address projecting future water demand, the socio-economic benefits from water policy reform, assessing the costs and benefits of water treatment, and analyzing links between trade and water use.

1. Meeting future water demand

9.35. Projecting future water demand is essential for water management; for developing countries, the MDG identifies specific targets for meeting targets for water and sanitation. Future water and sanitation requirements depend on many factors, including population growth, the volume and composition of economic growth, and technological change. How the requirements are met depends on available technologies, including innovative ones like water demand management and reuse of water, and water policies such as pricing and other incentives for water conservation. Scenario modeling designed to incorporate some of these factors, especially for influencing water demand and unconventional water supply, are useful tools for water managers. These models require sophisticated economic models, often built around water accounts integrated with IO tables (Box 9.1). The consistency between national accounts and water accounts allows the easy incorporation of water accounts in many different kinds of economic models.

Box 9.1: Water accounts and input-output analysis

There are many tools for economic analysis and those taking a multi-sectoral approach are often built around input-output tables. Multi-sectoral models include standard input-output analysis as well as other modeling approaches, notably computable general equilibrium modeling (which uses a Social Accounting Matrix, an IO table expanded for institutions) and econometric models. Various partial equilibrium models, such as those developed for Life-Cycle Analysis also use IO.

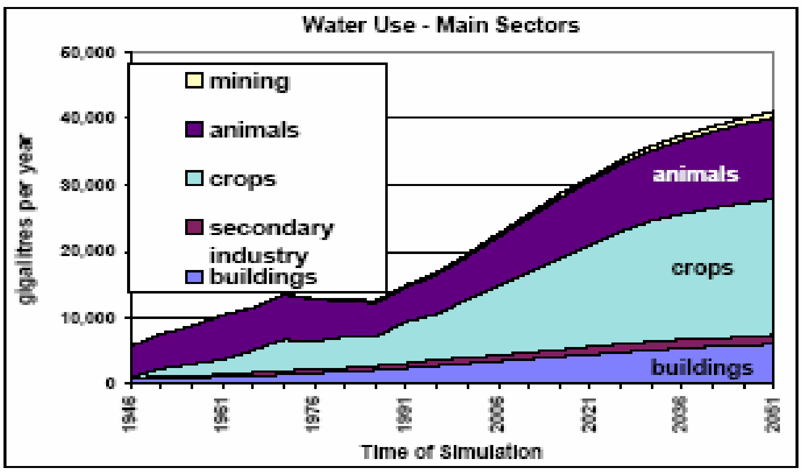
The water supply and use tables (SUT), described in chapters 3-5, are directly linked to the national accounts supply and use tables; just as the IO table is constructed from the SUT, water IO accounts can be derived from the water SUT. In modeling, water in physical units is included in the IO table as a primary input of production. IO analysis of the water accounts themselves provides very useful information regarding the structure of the economy, driving forces, and water use & pollution, as described in the previous section. IO-based, multi-sectoral models are also widely used for projecting future water demands, or analyzing different policy options and the economic instruments for achieving them. Statistics Denmark notes that their water accounts are most extensively used for IO analysis (Statistics Denmark, 2004).

9.36. In Australia, the water accounts have been used extensively for water planning at the regional and national levels (See summary by ABS in Vardon and Peavey, 2004). For example, Appels et al. (2004), on behalf of the Australian Productivity Commission, projected impacts on water demand under different scenarios for irrigated agriculture in the Murray-Darling Basin. CSIRO used the water accounts (along with other data) to project water requirements for Australia in the year 2050 under a range of alternative scenarios about population growth, growth of irrigated agriculture, technological improvements in water efficiency, and measures to improve or compensate for declining water quality

(Box 9.2). An example of projecting water use at the regional level is described for Sweden in section D.

Box 9.2: Projecting water use in Australia

CSIRO, a major Australian research center, undertook a study of water use in 2050, considering options for improved technology, as well as population and income growth and the expansion of irrigated agriculture. Using a range of data, including those from the Australian water accounts, in a simulation model, total managed water usage was projected to expand from a 24,000 gigalitres in 2000-2001 to more than 40,000 gigalitres per year by 2050. This is due to a major expansion of irrigated agriculture in northern Australia as constraints on the availability and quality of water are experienced in the south. The model assumes widespread introduction of best practice technology in non-agricultural sectors. The water requirements for industry, mining and domestic use represent about 20% of the total. The water use by animals reflects the growth of the dairy industry in particular, which is relatively water-intensive. The authors note the importance of international trade in driving water use: Australia exports an estimated 4,000 gigalitres of embodied water more than it imports. This is about the same amount used each year by urban Australia.



(Source: Foran and Poldy, 2002).

2. Social and economic gains from water policy reform

9.37. To evaluate the present distribution of water, and the social and economic gains from policy changes, criteria for evaluation need to be designed, and tools to measure them developed. Water policy concerns economic issues such property rights and water allocation, investment in infrastructure, and pricing. Among the many possible analyses, two important applications of water accounts to water policy are described here:

- Social and economic benefits of present water allocation and alternative allocations
- Consequences of water pricing reform

Social and economic benefits of water reallocation

9.38. Water consumption for production purposes, such as agriculture and industry, provide economic benefits such as incomes, employment, and foreign exchange earnings. Although these benefits do not measure the exclusive contribution of water to economic value (see discussion in Chapter 8), they are often used as indicators of broadly defined socio-economic benefits from the use of water in one industry relative to another, or in one region of a country relative to another. This indicator was introduced in Section A as the 'water productivity' indicator.

9.39. Water productivity measures the *direct* income and employment generated by water use in a sector, but there may be significant additional benefits, upstream and downstream from the direct user. It is often argued that agriculture generates relatively little direct income per unit of water input, but supplies food processing industries that in turn generate additional income and employment. An analysis of forward and backward linkages using the input-output approach described for trade and the environment provides a more comprehensive picture of the socio-economic benefits of water use in a particular activity, or a particular region. Box 9.3 describes an example of this analysis for South Africa. A great deal of similar analysis has been undertaken for Australia using the water accounts (e.g., CIE, 2004; Lenzen and Foran, 2001).

9.40. In many countries, water is often not allocated efficiently from an economic perspective, that is, to the uses that would generate the highest net economic returns. While economic efficiency is not the only consideration in water policy, it is an important aspect. Even when economic criteria are not used for water allocations, water managers would benefit from an understanding of the potential economic gains from improving the efficiency of water allocation.

9.41. The partial equilibrium approach of input-output may indicate the relationship between the present allocation of water and incomes and employment, but a different modeling approach is needed to determine what the optimal allocation of water in an economy would be. Optimization models for water (see Chapter 8 for a discussion of different modeling approaches) estimate the potential gains from reallocating water to the highest value users. All optimization models require a database for water use that could be provided by the water SUT described in Chapter 3 and 5. The results include projected water demands by industry, the value of water, and the resulting structure and level of economic activity (GDP). If pollution and pollution abatement costs or damage costs are included, the levels and costs of pollution are also calculated.

Water pricing reform

9.42. In many countries, even water-scarce developing countries, the price charged for water does not reflect its true financial cost, let alone the full economic cost. Where the costs are subsidized, there is little incentive for resource conservation. Subsidies, if any, can be calculated for each industry from information in the water SUT by subtracting the supply cost from the payment for water. Monitoring subsidies is clearly important both for sustainable management of resources as well as for equity by identifying which groups in society receive the greatest subsidy. In addition to monitoring, however, policy-makers need to know the potential consequences of water pricing reform: what would be the net gain or loss to national income and employment, and what industries or social groups would be most hard hit.

9.43. Economic models, such as those used for assessing the optimal allocation of water can introduce water price accounts to estimate the economy-wide impact of price reform. Similar analysis can be made for assessing the impact of increased charges for wastewater treatment and pollution taxes. Box 9.8 summarizes a simulation study for water charges in Australia.

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

Water resources are under increasing pressure in post-apartheid South Africa for several reasons, notably improved access to safe drinking water for millions of previously excluded households, and the emphasis on economic growth and job creation, often in water-intensive industries. An evaluation of the socio-economic benefits generated by each economic activity relative to its water use is an essential input into good water management. Hassan (2003) provided such an evaluation for different agricultural activities within the Crocodile river catchment for the Water Research Council of South Africa. He measured the *direct* value-added and employment generated per cubic meter of water used in each activity. He also extended the analysis to consider the *indirect* benefits by measuring the value-added and employment generated by upstream and downstream linkages to each agricultural activity.

Upstream linkages consist of inputs to agricultural activities, such as fertilizer and agricultural chemicals, fuels, etc. Downstream linkages consist mainly of food processing industries, and the wood processing industries including paper and pulp, wood products, furniture, etc. These linkages are measured using a well-established economic tool, input-output analysis. The analysis revealed that a simple comparison of benefits across sectors did not provide an accurate picture of the full, economy-wide benefits.

Considering only the direct effects, both the income generated (value-added) and employment are highest for mangoes, but when indirect effects are added, pine appears the best. This is largely because there is very little additional processing that adds value for mangoes, while pinewood is used in many wood products. At the opposite end, sugar cane appears to be the least beneficial crop when only the direct income and employment are considered, but taking into account the indirect effects, sugar moves to third place.

Table Socio-economic benefits from water use for different agricultural activities in the Crocodile River catchment, South Africa, in 1998

Value-added (Rands/m3 water input)				Employment (1000 Person days/m3 water)			
Direct		Total (direct + indirect)		Direct		Total (direct + indirect)	
Mangoes	2.8	Pine	21.3	Mangoes	20	Pine	114
Oranges	1.9	Eucalyptus	13.3	Oranges	18	Eucalyptus	78
Avocados	1.7	Sugar cane	9.9	Grapefruit	13	Sugar cane	44
Eucalyptus	1.5	Mangoes	8.9	Eucalyptus	12	Oranges	39
Grapefruit	1.5	Oranges	6.6	Bananas	7	Mangoes	37
Bananas	1.3	Grapefruit	4.9	Pine	6	Grapefruit	28
Pine	1.2	Avocados	3.4	Avocados	5	Bananas	12
Sugar cane	0.9	Bananas	3.2	Sugar cane	2	Avocados	7

Source: Adapted from (Hassan, 2003 Table 7 p. 192)

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

Since 1996-1997, water charges across Australia have, on average, doubled, and water trading has been introduced in part of the Murray-Darling River Basin, resulting in a significant improvement in water use efficiency (Centre for International Economics, 2004). The Centre for International Economics has developed a model to simulate over a 5-year period the impact on GDP of water pricing changes through induced changes in water use efficiency (WUE) that result in more water efficient technology and reallocation of water among sectors. For irrigated agriculture, they found that WUE would have to increase 1.5% annually to counterbalance the impact of increased water charges.

CIE then considered the impact of reducing current water diversions to increase environmental flows through alternative economic instruments: administered reduction applied proportionately to all users is considerably more costly than allocating the cuts through a market-based method of tradable of water rights.

Table Impact on GDP of improvements in water use efficiency under a doubling of water charges in Australia (million A$)

	Percent annual increase in water use efficiency (WUE)	
	1% annual increase	2% annual increase
Irrigated agriculture	-24	78
Dryland agriculture	-51	-112
Food and fibre processing	44	97
Other industries	262	410
Total impact on GDP	253	521

Source: Based on CIE (2004, Table 5.1, p.52).

9.44. The water accounts report emissions of pollution and, if fully monetized, include estimates of the cost of pollution, or the value of maintaining clean water. The economic valuation techniques that would be used for monetization were described in Chapter 9. There are no water accounts that have fully monetized water pollution accounts at this time. In part, the challenge is that most water accounts are compiled at the national level, while water pollution is a localized phenomenon. Based on a cost-benefit analysis rather than water accounts, Box 9.5 provides an example of valuing water quality, and using this approach to assess the costs and benefits of wastewater treatment.

3. Trade and the environment: water use and pollution

9.45. Water use and the emission of pollution is affected by water policies, but is also indirectly affected by policies in other sectors of the economy, which may not anticipate the impact on water resources. For example, agricultural trade policy may have a significant impact on what is produced in a country and indirectly the use of water. This section considers two aspects of trade and the use of water resources: trade in 'virtual water' and the impact of trade barriers on water allocation.

Box 9.5: Benefits of wastewater treatment in Wuxi, China

Zhang (2003) measured the costs and benefits of wastewater treatment in Wuxi, a rapidly industrializing city in China's Yangtze River Delta. Wuxi has over 200 km of waterways and borders a scenic lake that is popular for recreation. The study reported the discharge of 9 different water pollutants from 13 most important industries. The cost of water treatment was measured as the present value (over 20 years) of additional infrastructure and operating costs needed to meet water quality standards. The benefits from treatment were measured as the value of damage prevented. The damage was valued in terms of the reduced capacity of the lake to provide water services: potable drinking water, industry-standard water, water for fish farming, a clean environment for residents on the lake shore and for recreation and tourism.

Costs and benefits from wastewater treatment in Wuxi, China

	(millions of US dollars in 1992 prices)
Costs (investment + operating costs)	22.43
Benefits (damages and costs averted)	
Drinking water treatment	2.71
Industrial water treatment	7.28
Drainage costs	1.40
Fish farming productivity	2.86
Health benefits (reduced illness)	2.60
Residents' amenity benefits	3.60
Resident's recreational benefits	1.73
Tourism	3.73
Sub-total, benefits	25.91
Net benefit	3.48

Source: Based on (Zhang, 2003)

Trade in virtual water

9.46. Global water availability and use are characterized by large regional imbalances, but water itself is not a widely traded commodity. Trade in products allows trade in 'virtual water,' that is, the water used for the production of goods and services. Trade in virtual water allows a country to overcome its water scarcity by importing water-intensive goods; virtual water also provides a measure of a country's impact on global water resources (its 'water footprint') (See Champagain and Hoekstra, 2004). Distorted water pricing, including heavy subsidies to agriculture and omission of charges for ecosystem damage, means that international trade is unlikely to reflect the water 'comparative advantage' of countries. The World Water Council has recently identified virtual water as a critical issue for water management, and has launched a major initiative through its website to better define and measure virtual water (See http://www.worldwatercouncil.org/virtual_water.shtml). This work has also been strongly supported by UNESCO (Champagain and Hoekstra, 2004).

9.47. The measurement of virtual water should include both the direct and indirect water used in production. Direct water is the amount used during the production process; this figure is obtained from the water SUT. Indirect water is the amount used to produce all the non-water inputs to production of a given product. The difference between direct water use and total (direct + indirect) water use can be substantial: for example, very little water may be needed to produce a loaf of bread, but a great deal of water may be embodied in the grain used to make bread. The methodology for measuring total water use based on input-output models extended for direct water inputs (as described in Box 9.1) is well established in the economics literature (Førsund 1985, Miller and Blair 1985, Pearson 1989). Box 9.6 shows an analysis of trade in virtual water among Botswana, Namibia, South Africa, and between these three countries and the rest of the world.

Impact of trade policy on water allocation

9.48. Most of the world's water is used for crop irrigation. Trade protection can result in distorted international patterns of agricultural production. When agriculture depends on irrigation, trade protection can inadvertently divert water to irrigation, increasing pressure on water resources and reducing the water available for other, often higher-value uses. Economic models, either partial or general equilibrium, are used to assess the impact of trade protection on water use and pollution, and the environmental and economic consequences.

9.49. Several examples introduced in Chapter 8 discussed the impact of trade protection on agriculture and the demand for irrigation water. The example for Morocco (Bouhia, 2001) used a linear programming model (based on an input-output table with water use accounts) to assess the optimal allocation of water under several alternative scenarios. One of the alternative scenarios included the reduction of trade barriers (import quotas, voluntary export restrictions) on agricultural commodities. In the model, farmers could choose what crops to plant and whether to sell them in domestic or international markets; water was allocated on the basis of profitability of water. The model demonstrated the potential for significant economic gains from reducing trade barriers and allowing a reallocation of water to different crops.

D. Critical issues for water accounts: spatial and temporal characteristics

9.50. Water availability and demand as well as water quality can vary a great deal over time and space. It is difficult to address sustainability on a national level when sustainability of water use is determined on a local or regional basis. Recognizing this, water managers are adopting a regional approach and take into account temporal variations; this principle has been endorsed by IWRM. But this posses a challenge for water accounting because the temporal and spatial dimensions relevant to water often do not match those used for economic data in the national accounts. It is increasingly common for countries to construct water accounts on a regional basis—Australia, the Netherlands, Sweden, Morocco have done so. Seasonal water accounts have not yet been compiled.

1. Accounts at the river basin level or water management area

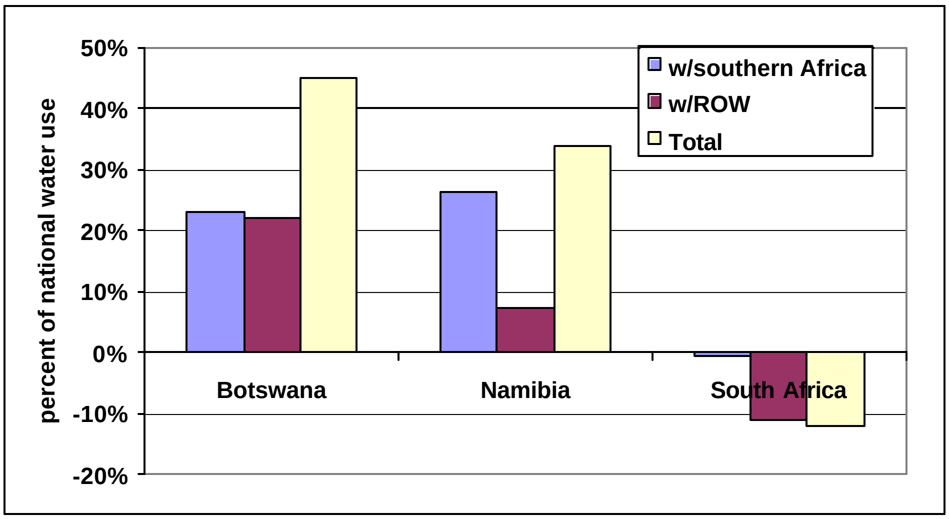
9.51. Water accounts must be national in coverage and compatible with the national economic accounts for decisions made at the national/macroeconomic level. But hydrological conditions affecting water supply vary considerably across many countries. Factors that drive water use, such as population, economic activity and land use, also vary across a country and may not be distributed where water resources are most abundant.

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

Botswana, Namibia and South Africa have designed strategies for economic development based in part on economic growth, diversification, and trade promotion. As in many developing countries, the structure of exports in these countries is heavily weighted toward primary commodities and processing of these commodities, which are often water-intensive. These three countries have identified water as a primary constraint to development and South Africa has already been categorized as a water-stressed country.

An input-output analysis of the total (direct + indirect) water content of trade among the 3 countries and with the rest of the world reveals that Botswana and Namibia are significant net water importers, 45% and 33% of total national water use, respectively. South Africa on the other hand, is a net water exporter, 11% of national water use in 1998.

Net water imports as percent of total national water use for Botswana, Namibia, and South Africa in 1998



Source: Based on (Lange and Hassan, 2002)

9.52. One of the important principles for IWRM is to approach water management at the river basin level (or other appropriate water management area). This concept is part of a number of national and regional water policies, such as the EU Water Framework Directive. Although the water accounts are typically constructed at the national level, in principle, the same accounting framework and analysis can be applied for a river basin, an aquifer, or any other region defined by relevant geohydrological characteristics including systems of water infrastructure that may integrate catchment and groundwater resources. In the case of the EU Water Framework Directive, a suitable area is the *River basin district*, that is the upper management unit, that can extend over several states.

9.53. In most cases, the catchment area, or river basin, level is the most appropriate geographical level for analysis. In some instances, water management at the catchment level may require international cooperation, for example, a catchment area may cover several countries, or several catchment areas may empty into a regional sea. Both cases require common management of water resources.

9.54. The actual catchment area may differ from the topographic surface watersheds (which are the portions of territory that can be delimited by the lines of crest) because of the existence of underlying groundwater resources. Furthermore, catchment areas generally do not match administrative areas, which constitute the basis for economic data. Because of the need to make hydrological and administrative regions coincide, a compromise is often made and the resulting region called an 'accounting catchment area.' In general, elaborating water accounts at the river basin level necessitates geographically referenced data water flows and discharges of pollutants, i.e. spatial identification of establishments, waste water treatment plants, etc

9.55. All of the indicators and policy analyses discussed earlier in this chapter can be applied at the catchment or regional level as well. The environmental economic profiles can be constructed for each water accounting catchment, as in Table 9.7 and Box 9.7 which shows the profiles for two of Sweden's sea basins. The accounts can also be used for modeling at the regional level as well.

Table 9.7: Environmental-economic profile for the Bothnian sea basin in Sweden, 2000

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

[1] *Excl 21, 24, 27*

[2] *NPISH*

[3] *Employed in NACE 90001 – not included, here part of NACE 90*

[9] *Discharge of treated water, for NACE 10-37 direct discharge*

[10] For NACE 24, 27 och 40, only establishment by the coast

[11] Data for year 2002

Source: Data provided by Statistics Sweden 2005.

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

Under the EU Water Framework Directive, Sweden prepared forecasts of water use in 2015 at the district level. The estimates were made by using a regional economic model developed by the Swedish Business Development Agency, which allocated 289 municipalities into five water districts. The model is built from relations at municipality level and has five submodels (1) Population, (2) Labour market, (3) Regional economy, (4) Housing market and (5) Supplementary model for municipalities. The regional model first forecast population, employment and economic development until 2015 for each water district and, based on these results, forecast water use based on water use parameters prevailing in the base year, 2000. For the three most water intensive industries—Pulp & paper, Chemicals, Basic metals (NACE 21, 24, 27)—an alternative forecast (scenario 2) was made assuming increased water efficiency (water use/production value), based on the same gains in water efficiency achieved between 1995-2000.

Table. Water use in 2015 by water district, Sweden (thousand m^3)

District/Sea Basin	Water use in 2000	Projected water use in 2015	
		Scenario1	Scenario 2
Bothnian Bay	380 214	477 000	454 400
Bothnian Sea	786 846	947 300	846 700
North Baltic Sea	493 312	590 100	579 000
South Baltic Sea	637 382	750 900	713 300
North Sea	943 550	1 164 500	1 098 500
Total	3 241 304	3 929 800	3 691 900

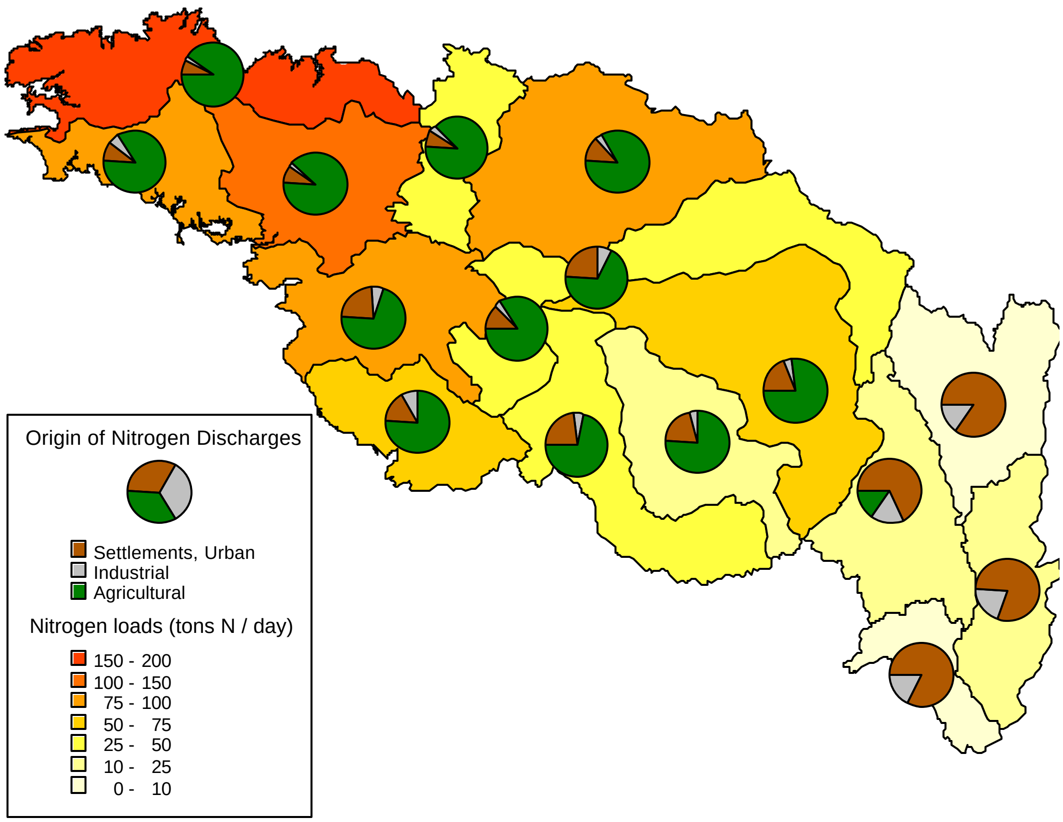
Note: Scenario 2 assumes increased water efficiency in the most water intensive industries.

Source: Statistics Sweden, 2004

9.56. Regional accounts are necessary for management of an individual river basin, but decision-making at the national level also needs an overview that brings together the different regions in a national accounting framework as in Figure 9.6. The overview helps national decision-makers in two ways: 1) it helps them set priorities for actions among different river basins by demonstrating the relative severity if water problems in each basin, and 2) it provides a tool for national water managers to negotiate with decision-makers in other sectors to coordinate policy.

9.57. Figure 9.6 shows an example for the daily discharge of nitrogen; indicating both the magnitude of nitrogen emissions in each part of the river basin as well as the source of pollution. Agriculture is the major source of pollution in all the heavily polluted parts of the river. Households are the second most important source, and the primary source of nitrogen in areas with little agriculture.

Figure 9.6: Location, level and origin of nitrogen discharges in the French river basin of Loire-Bretagne



Presentation of Ifen results – RBDE meeting, 14 march 2001

2. Temporal dimension

9.58. Water use is often concentrated in certain seasons, notably, the demand for irrigation water in the growing season. Because irrigation requires so much water—up to 80% of total water use in developing countries (MGTFWS, 2003)—it is extremely important to match seasonal supply and demand. Water pollution may also have a different impact on water quality depending on the time of the year. In some periods the quantity of water flowing may be so reduced that dilution of pollutants cannot occur. Abstractions and emissions usually cover an entire year, but this does not provide an accurate picture of the stress on water resources since seasonal variations may be hidden.

9.59. A first possibility is to reduce the duration of the accounting period: in many countries, quarterly national accounts are already built. Quarterly water accounts may be useful in some countries; for example, seasonal water accounts for Spain would reveal higher pressure on water in summer compared to winter. Abstraction of water and emissions are higher in the summer due to tourism, while the volume of available water is smaller. While the quarters of the year used for national accounts may not coincide with seasonal variations in water availability and demand for all countries, quarterly accounts for water would probably be a useful step toward representing seasonal variations.

9.60. Accidents resulting in unusually high discharge of polluting substances at a point in time present another challenge to water accounts. When added to annual discharge, the accidental discharges may not appear serious; averaging annual discharge over annual water resources may indicate an acceptable level of pollutant concentration. However, the temporary concentration from an accident may be high enough to cause serious damage. Even quarterly accounts may not adequately represent the impact of accidental spills. It is not feasible to produce monthly or weekly accounts, so indicators should be designed that would show the degree of damage caused by accidental spills. These indicators should complement the accounts by taking into account factors such as the concentration of a pollutant, the threshold for water abstraction over which aquatic life is impeded, and possible synergies between two or several pollutants.

9.61. The construction of these indicators implies a detailed knowledge of the absorption capacities of the different water bodies vis-à-vis the pressures exerted against them. Location and timeliness of the pressure are not independent in their effects since the critical thresholds vary, notably according to the volume and flow of the water body. The severity of the pressure is also related to the present state of the water environment, that is to say, to the pressures accumulated over time. For each place, each period, each type of pressure, thresholds should be estimated. Possible indicators include, for example, the number of days (in the year, in the quarter) in which thresholds have been exceeded. However this type of information cannot presently be handled in the framework of water accounts.

E. Links between water and other resource accounts (fisheries, forestry, land/soil)

9.62. Water is a cross-cutting natural resource because it is used as a commodity in every sector of the economy, it is widely used as a sink for pollution, and it provides ecosystem services to many sectors (Acquay, 2001). The quality and quantity of available water is affected not just by the direct abstraction of water, but by activities in agriculture, forestry, energy, human settlements and other land uses, etc. With regard to IWRM, the SEEA framework has an advantage over other water databases because it is designed for comprehensive representation of all important natural resources, not just water. The SEEA framework integrates water accounts with accounts for land and forests, fisheries, pollution, and any other resources necessary for IWRM, as well as with the economic accounts.

9.63. As treated in this Manual, water accounts are constructed for 1) the direct use of water as an intermediate input to production or as a final consumption good and 2) the use of waste assimilation services provided by water, represented by the emission of water pollutants from industry, government and households. Many other environmental services provided by water are not addressed here, notably, hydroelectric and navigation services, recreational services, and habitat protection. In managing water, it is important to account for these additional services, and for related resources and ecosystems that may affect the quantity or quality of water. The major issues are noted here; future revisions of the Manual for water accounting are likely to address these broader issues.

1. Dependence of water resources on other resources

9.64. The status of a river may depend greatly on land management and the health of forests and other vegetation in a river basin. Groundwater recharge and quality can be affected by deforestation and land use conversion (affecting rates of infiltration) and runoff of pollutants from agriculture and other economic activities. The water accounts do not usually address some important forms of water quality degradation such as increased turbidity from soil erosion, or increased salinity, although the framework can certainly accommodate this, and the Australian water stock accounts consider salinity.

9.65. Furthermore, in many countries, accounts for the emission of pollutants to water may include only point-source emissions, although non-point source emissions are very important, especially from agriculture. An exception to this is the Netherlands, which has made great progress in monitoring non-point source emissions. Non-point source emissions pose a major challenge to water accounting because the relationship between the use of polluting substances, such as fertilizers, and water quality is not easy to determine. Complex hydrogeological models are required to estimate the amount of fertilizer that leaves the farm field and the route and time it takes to travel from the field to a water body. It is not uncommon for the travel time to exceed one year, the typical accounting period for water accounts.

9.66. Water-based tourism and recreation have become important industries in many countries, both developed and developing. Some forms of water-based recreation may depend mainly on water flow, such as rafting and scenic beauty. But the habitat protection service of water may be extremely important for other forms of tourism that depend on the health of a water ecosystem like fishing or wildlife viewing. This requires accounting for water ecosystems, in addition to the more limited focus of water stock accounts, which emphasize the volume of water and quality classified in terms of suitability for drinking water. Accounts for ecosystems have been identified in the SEEA but are less well defined in practice. Wetland ecosystem stock accounts can be expressed in a combination of area (e.g., hectares) and qualitative classifications such as excellent, good, fair, bad, etc. Ecosystem accounts would monitor the numbers and proportions of key species of flora and fauna that indicate ecosystem integrity.

2. Dependence of other resources on water ecosystem health

9.67. Many other resources are equally dependent on water resources and their use. Fisheries are particularly sensitive to water quality, water flows, and aquatic ecosystem health, including sea grass beds, mangroves, coral reefs, lagoons, and others ecosystems. Agricultural land has suffered greatly from misuse of water for irrigation, resulting in losses of agricultural productivity due to salination and water logging of soil. Natural vegetation depends on river flow and on the level of groundwater. When groundwater is depleted, vegetation may lose its water source. Wildlife and biodiversity also depend on the health of aquatic ecosystems and an adequate supply of unpolluted water.

ANNEX Water accounting and water indicators

9.68. Water accounting has developed more recently than environmental statistics including water indicators, but water accounting provides a much more powerful tool for improved water management. Many water indicators can be derived from the water accounts, and, in contrast to water indicators and statistics, water accounts also provide data in a structured framework linked to economic accounts that can be used much more effectively for quantitative analysis.

9.69. The section addresses more thoroughly the link between the water accounts and water indicators. It begins by drawing together the wide range of indicators developed in separate chapters of this Manual to show how, together, they provide a comprehensive set of indicators for water and sanitation policy appropriate for IWRM. In the second part of this section, these indicators are then compared to alternative sets of indicators for water developed by other international organizations, including the indicators developed for the Millennium Development Goals (MDGs).

3. Indicators derived from the water accounts

9.70. As a broad concept rather than a technical methodology, IWRM does not adopt a particular set of indicators. However, the indicators measure derived from the water accounts cover many critical aspects of water management under an IWRM approach:

- Water resource availability
- Water use for human activities, pressure on water resources and opportunities to increase water efficiency
- Opportunities to increase effective supply through management of return flows, reuse, and system losses
- Water cost and pricing policy: the user-pays and polluter-pays principles
- Access to and affordability of water and sanitation services

Beyond the IWRM approach, new indicators are suggested in Chapter 7, dealing with quality issues.

9.71. Overall index of water quality, including the potential for diaggregating between quality and discharge shares

- Pattern and predominance indexes, focusing on the distribution and causes of the observed quality

9.72. The major indicators for each of these aspects of water management are discussed below. Although not shown explicitly, it should be understood that most of the indicators can be compiled not only at the national level, but at the regional level, such as for a river basin. The indicators can also be disaggregated by type of resource, for example, surface and groundwater. While a national overview is important, they will be more useful for IWRM if compiled at the level at which IWRM is likely to be implemented, the regional level, for a river basin or other water management area.

Water resource availability

9.73. IWRM promotes sustainable, long-term water use that does not compromise the ability of ecosystems to provide water services in the future, including both human water requirements as well as ecological water requirements. Treatment of water availability in the water accounts was addressed in chapters 6 and 7. Box 6.1 provides a list of indicators for water availability, which are included in Table 9.8. The first five indicators in this table assess water availability from a simple environmental perspective, the natural volume available. These indicators differentiate between domestic water resources and resources that originate externally because water managers must distinguish water resources that are entirely under national control (internal water resources) from those which must be shared with other countries.

9.74. The next indicator, Exploitable water resources, reflects some of the limitations on the naturally available water by taking into account the economic and technological considerations, as well as ecological obligations that constrain the amount of naturally available water resources that can be exploited. The remaining indicators reflect pressure on water resources from population, total water use, and vulnerability to depletion.

9.75. Indicators for several aspects of water management discussed in Chapter 6 were not reflected in Box 6.1, but could be compiled by countries where these issues are important. For example, indicators for total available water might take into account sequential reuse of water due to return flows and recycling [paragraphs 6.59-6.61]. Although the issue was discussed in chapter 3, none of the indicators presented take into account water reliability, the other major characteristic of water.

Table 9.8: Selected indicators of water resource availability and pressure on water derived from the water accounts

Indicator	**Definition and Source** (See chapters 3 & 4 for more detailed explanation)
Internal Renewable Water Resources	"Average annual flow of rivers and recharge of groundwater generated from endogenous precipitation." (FAO/AQUASTAT)
External Renewable Water Resources	"Part of the country's renewable water resources shared with neighbouring countries. Total external resources are the inflow from neighbouring countries (trans-boundary groundwater and surface water inflows), and the part of the shared lakes or border rivers. The assessment considered the natural resources generally; if there are reservations in neighbouring countries, they are called actual resources." (FAO/AQUASTAT)
Total Natural Renewable Water Resources	The sum of internal and external renewable water resources. It corresponds to the maximum theoretical amount of water available for a country on an average year on a long reference period." (FAO/AQUASTAT)
Total Actual Renewable Water Resources	"(Fresh water resources total) The sum of internal and external renewable water resources, taking into consideration the quantity of flow reserved to upstream and downstream countries through formal or informal agreements or treaties and reduction of flow due to upstream withdrawal. cf. external surface water inflow actual or submitted to agreements. It corresponds to the maximum theoretical amount of water actually available for a country at a given moment. The figure may vary with time. Their computation is referring to a given period and not to an inter-annual average. " (FAO/AQUASTAT)

Dependency ratio	"Ratio between the external renewable resources and total natural renewable resources. Indicator expressing the part of the total renewable water resources originating outside the country." (FAO/AQUASTAT, WWDR 2003, Margat 1996)
Exploitable water resources (Manageable resources)	"Part of the water resources which is considered to be available for development under specific technical, economic and environmental conditions." (FAO/AQUASTAT)
Per capita renewable resources	Ratio between Total renewable water resources and population size. (WWDR 2003, Margat 1996)
Density of internal resources	Ratio between the average internal flow and area of the territory (Margat, 1996)
Annual Withdrawals of Ground and Surface Water as a Percent of Total Renewable Water Exploitation index	The total annual volume of ground and surface water abstracted for water uses as a percentage of the total annually renewable volume of freshwater. (UN, 2001)
Consumption Index	Ratio between Water Consumption and Total Renewable Resources. (Margat, 1996)
Water Use Efficiency	Total of return-flows *100 / (Average of renewable resources - sum of final consumptions)

Water use for human activities

9.76. Water availability indicators provide policy-makers with a picture of water availability and stress, but in order to address water problems and prioritize actions, more detailed information is needed about how water is used in an economy and the incentives facing water users, the environmental impacts of water use and pollution, and the social aspects of water use. IWRM calls for treating water as an economic good, which takes into account the value of water in different uses, the costs of water pollution from economic activities, as well as the broader socio-economic benefits generated by use of water by different economic activities. The indicators derived from the supply and use tables in Chapters 3 and 5 are particularly useful for this aspect of IWRM.

Table 9.9: Selected indicators of water intensity and water productivity

1. Water use and pollution intensity (physical units)		
	m^3 water/unit of physical output	Water use or tons of pollution emitted per unit of output, such as --population, --number of households, or --tons of wheat, steel, etc. produced
	Tons of pollution/unit of physical output	
2. Water and pollution intensity (monetary units)		
	m^3 water/value of output	Water use or tons of pollution emitted per unit of output measured in currency units
	Tons of pollution/value of output	

3. Water productivity ratios		
	GDP/ m^3 water	
	Value-added by sector/m^3 water	
4. Water 'pollutivity' ratios		
	Sector share of pollution/sector share of GDP	

Opportunities to increase effective water supply: return flows, reuse and system losses

9.77. Water supply and water productivity are not determined solely by natural conditions. The way that water is managed affects the amount of water that can be utilized by end-users and the productivity of water. Ways in which water availability and productivity can be increased include:

- Increase use of return flows by directing water to storage or other uses and minimizing pollution and salinity of return flows.
- Increase reuse of water
- Reduce system losses from leakages and other causes;

9.78. IWRM focuses strongly on these measures to increase effective supply of water. Indicators that could be derived from the water accounts for return flows, reuse, and losses are listed in Table 9.10.

Table 9.10: Indicators of opportunities to increase effective water supply

1. Return flows	
Quantity of return flows by source	May distinguish return flows from treated return flows (from municipal and industrial users) from untreated return flows such as agriculture
2. Water reuse	
Reuse water as share of total industry water use	May distinguish reuse of water within a plant from water recycled by municipal water utility
Recycled water as share of total water use by sector	
3. Losses	
Losses in abstraction and treatment as share of total water production	Both the amount and the reason for these losses are usually known by the water utility
Unaccounted for losses as share of total water use	These losses occur for a variety of causes and it is usually not certain how much each cause contributes

Water cost, pricing and incentives for conservation

9.79. 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 9.11: for supply cost and price of water and wastewater treatment services

1. Supply cost and price of water

Implicit water price	Volume of water purchased divided by supply cost
Average water price per m^3 by industry	Volume of water purchased divided by actual payments by that industry
Average water supply cost per m^3 by industry	Volume of water purchased divided by cost of supply to that industry
Subsidy per m^3 by industry	Average water price minus average water supply cost
2. Supply cost and price of wastewater treatment services	
Implicit wastewater treatment price	Volume of water treated divided by supply cost
Average wastewater treatment cost per m3 by industry	Volume of wastewater divided by treatment cost for that industry
Average wastewater treatment price per m3 by industry	Volume of wastewater divided by actual payments for treatment by that industry
Subsidy per m3 by industry	Average wastewater price minus average wastewater supply cost

Access to and affordability of water and sanitation services

9.80. Sustainable development requires that all people receive the basic amount of safe drinking water necessary for survival. Basic water must be affordable. The allocation of water and sanitation services among different social groups, and between countries sharing water resources, should be perceived as fair.

9.81. Three factors affect access: pricing, infrastructure, and proper management of water systems. In some countries (or parts of a country), insufficient water supply infrastructure results in reduced access of the poor. In other countries, infrastructure is adequate, but water and sanitation services are unaffordable. Poor management may also result in reduced access to water and sanitation services, even if the infrastructure is adequate. The water accounts represent water management water infrastructure investment expenditures (Chapter 5), but not the stock of infrastructure.

9.82. Most water accounts disaggregate use of water by rural and urban households, especially in developing countries, but supplemental information would be needed to derive most of the indicators of social sustainability listed in Table 9.12.

9.83. While national figures such as percent of urban and rural households with access to safe drinking water are widely used indicators of sustainable development, it is useful to disaggregate all these indicators by households of different income groups or region. In virtually all countries, well-off households have adequate drinking water and sanitation services because either they live in areas with adequate infrastructure or they can afford to provide the services themselves. Access and affordability of water can vary enormously not only among income groups but also among different regions within a country. Water accounts can provide social sustainability indicators for different social groups if the water accounts are linked to the most fully developed form of the SNA—the Social Accounting Matrix, which disaggregates households into different categories such as income, rural/urban residence, and other characteristics.

Table 9.12: Indicators of access to and affordability of water and sanitation services

1. Access to water and sanitation services
Average daily water consumption by households, differentiating rural and urban households
Percent of urban households with access to safe drinking water
Percent of rural households with access to safe drinking water
Percent of urban households with access to sanitation services
Percent of rural households with access to sanitation services
2. Affordability of water
Household expenditures for water as % of total expenditures, differentiating rural and urban
Average price of water to households, differentiating rural and urban
Average price of water for subsistence agriculture (irrigation and livestock watering)

4. Comparison of indicators derived from water accounts to alternative systems of water indicators

9.84. The indicators described in this manual draw heavily on indicators developed by FAO, but there are many alternative sets of indicators developed by other organizations, often for different purposes and utilizing different conceptual approaches. The most widely used framework is the pressure-state-response framework and its variants, such as the driving force- pressure-state-impact-response (DPSIR). This framework provides the basis for UNCSD's Indicators of Sustainable Development, the UN's Framework for Development of Environmental Statistics, OECD's Environmental Indicators and European Community's Environmental Pressure Indices (Strzepek et al., 2002). The United Nations World Water Assessment Program has drawn up an extensive set of indicators and has proposed some additional ones, which are reported in the 2003 *World Water Development Report* (UN, 2003) but the framework has not yet been finalized.

9.85. The International Water Management Institute has developed an extensive set of indicators related to agricultural water use (e.g., Molden, 2001; Molden et al., 2001). Less comprehensive sets of indicators for access to water and sanitation services have been developed for the Millennium Development Goals (MDGs). There are also several indexes of water availability, such as the Falkenmark Water Stress Index (Falkenmark et al., 1989), Water Resources Vulnerability Index (Raskin, 1997), the Indicator of Relative Water Scarcity (Seckler et al., 1998) and the Water Poverty Index (Sullivan et al., 2002). (See for a description of two of these indexes.)

9.86. It is not possible to compare the indicators derived from the water accounts to all alternative sets of indicators. A table showing the indicators that can be derived from the water accounts in relation to the DPSIR framework.

Box 9.8: Measuring Water Scarcity

1. Falkenmark Water Stress Index (Falkenmark et al., 1989), has been one of the most widely used indexes. It measures the per capita amount of annual renewable freshwater (surface and groundwater) available in a country. Three levels of stress are defined:

Occasional or local stress occurs when water availability is > 1700 m^3 of water per capita

Regular water stress occurs when water availability is 1000 to 1700 m^3 per capita

Chronic water scarcity that begins to hamper economic development and human health occurs when water availability is 500 to 1000 m^3 per capita

Absolute water scarcity occurs when water availability is < 500 m^3 of water per capita

This index of water availability does not adjust for temporal and spatial variations or whether a country has the infrastructure and capacity to utilize its water endowment, and excludes the amount of precipitation used for agriculture and vegetation.

2. Water Poverty Index (Sullivan et al., 2002) is a recently developed measure, which attempts to assess poverty in relation to water availability. It is based on five attributes of water: water resource availability adjusted for reliability and quality, access to water including affordability of water, capacity (financial and human capital) to manage the system, use (shares) of water for different purposes, and integrity of the environment. The table below shows both the overall index (last column) as well as the components of the index. Australia, for example, ranks second in the overall WPI, but 4th in terms of use, while Haiti's WPI ranks last, although it is 3rd in terms of water resources.

Water Poverty Index for selected countries

Country	Resource	Access	Capacity	Use	Environment	WPI
Finland	12.2	13.5	18.0	19.3	17.4	80.5
Australia	11.9	13.7	17.6	8.6	13.2	65.0
South Africa	5.6	12.1	12.7	14.7	11.1	56.3
Jordan	0.4	12.9	14.9	18.2	5.5	51.9
Haiti	6.1	4.8	10.5	3.4	7.0	31.8

Source: Adapted from Sullivan et al. 2002.

Table 9.13: Water accounts and indicators in the DPSIR framework

INDICATORS & TYPE			ACCOUNTING VARIABLES: Natural Asset, Supply & Use, Emission (hybrid) accounts, Satellite accounts	ACCOUNTING VARIABLES: Satellite accounts, SNA	COMPUTABLE INDICATORS	
			Physical	**Monetary**	**Physical**	**Monetary**
DRIVING FORCES	*Socio-economic values*	**Consumption**	Water received by sectors and self-supply	Intermediate and final consumption of water (national accounts)	Accounting variables	Accounting variables
		Production, Supply	Operation of the water resource by the sectors, dams, Supply of water to sectors	Investments in dams, channels, irrigation schemes, sewerage...; running costs of water supply and prices; turnover of the distribution of water	Accounting variables	Accounting variables
		Other	Seasonal demands for amenities (sport, tourism, parks, private gardens…), Abstraction rights allocated	Turnover of sectors depending on water, Abstraction rights allocated	Accounting variables	Accounting variables
PRESSURE	*Use of the resource & Emissions*	**Use**	Abstraction from water bodies (by sectors), minus Water lost in transport and irrigation (returns); Artificial evapo-transpiration & direct discharge to sea (consumption of water)	Abstraction rights used, Value of the distributed water	Accounting variables	Accounting variables
		Emissions	Discharge of waste water, discharge of pollutants (fluxes)	-	Accounting variables	Non internalised costs (social costs) of the use of the water system as a sink
STATE	*Availability & Limiting factors, Water quality*	**Stocks**	Natural and semi-natural assets (reservoirs, lakes, channels, rivers, groundwater, water in soil…)	-	Accounting variables	Asset value of water in reservoirs
		Flows	Precipitation, runoff, infiltration, evapotranspiration; availability of the water resource	-	Accounting variables	-
		Quality	Quality of the available water resource by type of water bodies	-	Accounting variables	Damage costs (Restoration costs or Avoidance costs)
IMPACTS	*Vulnerability of economy, ecosystem and human life*	**Depletion of the resource**	Storage and transport of water; treatment before use	Transport and storage of water, Purification before use	Accounting variables & Seasonal stress, Local shortages, Stress on the river ecosystems	Accounting variables & Economic losses due to water shortages, to the maintenance of minimum flows in rivers
		Degradation of the environment	Quality of aquifers and rivers, quality/ health of water ecosystems	-	Accounting variables	Damage costs (Restoration costs or Avoidance costs)
		Health	Supply of polluted water to households	-	Accounting variables	Health costs related to use of polluted water
RESPONSES	*Society responses*	**Protection activities**	Sewerage and water treatment	Protection expenditure	Accounting variables	Accounting variables
		Changes in Process & Behaviour	Recycling of water, irrigation techniques, desalination of sea water	Costs and economic benefits	Accounting variables	Accounting variables & ecological benefits calculations
		Economic and legal instruments	Abatement of polluting discharges to water; minimum flows and reserves	Taxes, Incentives	Accounting variables	Accounting variables

Source: Weber, 2004

Water accounts and the Millennium Development Goals

9.87. The Millennium Development Goals (MDGs) have been widely adopted by the international community as comprehensive guidelines for development that is environmentally, economically, and socially sustainable in the 21st century. The MDGs define 18 Targets for achieving these goals, of which MDG Target #10 deals specifically with water: halve the proportion of urban and rural population without sustainable access to safe drinking water and to basic sanitation by 2015 (MPTFWS, 2003). Virtually all the population in industrialized countries has access to safe drinking water and sanitation, but this is not the case for developing countries, where most of the world's population lives. Rural areas fare worse than urban areas, sanitation services lag behind drinking water, and the least developed countries have the lowest access to both drinking water and sanitation services.

9.88. Four indicators are needed to assess progress toward the MDG Target for water and sanitation:

- Proportion of urban population with sustainable access to improved water source;
- Proportion of rural population with sustainable access to improved water source;
- Proportion of urban population with access to improved sanitation;
- Proportion or rural population with access to improved sanitation.

9.89. These indicators require information about rural and urban population, which may be included in the water accounts as supplemental tables. Although water accounts do not always distinguish rural and urban households, it is common to make that distinction for developing countries (see Lange et al., 2003 for an example in the water accounts for Botswana, Namibia, and South Africa).

9.90. The Millennium Project Task Force on Water and Sanitation noted that good water management also contributes substantially to achieving the other MDGs (MPTFWS, 2003); specific contributions to each MDG are identified in the Third World Water Development Report (United Nations, 2003).

Table 9.14: Percent of population with access to improved water supply and sanitation in 2002

	World Population	Access to improved drinking water			Access to improved sanitation		
		Total	Urban	Rural	Total	Urban	Rural
Developed	16%	98	100	94	98	100	92
Eurasia	5%	93	99	82	83	92	65
Developing	80%	72	99	70	49	73	31
World	100%	83	95	72	58	81	37

Note: WHO/UNICEF has adopted the term 'improved' instead of 'safe' or 'basic.' The figures are the same.

Source: WHO/UNICEF Joint Monitoring Project. 2004.

References

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

Appels, D., R. Douglas, and G. Dwyer. 2004. Responsiveness of demand for irrigation water: a focus on the Southern Murray-Darling Basin. Productivity Commission Staff Working Paper, Canberra, Australia.

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

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

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

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

Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, OJEC L327/1 22/12/2000, pp. 1-72.

Duarte, R., J. Sanchez-Choliz, and J. Bielsa. 2002. Water use in the Spanish economy: an input-output approach. *Ecological Economics*. 43:71-85

Eurostat. 2001. Eurostat Statistics in focus – Theme Environment and energy n° 6/2001

Falkenmark, M., J. Lundqvist, and C. Widstrand. 1989. Macro-scale water scarcity requires micro-scale approaches: aspects of vulnerability in semi-arid development. Natural Resources Forum. Vol. 13, No. 4 pp 258-267.

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

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

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

Gleick, P., E. Chalecki and A. Wong. 2002. Measuring water well-being: water indicators and indices. In Gleick et al. (eds) *The World's Water 2002-2003: Biennial Report on Freshwater*, Island Press: Washington, D.C.

Gleick, P., A. Singh, and H. Shi. 2001. *Emerging Threats to the World's Freshwater Resources*. A report of the Pacific Institute for Studies in Development, Environment and Security. Oakland, California.

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

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

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

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

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

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

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

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

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

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

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

Molden, D. 2001. Accounting for water use and productivity. SWIM Paper No. 1. International Irrigation Management Institute: Colombo, Sri Lanka.

Molden, D., R. Sakthivadivel, and Z. Habib. 2001. Basin-level use and productivity of water: examples from South Asia. Research Report No. 49. International Water Management Institute: Colombo, Sri Lanka.

OECD. 2002. Indicators to measure decoupling of environmental pressure from economic growth. OECD: Paris

Pan, X. and S. Kraines. 2001. Environmental input-output models for life-cycle analysis. *Environment and Resource Economics*. 20: 61-72.

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

Raskin, P. 1997. *Comprehensive Assessment of the Freshwater Resources of the World Water Futures: Assessment of Long-Range Patterns and Problems*. Stockholm Environmental Institute: Stockholm, Sweden.

Seckler, D., U. Amarasinghe, D. Molden, R. da Silva, and R. Barker. 1998. World water demand and supply, 1990 to 2025: scenarios and issues. Research Report No. 19. International Water Management Institute: Columbo, Sri Lanka.

Statistics Denmark. 1999. NAMEA with water extraction and use. Environmental Accounting Project Report to European Community Project, DG XVI ERDF file nº 97/01/57/009. Statistics Denmark: Copenhagen, Denmark

_______________. 2004. *The Danish Environmental Accounts 2002*. Statistics Denmark: Copenhagen.

Statistics Sweden. 2000. Water accounts 2000 with disaggregation to sea basins. Statistics Sweden: Stockholm.

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

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

Strzepek, K., S. Gangopadhyay, and A. McCluskey. 2002. 1st world water development report: development of indicators. Report to the World Water Assessment Program.

Sullivan, C., J. Maigh, and T. Fediw. 2002. Derivation and testing of the water poverty index. Report to DfID from the Centre for Ecology and Hydrology.

United Nations. 2003. *World Water Development Report 2003*. UN: New York

Van der Veeren, R., R. Brouwer, S. Schenau, and R. van der Stegen. 2004. NAMWA: a new integrated river information system. Central Bureau of Statistics: Voorburg, Netherlands.

Vardon, M. and S. Peevor. 2004. Water accounting in Asutralia: use and policy relevance. Paper presented to the London Group on Environmental Accounting, Copenhagen, Denmark.

Victorian Government Department of Sustainability and the Environment. 2004. *Securing Our Water Future Together.* Victorian Government White Paper.

WHO/UNICEF Joint Monitoring Project. 2004. Meeting the MDG water and sanitation target: a midterm assessment of progress.

Wolf, G. and P. Gleick. 2002. The soft path for water. In Gleick et al. (eds) *The World's Water 2002-2003: Biennial Report on Freshwater*, Island Press: Washington, D.C

Zhang, F. 2003. Marginal opportunity cost pricing for waste water disposal: a case study of Wuxi, China. Research report of the Environmental Economics Program for Southeast Asia.

Chapter 10 Valuation of water resources [NEW VERSION - TO BE EDITED]

A. Scope of the chapter

10.1. The national accounts treat water like all other products: water use is valued at prices charged and water supply at the cost of production. Unlike many other products, however, the prices charged often provide only a poor, inadequate indicator of water's economic value, a situation arising from certain unique characteristics of water:

10.2. 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; ironically, this situation is sometimes most severe in water-scarce developing countries where water may be provided to some users at no charge. Administered prices occur in part because the natural characteristics of water inhibit the emergence of competitive markets that establish economic value. (For a more detailed exploration of this topic, see Easter et al., 1997; Young, 1996.)

- Water supply often has the characteristics of a natural monopoly because water storage and distribution are subject to economies of scale.
- Property rights, essential for competitive markets, are often absent and not always easy to define when uses of water exhibit characteristics of a public good (flood mitigation), a collective good (a sink for wastes), or when water is subject to multiple and/or sequential use.
- Water is a 'bulky' commodity, that is, its weight-to-value ratio is very low, inhibiting the development of markets beyond local area.

10.3. Large amounts of water are abstracted for own use by industries other than ISIC 041 or 41, such as agriculture or mining. Use of self-abstracted water 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 Operating surplus of agriculture.

10.4. The economic value of water is much more useful than observed water price for in many policy areas: economic value can be used to assess efficiency in the development and allocation of water resources. Efficient and equitable allocation of water takes into account the value of water used by competing end-users in the present generation, the allocation of resources between present and future generations, and the degree of treatment of wastes discharged to water or other activities that affect water quality. Water valuation is also useful in setting water pricing policy and in the design of economic instruments to achieve better use of water resources. Instruments for water include property rights, tradable water markets, taxes on water depletion and pollution, and subsidies for water demand management.

10.5. Economists have developed techniques for estimating the value of water. The chapter reviews the techniques for valuation and suggests which ones might best be used for the SEEA water accounts. The valuation techniques reviewed include those commonly used for the water goods and services presently included in the Water Accounts:

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

(ii) Water as a final consumer good

(iii) Environmental services of water for waste assimilation

10.6. Other water values, notably for recreation, navigation and biodiversity protection, and water qualities, such as reliability and timing of water availability, are not addressed here because they are not yet included in the Water Accounts.

10.7. Section B summarizes the usefulness of different valuation techniques for the water accounts and addresses some additional issues that arise in monetising water accounts such as aggregation of water values from the local to national level. Given the highly site-specific natural of water value, it will be difficult and expensive to monetise national water accounts. A more fruitful approach might be to monetise water accounts for selected water management areas like river basins. Section C provides a more detailed overview of economic valuation and Section D discusses the strengths and weakness of each water valuation technique using empirical examples.

B. Water valuation and the water accounts

10.8. This section the issues that arise for valuation of water goods and services, and the recommendations for the Water Accounts. Valuing water assets as the capitalized flow of goods and services provided over time is addressed in Chapter 6.

National and local valuation: scaling and aggregation of water values

10.9. Water valuation has a long history in economics, mostly at the project or policy level. Projects and policies are often implemented for a designated water management area, such as a river basin. There has been little experience of aggregating these localized values to the national level.

10.10. Because water is a bulky commodity and the costs of transporting and storing water are often high, the value of water is determined by local and regional site-specific characteristics and options for use. For example, the value of water as an input to agriculture will often vary a great deal by region because of differing factors that affect production costs and product value, including soil, climate, market demand, cost of inputs, etc. In addition, the timing of water availability, water quality and reliability of supply are also important determinants of water value. Consequently, the value of water can vary enormously within a country even for the same sector.

10.11. The site-specific nature of water values means that water values estimated for one area of a country cannot be assumed to hold in other areas. This poses a problem for constructing accounts for water value at the national level, because the method commonly employed for national accounts - scaling up to the national level from sample data - cannot be as readily applied. It is more accurate and useful to policymakers construct water accounts at the level of the water management area, often a river basin, and to compile national accounts by aggregating the river basin accounts. River basin accounts will also be more useful for policymakers because many water management decisions are taken at the river basin level, and even policy at the national level must take into account regional variations in water supply, demand and value. Furthermore, in some countries, there may be extensive transfers of water between river basins. Inter-basin transfers are valued according to the use made of the water in the receiving river basin.

Double-counting

10.12. 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 SNA, although it is rarely explicitly identified:

- For users purchasing water from ISIC 1.40 and 41, the water value in the SNA is spread out among three components of an industry's production costs: the tariff paid; any additional costs (purchases of equipment, energy, labour, and other inputs) incurred by a company for treatment, storage, or transport of water; and industry value-added where any residual water value accrues.

- For industrial self-providers, the value of water is split between costs incurred for abstraction, transport, treatment, or storage of water; and industry value-added.

For households, water value in the SNA includes the portion paid to water utilities or incurred by self-providers for direct abstraction. There is no measure of any additional value included in the SNA.

10.13. The value of wastewater treatment may be partly reflected in the costs of services provided by ISIC 90 and the costs for self-treatment by industry and households. Damages from changes in water quality to industrial productive capacity or industries' costs of averting behaviour are already included in the SNA as part of the affected industries' costs of production. Some consumer averting behaviour and health costs may be included in the SNA as part of consumer expenditures, but others may not be, or may not be easy to identify. The value of recreational or aesthetic water services to consumers may also be at least partly reflected in the market prices of land, housing, or tourism facilities.

Valuation techniques; marginal *vs*. average value

10.14. Valuation techniques for many uses of water are widely accepted by policy-makers. However, there are many valuation techniques and, because of their foundation in cost-benefit analysis and its emphasis on economic welfare, they can produce three conceptually different measures of 'value:'

- marginal value, the price the last buyer would be willing to pay for one additional unit. This value corresponds to price in a competitive market, and in principle is compatible with the SNA approach to value

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

- total economic value, a measure of total economic welfare that includes consumer surplus' and 'producer surplus, that can be used to estimate average value.

10.15. These concepts are defined and explained in section C; their implications for valuation are described further in Section D. Because average value includes consumer/producer surplus, a concept that is not compatible with the concept of value in the SNA, it would certainly be preferable to use techniques that measure marginal value, but often it is not possible to measure marginal value (see sections C and D). Is it still useful and reasonable to apply average value for monetizing the water accounts? There are several answers to this question.

10.16. Some people may argue that virtually no markets in the world are perfectly competitive so no prices in the SNA reflect marginal values, and hence, it is of little consequence whether water is valued at an average or marginal price. Others may argue that the difference between average and marginal is an empirical issue, and it is probably better to have some value for water rather than none (which may be wrongly interpreted as an implicit zero value).

10.17. When economic values are intended to contribute to a discourse on valuation, evaluation and policy, then it may be appropriate to include all values for which there are reasonable estimates, regardless of whether they are average or marginal values. In any case, there are very few point estimates of value, whether marginal or average, that can be provided with great certainty. Valuation studies often provide a range of values because of the uncertainty and considerable amount of judgment underlying the method and its implementation. The annual report on cost-benefit analysis of federal regulations in the United States, for example, reports a range of values, sometimes quite large, and guidelines specify some of the alternative assumptions and parameters to be used, such as discount rates (OMB, 2003).

10.18. A useful approach to the valuation challenge would be to include values for all water services that can be estimated with fairly reliable data and techniques, and to identify whether the values are marginal or average so that the user is aware of how this may distort policy analysis.

Recommendations

10.19. *Scale of valuation*: Because water value is highly site-specific, national values cannot always be reliably obtained from case studies, and surveys would be very expensive. Consequently, it is unlikely that water valuation can be applied at the national level to the water accounts. It will probably be most useful to construct water value accounts at a regional level (e.g., river basin), or for a critical sector, such as agriculture.

10.20. *Double counting*: it must be recognized that most values for water are already included in the SNA, but not explicitly attributed to water. The role of water valuation is to make those values explicit, but they should not be interpreted as additional values not included in the SNA. The only exception to this is unpaid-for value of water as a consumer good.

10.21. *Valuation Techniques*: it is useful to value water using whatever techniques can reasonably be applied, whether they measure marginal or average value, as long as the type of value is clearly identified.

C. Economic approach to the valuation of water

10.22. In economic terms, water is an essential commodity so the value (willingness-to-pay) for a basic survival amount is infinite. Once basic needs are met, economic valuation can make an important contribution to decisions about water policy. A commodity has economic value when users are willing to pay for it rather than do without. The economic value of a commodity is the price a person would pay for it (or, on the other side of the transaction, the amount a person must be paid in compensation to part with it). Economic values can be observed when people make a choice among competing products available for purchase (or for barter trade—values need not be expressed only in monetary units). In competitive markets, the process of exchange establishes a price that represents the marginal economic value, that is, the value of the last (marginal) unit sold. In the absence of water markets or where markets function poorly, valuation techniques must be used to estimate the economic value of water, which is called a 'shadow price' (See Box 10.1).

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

10.24. Water valuation can be quite complex: data are often not available and expensive to collect, water values are usually very site-specific and benefits transfer (a method of applying values obtained from one study site to other sites) is not well developed for many aspects of water, methods and assumptions are not standardized, and uncertainty may be quite high. In addition, many valuation techniques depart from the concept of value in the SNA, raising major challenges to monetizing water accounts in a manner that is consistent with the SNA.

Box 10.1: Shadow Prices

In economic analysis, such as an evaluation of alternative allocations of water among competing users, it is necessary to express the benefits and costs in monetary terms using prices and quantities. Often observed prices are used. However, observed prices sometimes fail to reflect true economic values. Examples include government regulation that sets prices for commodities like water and energy, taxes or subsidies that distort market prices of agricultural commodities, minimum wage that is set above market clearing prices, or trade restrictions that increase the price of domestically produced goods. In such cases, it is necessary to adjust the observed market price for these distortions. In other cases, there may be no market price at all, and the price must be estimated. The resulting adjusted or estimated price is called a 'shadow price.'

10.25. The SNA records actual market (and near market) transactions, and the SNA-value of a product is its market price. In competitive markets, prices represent marginal values of goods and services. There are many instances, however, in which observed prices may differ from marginal values, sometimes significantly, due to factors such as market failure, administered prices, taxes and subsidies, trade protection, and so on. Sometimes these distortions may be large, sometimes small.

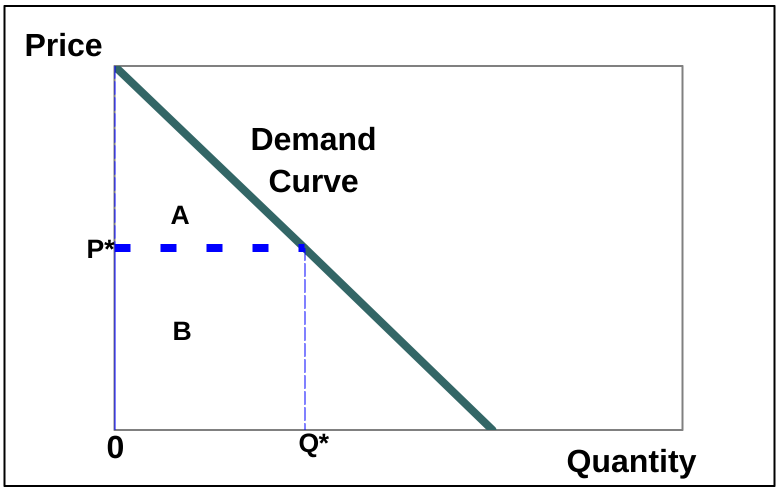
10.26. Non-market valuation techniques estimate either marginal value, average value or total economic value (TEV), which includes 'consumer surplus' in addition to the market price paid. Consumer surplus is the difference between what an individual is willing to pay and the price that the individual actually pays. The difference arises because the same price is charged to all consumers in a given market regardless of what the consumer is willing to pay. Prices in the SNA may be quite different from marginal values, but the SNA does not include measures of consumer surplus. The relationship among these three concepts of economic value is illustrated in Figure 10.1.

- Total economic value of water is measured as the sum of total willingness-to-pay of all consumers, and is typically displayed as the area under the demand curve. For quantity Q*, *total economic value* is the area A+B. This measure is appropriate in applications such as cost-benefit analysis when the purpose is to measure the total change in economic welfare.
- The figure (A+B)/Q* represents the *average value* of a unit of water when Q* units of water are used. The average value is larger than marginal value (by the amount A/Q*) because

it includes a portion of consumer surplus, the difference between consumers' willingness-to-pay (the demand curve) and market price.

- P* represents the *marginal value* of a unit of water at Q*. For an individual, the marginal value represents the benefit from the use of one more unit of water. For a business, the marginal value represents the increase in net revenue made possible by increasing water input by one unit. The marginal value is relevant for assessing the economic efficiency of the allocation of water among alternative uses. Competitive market prices equal the marginal value.

Figure 10.1: Demand curve for water



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

10.27. In some instances it is easier to measure total and average values than marginal values, but the consequences for valuation can be large. For example, it is not uncommon for practitioners to estimate the total damages from water pollution, then divide by the tons of pollutant emitted to obtain average damages per ton of pollutant. This average value is likely to differ significantly from marginal values if the dose/concentration-response function is nonlinear. It can be quite misleading to apply the average value obtained from one study in one location to another location, or even the same location at a different point in time. As mentioned earlier, water services are often provided and acquired without trade or through trade in imperfect markets and hence information is not available for specification of proper demand functions and calculation of marginal or total economic values. In such cases cost rather than benefit-based measures are commonly used to value water.

Overview of valuation methodologies

10.28. People value an environmental good such as water for many purposes, which economists classify into use values and non-use values (). (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, either the direct use of water as a resource or the indirect support provided by water ecosystem services. Option values refer to the value of maintaining the option to enjoy direct or indirect use of water in the future.

Non-use values include the value of knowing that water and water ecosystems will be available to future generations (bequest value) and the intrinsic value of water ecosystems (existence value).

10.29. An estimate of the total value of water should include all use and non-use values. 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. Valuation of some indirect uses, like waste assimilation services, is also fairly well developed. But valuation of other indirect services such as habitat protection and cultural values associated, and the non-use values are more controversial and not as well developed. Since these services are not yet included in the Water Accounts, they will not be discussed further.

Box 10.2: Categories of economic values for water

Use Values

Direct use values: The direct use of water resources for consumptive uses such as input to agriculture, manufacturing and domestic use, and non-consumptive uses such as hydropower, recreation, navigation and cultural activities.

Indirect use values: The indirect environmental services provided by water such as waste assimilation, habitat and biodiversity protection, hydrologic function.

Option value: the value of maintaining the option for use of water, direct or indirect, in the future.

Non-Use Values

Bequest value: the value of nature left for future generations.

Existence value: the intrinsic value of water and water ecosystems, including biodiversity, the value people place simply on knowing that a wild river, for example, exists even if they never visit it.

10.30. Table 10.1 shows the valuation techniques that have been most often applied to the water uses included in the Water Accounts. All except contingent valuation are based on what economists call 'revealed preference' methods, that is, water value is derived from observed market (revealed) behaviour toward a marketed good related to water. Contingent valuation is a 'stated preference' technique based on surveys that ask people to state (stated preferences) their values. Economists are often more comfortable with estimates derived from actual market behaviour, but for some water services, even indirect market information may not be available such as protecting wetlands or endangered species. Each technique is described in greater detail in the next section. A more detailed discussion of valuation methodologies for water with references to many studies in the literature can be found in (Gibbons, 1986, Turner, et al., 2004; and Young, 1996). Frederick et al. (1996) provide an exhaustive review of water valuation studies in the United States.

Table 10.1: Valuation techniques for water

1. Water as an intermediate input to production: agriculture, manufacturing	**Comments**
Residual value Change in net income Production function approach	Techniques provide average or marginal value of water based on observed market behavior

Mathematical programming models	
Sales and rentals of water rights	
Hedonic pricing	
Demand functions from water utility sales	
2. Water as a final consumer good	
Sales and rentals of water rights Demand functions from water utility sales Mathematical programming models Alternative cost Contingent valuation	All techniques except Contingent valuation provide average or marginal value of water based on observed market behavior. Contingent valuation measures total economic value based on hypothetical purchases
3. Environmental services of water: waste assimilation	
Costs of actions to prevent damage Benefits from damage averted	Both techniques provide information on average or marginal values

D. Empirical applications of water valuation

10.31. This section discusses the concepts and empirical application of valuation techniques organized by the major categories of uses addressed in the Water Accounts: water as an intermediate input to agriculture and manufacturing, water as a final consumer good, and environmental services of water for waste assimilation.

10.32. Examples are given to illustrate some of the problems that arise when applying these techniques and how different practitioners have solved them. The majority of water valuation studies have addressed water value for irrigation, waste disposal and recreation (Frederick et al., 1996; Gibbons, 1986; Young, 1996). The reader should keep in mind that some important attributes affecting water quality cannot be dealt with in such a brief overview. For example, the value of water is likely to change with location and the season (irrigation water has low value outside the growing season). The value of water in a particular use will also be affected by quality of water and the reliability of supply.

1. Valuing water as an intermediate input to agriculture and manufacturing

10.33. Irrigation is the single largest use of water in the world (Gleick, 1993), but it is also among the lowest-valued uses of water (Gibbon, 1986). Production decisions in agriculture are highly complex and filled with uncertainties. In a review of irrigation water valuation studies, Young (1996) finds most of them flawed, with a tendency to overestimate the value of water. The most commonly applied valuation technique is the residual valuation approach and its variations, change in net income and the production function approach.

10.34. In some countries with relatively little irrigated agriculture, industry is the major user of water. For example, in Sweden, two industries alone, Pulp & paper and Chemicals, accounted for 43% of total freshwater water use in 1995 (Statistics Sweden, 1999). It is often assumed that industrial value of water is relatively high, compared to agriculture, but this use of water has received much less attention than other uses (Wang and Lall, 1999). In a review of valuation of water studies in the United States, Frederick et al. (1997) found 177 estimates for irrigation water, 211 estimates for the recreational value of water, and only 7 estimates for industrial water value. This section begins with the most commonly used valuation techniques, residual value and its variants, then presents examples of mathematical programming and hedonic pricing applications.

Residual Value, Change in Net Income, and Production Function Approaches

10.35. Residual value and its related techniques of Change in net income (CNI) and Production function approach, are techniques applied to water used as an intermediate input to production based on the idea that a profit maximizing firm will use water up to the point where the net revenue gained from one additional unit of water is just equal to the marginal cost of obtaining the water. Residual valuation assumes that if all markets are competitive except for water then the total value of production exactly equals the opportunity costs of all the inputs. When the opportunity costs of non-water inputs are given by their market prices (or their shadow prices can be estimated), the shadow price of water, then, is equal to the difference (the residual) between the value of output and the costs of all non-water inputs to production:

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

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

where

TVP = total value of the commodity produced;

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

VMP_w = value of marginal product of water;

q_w = the cubic meters of water used in production.

10.36. Although the literature terms the shadow price of water its ‘value marginal product’ residual value actually measures average value because VMP is measured for the total amount of production and total non-water inputs, rather than marginal output and marginal costs of non-water inputs. Average and marginal values are identical only in cases where production functions exhibit constant returns to scale. Whether average value diverges significantly from marginal values depends on the nature of the production function, which is an empirical question.

10.37. In applying this technique to water accounts it should be noted that, as formulated above, the value of water includes some costs incurred by the user for abstracting, transporting and storing water, as well as water tariffs. These costs are already included in the national accounts and should not be double-counted.

10.38. The residual value method has been widely used for irrigation because it is relatively easy to apply, but is quite sensitive to small variations in the specification of the production function and assumptions about market and policy environment. If an input to production is omitted or underestimated, its value is wrongly attributed to water. In some cases, researchers conduct extensive farm surveys of crop production and inputs. In other cases, secondary data are used to derive average crop yields and production costs. Secondary data may differ considerably from actual inputs and yields of the farming area being assessed. Box 10.3 demonstrates this method using a case study from Namibia.

10.39. Assuming the model specification is accurate, the prices for all inputs and products must be reviewed because some inputs, notably family labour, may not be paid, and the prices of other commodities may differ significantly from their marginal values due to taxes, subsidies for energy, trade protection, etc. Water is a major input to irrigation and its unit value is extremely sensitive to the volume of water used for production. Yet, in many countries, irrigation water is not metered and only estimates are available, based on 'rules of thumb' applied to hectares under irrigation and the type of crop cultivated (Johansson, 2000). In the Namibian case study described in the Box 10.3, farmers' own estimate of the water used was at least 50% higher than the guidelines used by water management authorities (Lange, 2006; 2002).

10.40. Labour is a significant input to agriculture, and often at least some portion of this labour is unpaid. Unless a value is estimated for this input, the value of water will be overestimated. Family labour is often unpaid in both developed and developing countries and a shadow price must be estimated, usually in terms of the opportunity costs of workers. Farm management is a distinct contribution of the farmer and sometimes less easy to value unless there is comparable farms which hire manager.

10.41. It is not uncommon for governments to subsidize the costs of critical inputs to agriculture, notably fertilizer and energy. Some developing countries also fix the price paid for major agricultural crops, often below their marginal value. In other countries, the price of agricultural commodities may not be directly subsidised, but trade protection is used to maintain high crop prices. In applying the residual value technique these distorted input and output prices must first be corrected.

10.42. Box 10.3 shows two examples of residual value adjusted for trade protection. In the UK example, the authors did not have information about the amount of water used for each crop, so the residual value is given as the value per hectare, meaning for the total amount of water required to cultivate a hectare's worth of a given crop. After correcting for trade protection, only one crop, potatoes, would generate a positive return to water.

Box 10.3: Calculating residual value: and example from Namibia

The residual value technique was applied to agricultural production in the Stampriet region of Namibia, where farmers abstract groundwater to raise cattle and irrigate crops including lucerne for their livestock (Lange et al., 2000; Lange, 2002; 2004). A survey was undertaken in 1999 and data for farm income and costs were obtained for 16 of the 66 farmers in the region. The data about some items are considered reasonably accurate, notably farm income, inputs of most goods and services, and compensation of employees. Fixed capital costs, one of the largest cost components, were difficult to estimate because farmers often did not keep good records. Farmers also do not always meter their water and the estimates of water use must be treated with caution. From the survey, average farm income and costs were calculated. Average residual value was calculated as Gross farm income – Inputs of G&S – Compensation of employees – Farmers' imputed income – Capital costs (depreciation, working capital, cost of fixed capital).

Despite the weakness of the data, the results are useful to illustrate the sensitivity of the residual method to the assumptions made. The table shows the costs of production and residual value of water under different assumptions about the cost of capital. Assuming a 5% cost for capital investments, the residual value of water was Namibia $0.19 per cubic meter. But if the real cost of capital, rose to 7%, farmers would not even earn enough to cover all the capital costs and the value of water would be negative.

Farm revenue & costs (in 1999 Namibia $)		Data source
Gross farm income	$ 601,543	Output x market prices from survey
Inputs of goods and services	$ 242,620	Inputs x prices from survey
Value-added, of which:	$ 358,923	
Compensation of employees	$ 71,964	Wages paid + in-kind payments from survey
Gross operating surplus, of which:	$ 286,959	
Imputed value of farmers' labour	$ 48,000	Imputed based on average salary of hired farm manager
Depreciation	$ 66,845	Standard depreciation rates x Farmers' estimated historical cost of capital in survey
Cost of working capital	$ 17,059	Imputed as % of the value of fixed capital
Cost of fixed capital including land, 3% -7%	$75,739 to $176,724	Based on farmers' estimated historical cost of capital reported in survey
Residual value of water	$79,316 to -$21,669	
Amount of water used (m3)	154,869	Farmers' "best guess;" water is not metered
Residual value N$/m3	$0.51 to -$0.14	

Source: adapted from (Lange, 2004; Lange et al., 2000).

Box 10.4: Adjusting the residual value of water for market distortions

The case studies for UK and Jordan show the importance of adjusting for market distortions from trade protection. In both cases, the residual value of water is calculated with and without the effective subsidies from trade protection and substantial differences occur.

Case 1. United Kingdom. Bate and Dubourg estimated the residual value of water used for irrigation of 5 crops in East Anglia from 1987 to 1991 using data from farm budget surveys. However, data about actual water use was not available so the residual value is calculated for the amount of water needed to cultivate a hectare of a given crop. When the effective subsidies from the EU's Common Agricultural Programme are taken into account, the residual value is negative for all crops except potatoes.

	£ per hectare*	
	Not adjusted for CAP subsidies	Adjusted for CAP subsidies
Winter wheat	101.12	-176.48
Barley	13.45	-164.70
Oilseed rape	220.04	-146.48
Potatoes	1428.84	880.04
Sugar beet	327.93	-3565.10

*Actual amount of water used per hectare of a crop is unknown.
Source: Adapted from (Bate and Dubourg, 1997)

Case 2. Jordan. Schiffler calculated residual value for fruit crops (apples, peaches, olives, grapes) and vegetable crops (tomatoes, watermelon, cucumbers, squash and wheat) in 1994 based on data from farm surveys. Values were calculated with and without trade protection. The difference was small (7%) for fruit crops, but nearly 50% for vegetables.

	Jordanian dinar per m^3 of water input	
	Not adjusted for trade protection	Adjusted for trade protection
Fruit crops	0.714	0.663
Vegetable crops	0.468	0.244

Source: Adapted from (Schiffler, 1998)

10.43. For irrigation farming, capital can be a substantial component of costs, and the correct costing of capital raises several challenges. In some studies, fixed capital may be omitted entirely or in part (e.g., Al-Weshah, 2000). This may be appropriate in situations of short-term disruption of water supply such as a drought, where the objective is to maximize profits by allocating water to higher value crops under unusual short-term conditions. But these short-term values of water do not reflect the long-term values and are not appropriate for long-term water management because they are overestimated.

10.44. Residual value as described above is suitable for a single crop or single product operation, but for multiple products, a slightly different version is used, the *Change in Net Income (CNI) approach*. CNI measures the change in net income from all crops resulting from a change in the water input, rather than the value of all water used in production. It is often used to compare the value of water under present allocation to the value that would be obtained under an alternative allocation of water. For example, it might be used to assess a farmer's response to a policy change intended to bring about a change in crop mix or production technology. In contrast to residual value, by measuring the impact of a change, CNI measure the marginal value of water rather the average value obtained with the residual value approach.

10.45. Young (1996) notes that the change in net income approach is used more often than the single-crop residual value approach. CNI faces the same problems in correctly specifying the production function and correcting for missing or distorted prices. Since CNI is essentially a comparison of existing production to a hypothetical change, it faces additional data challenges in correctly specifying the resulting income and costs of production for the alternative.

10.46. The *production function approach* uses regression analysis, usually to a cross-section of farmers or manufacturers, to estimate a production function, or, equivalently, a cost function which represents the relationship between inputs and outputs, specifically water and crop yields. The functions are developed from experiments, mathematical simulation models, and statistical analysis of survey or secondary data. The marginal value of water is obtained by differentiating the function with respect to water, that is, measuring the marginal change in output (or reduction in costs) that results from a small change in water input.

10.47. The production function approach and mathematical programming (see below) are the most widely applied techniques for water valuation in manufacturing. The residual value method has not been used for industry water valuation because the cost share of water is quite small in most industrial applications and the residual value method is very sensitive to the quantity of water input. Renzetti and Dupont (2003) used a production function approach to measure the marginal value of water in manufacturing (See Box 10.5). A similar study was undertaken in China by Wang and Lall (1999), using data for about 2,000 firms, mostly medium and large state-owned enterprises, in 1993.

Box 10.5: Marginal value of water by industry in Canada, 1991

Using a production function approach, Renzetti and Dupont (2003) estimate the marginal value of raw water for 58 manufacturing industries in Canada over three years, 1981, 1986, and 1991. Assuming firms minimize their costs, they formulate a translog cost function based on the quantity of output, the quantity of water, the price of capital, labor, energy, materials, water re-circulation, in-plant water treatment, as well as several dummy variables that take into site-specific and industry-specific characteristics such as the aridity of a province and the share of raw water that is used for industrial processes. In the cost function approach, the shadow price of water is estimated as the marginal change in costs resulting from an incremental change in the quantity of raw water intake. The mean shadow value across industries was C$ 0.046/m3 in 1991 prices. In very dry provinces the shadow value was higher than in water-abundant provinces, C$0.098 and C$0.032, respectively.

Industry	Shadow price of water C$/1000m^3
Food	17
Beverages	38
Rubber	6
Plastic	32
Primary textiles	14
Textile products	5
Wood	20
Paper and allied products	31
Basic metals	107
Fabricated metal	48
Transport equipment	25
Non-metallic minerals	23
Refined petroleum/coal	288
Chemicals	72

Source: Adapted from Renzetti and Dupont (2003).

Mathematical programming models

10.48. Various forms of *mathematical programming models* have been developed to guide water allocation and infrastructure development decisions. These models specify an objective function (such as maximizing the value of output) subject to production functions, water supply, and institutional and behavioral constraints. These models may be applied to one sector, such as agriculture to determine the optimal mix of crops, to a watershed to determine the optimal allocation of water among all users, or to a national economy. These may be linear programming models or, simulation models, or more commonly for economy-wide analysis, computable general equilibrium (CGE) models.

10.49. The models calculate shadow prices or marginal value of all constraints including water. Optimisation models, as the name implies, estimate marginal values for water based on an 'optimal' allocation of water and the corresponding reconfiguration of economic activity and prices. An example of a linear programming approach to agriculture in Morocco is given in Box 10.6. An economy-wide approach may use linear programming, simulation, or, more commonly, a CGE (computable general equilibrium) model. Diao and Roe (2000) use a CGE model of Morocco to determine the impact of trade reform on the shadow value of water in agriculture. The long-term change in shadow prices (the shadow prices themselves are not reported) range from –22% for wheat to +25% for fruits and vegetables.

Box 10.6: Linear programming approach to valuing irrigation water

Shadow price of water in selected sectors in Morocco, 1995

Bouhia (2001) develops a linear programming model for Morocco to assist in water management and water policy design. The economic part of the model is based on the Moroccan Social Accounting Matrix, expanded to include 13 irrigated crops and one rainfed agricultural sector. Four types of water are distinguished: water inputs from a network, groundwater, precipitation, and return flows.

	dirham/m^3
Sugar cane	2.364
Other cereals	3.013
Sugar beat	3.042
Fodder	3.047
Barley	3.291
Maize	3.426
Citrus	3.692
Legumes	5.603
Sunflower	6.219
Wheat	7.498
Vegetables	12.718
Livestock	25.019
Industrial crops	48.846
Industry and services	92.094

Source: Adapted from (Bouhia, 2001, Table 4-29).

Hedonic pricing

10.50. Hedonic pricing is based on the idea that the purchase of land represents the purchase of a bundle of attributes that cannot be sold separately, including water services. For agriculture, the bundle includes such things as soil quality, existing farm infrastructure, and water resources. Regression analysis of land sales (or reasonably assessed values of land) on the attributes of the land, both positive and negative, reveals the amount that water services contributes to the total value of land. The marginal value of an attribute of land, such as water quantity or quality, is obtained by differentiating the hedonic value function with respect to that attribute. This technique has been most widely used to estimate recreation values of water and to a lesser extent to estimate the value of water for agricultural. Box 10.7 provides an interesting example of hedonic pricing that combines both water quantity and water quality in Cyprus. Many similar studies have been carried out throughout the world where water quality is an issue.

Markets for water and tradable water rights

10.51. A few water-scarce countries have instituted markets for trading water or water rights either on a temporary or permanent basis, notably Australia, Chile, Spain, and parts of the United States. (See Garrido, 2003 for an overview of these markets and how they have functioned.) Trading in a competitive market could establish a price that represents the marginal value of water. In the countries that have established water markets, market trades have generally increased the efficiency of water use by providing strong incentives for allocating water to higher-value uses and for water conservation.

However, evidence suggests that the transactions prices do not represent the marginal value because the conditions necessary for a competitive market are not present (Young, 1996).

Box 10.7: Hedonic valuation of irrigation water quantity and quality

> Koundouri and Pashardes (2002) use hedonic pricing to estimate the value of water for irrigation use in Cyprus where saltwater intrusion is occurring in coastal areas. The authors must address an additional challenge to hedonic modelling: land can be used for either agriculture or tourism. Land that is closer to the sea is less productive for agriculture due to saltwater intrusion, but increases in value for tourism. The authors regress land values (from a 1999 survey of 282 land owners) on a number of variables reflecting existing infrastructure, location, quality of land and the salinity of the underlying groundwater, which was represented by proximity to the coast. The sample selection included only agricultural land users, excluding land used for tourism so that the value of land would not be affected by tourism land demand. The farmers' marginal WTP for avoiding saline groundwater was £10.7 per hectare.

10.52. A competitive market requires, among other things, a large number of buyers and sellers and frequent transactions. In Chile, water trades accounted for only 1% of total abstractions by the mid-1990s and prices ranged from US$250 to $4,500 a share (4,250 m^3) (Brehm and Quiroz, 1995; Hearne and Easter, 1995). Development of water markets was greatest in areas with effective water-use associations, well-defined property rights and good irrigation infrastructure (large reservoirs, adjustable gates with flow meters); in areas without these characteristics, high transactions costs limited water market development. In a few countries tradable water rights may provide a basis for water valuation in the future, but this technique has not been applied yet.

2. Consumer and municipal water use

10.53. Municipal water use includes a number of distinct groups: households, government, and sometimes commercial and industrial use. Most studies focus on household demand when it can be readily separated from other users. The two most common approaches to valuing domestic use of water, above a basic survival amount, involve *estimation of the demand curve* either from actual sales of water (revealed preference), or using *contingent valuation approach* (stated preference). Both approaches estimate the average value of water.

Demand functions estimated from water sales

10.54. This approach uses econometric analysis to measure total economic value (consumer surplus), which is then used to calculate average value, based on an estimate of what the average consumer would pay. The conditions under which a demand curve can be derived are rather stringent and are often not obtained, even in developed countries. (See Walker et al. (2000) for more detailed discussion). Water use must be metered to provide accurate data about volume consumed and water charges must be based on volume consumed, because when consumers pay a lump sum, the marginal cost is zero and their consumption does not reveal marginal value. Demand curves cannot be estimated where water is rationed or where a single marginal price is charged to all consumers. Where a single price is charge, a less reliable alternative sometimes used is to trace the real tariff over time and changes in water consumed. Walker et al. also point out that the water demand function of households with piped water differs substantially from those relying on unpiped water supply, a common situation in most developing countries. An accurate estimate of consumer demand must include both types of households. Appropriate sales data will provide two or more points to which a demand curve is fitted, usually assuming a semi-log demand function. The value of water is highly sensitive to the functional form assumed for the demand curve.

Contingent Valuation Method

10.55. The contingent valuation methodology (CVM) differs from all the previous methods in that it does not rely on market data, but asks individuals about the value they place on something by asking them how much they would be willing to pay for it. This is particularly useful for eliciting the value of environmental goods and services for which there are no market prices, such as recreation, water quality, and aquatic biodiversity. CVM was first used several decades ago, but became a much more popular technique after 1993 when standardized guidelines for CVM applications were set out by a prestigious panel of economists following a disastrous oil spill off the Alaskan coast (NOAA, 1993). The technique has some application to consumer water demand, in which consumers are asked how much they would be willing to pay for water. CVM typically measures total economic value from which an average value can be estimated.

10.56. Box 10.8 discusses a case where consumer demand curves are derived using both methods, CVM and estimated demand functions. Although the results are similar in some cases, they are quite different in others. The authors consider the demand function approach more reliable because it is based on actual market behaviour. They conclude that for estimating consumer water demand CVM is not a good substitute for revealed preference (Walker et al., 2000). A comparison of values derived from CVM and revealed preference studies for a wider range of environmental services show a similar disparity (Hanley and Spash, 1993).

3. Valuing the environmental services of water for waste assimilation

10.57. The SEEA identifies two principles for the direct valuation of environmental degradation: cost-based and damage-based. The former is based on the cost of preventing environmental degradation and has been referred to in the past as the ‘maintenance cost’ approach. The latter is based on the benefits of averting damage incurred from environmental degradation.

Benefits from Averting Damage from Water Degradation

10.58. This approach measures the value of water’s waste assimilation services in terms of the benefits from averting damages resulting from loss of this service. Damages include human illness and premature death, increased in-plant treatment of process water required by industry, increased corrosion or other damage to structures and equipment, siltation of reservoirs, or any other loss of productivity attributable to changes in water quality.

Box 10.8: Two approaches to measure the value of domestic water in Central America

Walker et al. (2000) used two different methods to estimate the value of water, revealed preference and contingent valuation. The revealed preference approach derived a demand curve based on surveys of household water consumption and expenditure from 1995-1998 in 7 cities in Central America. The survey distinguished households with piped and unpiped water. The price paid for a cubic meter of water is different for households with piped and unpiped water, and a demand curve could be derived from the 2 points. For households relying on unpiped water, water expenditure included both cash payments for water plus the opportunity cost of the time required to haul the water, so there were further variations in the cost per cubic meter of water depending on the distance to water source.

The CV survey asked households how much they would be willing to pay for improved service with monthly consumption of 30m^3. Each household was given only one price to respond to and could answer yes or no. Different households were given different prices and the distribution of yes and no answers for the different prices was used to derive a demand curve. In 4 cities, the revealed preference and CVM estimates were fairly similar, but in the other 3 cities, the two approaches differed by 100%. The authors conclude that the variation is too great to use CVM when good revealed preference data are available.

	Price at which consumers would demand 30 m^3 (US$/m^3)	
	CVM	**Revealed preference**
Sand Pedro Sula, Honduras	0.13	0.49
Intermediate cities, Honduras	0.10	0.14
Managua, Nicaragua	0.16	0.23
Sonsonate, El Salvador	0.32	0.16
Santa Ana, El Salvador	0.21	0.19
San Miguel, El Salvador	0.49	0.17
Panama and Colon, Panama	0.51	0.40

Note: figures represent average value

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

10.59. The first task in providing this value is to identify standards for the waste assimilation capacity of a water body. Water standards have been established by international organizations like WHO as well as by national agencies in terms of concentrations of substances. These concentrations are often grouped according to the maximum level acceptable for a particular use, with human consumption requiring the highest standard. Recreational water usually does not have to meet such a high standard. Some industrial processes require extremely clean water while others may not, e.g., water used for cooling, although polluted water may damage or corrode equipment. Water for irrigation also does not have to meet the highest standards.

10.60. The next step is to determine the extent of damage caused by a change in water quality. For human health damage, a 'dose-response' function is used, which relates a change in a specific aspect of water quality to the incidence of human illness and death. Engineering studies provide similar concentration-response functions for damage to land, buildings, structures and equipment, and the environment. These damages must then be valued.

10.61. The value of clean drinking water can be measured, for example, as the value of waterborne disease and premature deaths averted. The value of health risks averted usually includes the cost of medical treatment and value of lost work time, but not the value of social disruption, loss of educational opportunities for children, personal suffering and loss of leisure time. Damage to land and property includes, for example, the cost of declining agricultural productivity, the loss in hydroelectric power resulting from accelerated siltation of a dam, or the cost of accelerated corrosion of structures from increased salinity.

10.62. Measuring and valuing damage can be particularly challenging: damages may not occur during the same accounting period as the change in water quality, there may be great uncertainty about the degree of damage caused by a change in water quality, or damages may occur further downstream, even in another country. Even when damages can be measured, it is not easy to value them, particularly environmental damages. In most instances, total damages are estimated and an average damage cost per unit of pollutant is estimated. A great deal of effort has gone into estimating marginal damage functions, although these estimates are more widely available for air pollution than for water pollution.

Costs of Averting Damage from Water Degradation

10.63. Like the damage-based valuation approach, the maintenance-cost approach is also based on environmental degradation, but rather than looking at the cost of damages caused, it is based on the cost of actions to prevent damage. It is based on the premise that, for actions by individuals (such as purchasing bottled water), an individual's perception of the cost imposed by adverse environment quality is at least as great as the individual's expenditure on goods or activities to avoid the damage. Actions taken by society, such as regulation and collective treatment of waste water, represent a social perception of relative costs and benefits. As in the damage-based approach, information needs include: the assimilative capacity of water bodies, the emission of pollutants by specific activities (including consumption), the relationship between concentrations of pollutants and environmental function, and the relationship between levels of activities and emission of pollutants. Since these relationships are likely to be non-linear, they pose a significant challenge for the policymaker.

10.64. The cost-based approach has three variants: structural adjustment costs, abatement cost and restoration cost. *Structural adjustment costs* are those costs incurred to restructure the economy (production and/or consumption patterns) in order to reduce water pollution or other forms of environmental degradation to a given standard. It addresses both production activities and consumption. The level of specific activities may be reduced or entirely eliminated. Measuring the cost of structural change often requires complex economy-wide modelling.

10.65. The *abatement cost approach* measures the cost of introducing technologies to prevent water pollution. Technologies include both end-of-pipe (e.g., filters that remove pollutants from the wastewater stream) or change in process (e.g., substitution of less polluting materials) solutions. At the consumer level, it includes expenditures for substitute goods, such as buying bottled water instead of using tap water, or the cost of activities like boiling water for drinking. *Restoration cost approach* measure the costs of restoring a damaged water body to an acceptable state. The abatement cost approach is the most widely used of the cost-based approaches.

10.66. The cost of preventing emission of pollutants was used to value loss of water quality in some of the early water degradation accounts in developing countries like the Philippines (NSCB, 1998) and Korea (KEI, 1998). Pollution abatement costs were estimated using benefits transfer, which is a process of adjusting parameters, cost functions, damage functions, etc. developed at one time in one setting for use in another context. In principle, marginal abatement curves should be applied to estimate the marginal and total costs of pollution reduction in each plant. In practice, an average figure per unit of pollutant was used because information about specific plants was not available. The advantage of this valuation approach is that, at the time, it was easier to obtain estimates of the costs of technologies used to reduce pollution emissions than to estimate the benefits from reduced pollution. There is a growing body of literature on the health and industrial production impacts of pollution, which now makes it easier to estimate the damages averted from changes in water quality, although many of these damages are average rather than marginal values.

10.67. The benefit from damages averted is a widely used approach in the cost-benefit literature and the preferred technique for the SEEA. Often, the results are reported as the total benefit from costs averted or average cost per statistical life saved (or illness prevented). Marginal costs, which relate potential damages averted to marginal changes in water quality (measured as the concentration of substances), are not often reported. One study that does use marginal damage cost functions is *Value of Returns to Land and Water and Costs of Degradation* by CSIRO, a report to the Australian National Land and Water Resources Audit. Part of the results is shown in Box 10.9.

Box 10.9: Marginal cost of water degradation

In a report to the Australian National Land and Water Resources Audit, Hajkowicz and Young (2002) estimated the value of water in different uses, and the costs of water degradation nationwide. The latter includes water degradation due to salinity, erosion, sedimentation, and turbidity. They estimated marginal damage costs using cost functions derived from engineering studies. With salinity, the major problem is corrosion of equipment. The marginal damages from a unit increase in salinity are shown below. Households use the most water (85%) and suffer the highest costs from a marginal increase in salinity, mainly from damage to plumbing systems, hot water heaters and rain tanks. For industry, the major damages are to cooling towers and boiler water feeders.

Marginal damage costs from a unit increase in salinity for urban and industrial water users, Murray River (1999 Australian $ per unit of EC*)

	Marginal cost of salinity	Share of total water use
Households	111,270	85%
Industrial	54,780	12%
Commercial	7,400	4%

*EC = electrical conductivity units, a measurement of water salinity roughly equivalent to 1.6 x Total Dissolved Solids in water (mg/L).

Source: Adapted from (Hajkowicz and Young, 2002, p. 29).

REFERENCES

Acharya, G. and E. Barbier. 2000. Valuing groundwater recharge through agricultural production in the Hadejia -Nguru wetlands in northern Nigeria. *Agricultural Economics* 22:247-259.

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

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

Bateman, I. and K. Willis (eds). 1999. *Valuing Environmental Preferences: Theory and Practice of Contingent Valuation Method in the US, EU and Developing Countries*. Oxford University Press: Oxford.

Bockstael, N., M. Freeman, R. Kopp, P. Portney, V.K. Smith.. 2000. On measuring economic values for nature. *Environmental Science and Technology 34*, 1384-1389.

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

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

Carson, R.T. 2000. Contingent valuation: a user's guide. *Environmental Science and Technology 34*, 1413-1418.

Dasgupta, P. 2001. *Human Well-Being and the Natural Environment*. Cambridge University Press: Cambridge.

Davis, J, A. Kang, and J. Vincent. 2001. How important is improved to water infrastructure for microenterprises? Evidence from Uganda. *World Development* 29(10) 1753-1767

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

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

Eurostat. 2002. *Accounts for Recreational and Environmental Functions of Forests*. Luembourg: Office of the European Communities

__________. 2001. *Environmental Accounts for Forests: Non-ESA/SNA Functions*. Luembourg: Office of the European Communities

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

Freeman, M. 1993. *The Measurement of Environmental and Resource Values*. Resources for the Future: Washington, D.C.

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

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

Gleick, P. ed. 1993. *Water in Crisis: A Guide to the World's Freshwater Resources*. Oford University Press: NewYork.

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

Hajkovich, S. and M. Young (eds.). 2002. *Value of Returns to Land and Water and Costs of Degradation*. 2 volumes. Report to National Land and Water Resources Audit. CSIRO Land and Water: Canberra.

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

Hassan, R; Olbrich, B; and Crafford, J. 2001. Comparative analysis of the economic efficiency of water use in the Crocodile River Catchment. Second Draft Report to the Water Research Commission. WRC: Pretoria, South Africa.

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

Howe, C. and M. Smith. 1994. The value of water supply reliability in urban water systems. *Journal of Environmental Economic and Management* 26:19-30.

Hrubovcak, J. M. LeBlanc, and B. K. Eakin. 2000. Agriculture, natural resources and environmental accounting. *Environment and Natural Resource Economics*. 17:145-162.

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

Khoundouri, P. and P. Pashardes. 2002. Hedonic price analysis and selectivity bias: water salinity and demand for land. In P. Pashardes (ed.) *Current Issues in the Economics of Water Resource Management.* Kluwer Academic Publishers: Dordrecht, the Netherlands.

Kopp, R., A. Krupnick, and M. Toman. 1997. Cost-benefit analysis and regulatory reform: an assessment of the science and the art. RFF Discussion Paper 97-19. Resources for the Future: Washington, D.C.

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

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

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

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

Legget, C. and N. Bockstael. 2000. Evidence of the effects of water quality on residential land prices. *Journal of Environmental Economics and Management.* 39: 121-144.

Lovei, L. and D. Whittington. 1991. Rent seeking in water supply. World Bank Discussion Paper. World Bank: Washington, D.C.

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

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

OECD. 2003. *Sustainable Management of Water in Agriculture*. OECD: Paris.

_______________. 1999. *The Price of Water: Trends in OECD Countries*. OECD: Paris.

Olbrich, B.W. and R. Hassan. 1999. A comparison of the economic efficiency of water use of plantations, irrigated sugarcane and sub-tropical fruits. Water Research Commission Report No. 666/1/99. WRC: Pretoria, South Africa.

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

Palmquist, R. and V.K. Smith. 2001. The use of hedonic property value techniques for policy and litigation. *International Yearbook of Environmental and Resource Economics 2002/2003*. Edward Elgar: Cheltenham, UK.

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

Rogers, P., R. Bhatia, and A. Huber. 1998. Water as a social and economic good: how to put the principle into practice. Global Water Partnership TAC Background Paper No. 2. GWP: Stockholm.

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

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

Walker, I., F. Ordoñez, P. Serrano, and J. Halpern.2000. Pricing, subsidies and the poor: demand for improved water services in Central America. World Bank: Washington, D.C.

Wang, H. and S. Lall. 1999. Valuing water for Chinese industries: a marginal productivity approach. Paper for the World Bank Development Research Group. World Bank: Washington, D.C.

Young, R. 1996. Measuring economic benefits for water investments and policy. World Bank Technical Paper No. 338. World Bank: Washington, D.C.

Young, R.A. and R.H. Haveman. 1985. Economics of water resources: a survey, in A. Kneese et al. (eds) *Handbook of Natural Resource and Energy Economics*, Kluwer Academic Publishers: Dordrecht, the Netherlands