GLOBAL COMMISSION on the ECONOMICS OF WATER

TECHNICAL REPORT

Water Accounts and Water Accounting

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Executive summary

A range of different information is needed for water management and governance, but this is often lacking or of poor quality. This is due to several factors including that: (1) the socio-economic and environmental data related to water are held by a range of agencies; (2) various professions have developed their own theories, practices and terminology, and (3) resources available for data collection, curation and integration are limited. These factors are compounded by the multiple values of water and a lack of consensus on the way, or even if, these values can be represented by money. Water accounting can help overcome these problems.

Water accounts are a framework for assembling multiple data sources into a coherent information system. There are many types of water accounts covering the hydrological cycle, water quality, the water supply and sewerage industries, water fees and charges, defensive and restoration expenditures, and financing as well as for water-related ecosystem services, like water purification, water regulation and flood control. Through the consistent application of concepts, definitions, classifications and structures, water accounts can be linked to other types of environmental information and in particular ecosystem accounts and the System of National Accounts (SNA). The SNA is used by every country in the world for economic management and policy. Water accounting can provide the integrated information that can support water governance and management, just like the national accounts support economic management and policy.

Water accounting has evolved over more than three decades, and this experience is brought together in the System of Environmental-Economic Accounting (SEEA). Nearly 100 countries use or are developing this system, and 73 countries and regions have produced water accounts, using a range of data sources and methods, and with production growing steadily over time. The production and use of water accounting is global and is undertaken in all types of countries (e.g. low- to high-income, small to large, and at various levels of water stress).

This review of water accounts provides examples of their production and actual or potential use in water governance and management. The review also assesses the strengths and weaknesses of water accounting, enabling best practices to be identified. Best practice includes: a collaborative development process recognising the diversity of stakeholders and stakeholder values to ensure the relevance of the accounts; comprehensive coverage of water resources (surface, ground and soil water), industry and sectors (e.g. agriculture, mining, energy, water supply and sewerage industries plus households); development of multiple account types (stocks and flows, physical and monetary measurement units); regular, frequent and timely production; clear statements of data quality (including limitation); and using a continuous improvement process.

With water accounts, decision makers in water governance and management will have a rich information source that can be used to balance the competing demands for water and can ensure that water use is sustainable and equitable. In this, water accounts can feed into decision-making processes and be used to identify problems and to design, implement, monitor and adapt solutions.

1 Introduction

This report describes water accounts and water accounting with particular focus on the System of Environmental-Economic Accounting (SEEA).[1] It explains the key concepts of water accounting, the structure of accounts and how water accounts can be used for water management and governance, and for policymaking. Based on an assessment of countries' experiences to date, the report outlines the strengths, weaknesses, opportunities and challenges of water accounting and identifies the factors of success and the steps towards best practice.

The report aims to increase the awareness and understanding of water accounting in agencies and professionals involved in water economics, governance and management. A better appreciation of the information within water accounts, how it relates to other environmental and economic information, and how it can and has been used, should lead to a greater uptake and use of water accounting.

While the uptake of water accounting has been growing, its use in decision-making is lagging. This may be attributed to the relatively small water accounting community, the complexity of the water accounts, the existence of several water accounting frameworks, the many types of water accounts, differences in terminology between hydrology, other environmental sciences, economics and accounting, and few examples of real-life applications. All of this creates confusion, and decision makers are inclined to stick with traditional sources of water information for water management and governance.

This report is one of several technical reports that will be inputs to the Midterm Comprehensive Review of the Implementation of the Objectives of the International Decade for Action, to be presented at the World Water Day Conference "Water for Sustainable Development" 2018–2028 (UN Water Conference). The UN Water Conference will be co-hosted by the Netherlands and Tajikistan, and held 22–24 March 2023 in New York, United States of America (US).[2] The conference aims to provide:

> " . . . a greater focus on the sustainable development and integrated management of water resources for the achievement of social, economic and environmental objectives, the implementation and promotion of related programmes and projects, as well as on the furtherance of cooperation and partnerships at all levels, in order to help to achieve the internationally agreed water-related goals and targets . . ." (from UN GA Resolution 73/226).[3]

1.1 Water accounting frameworks

Water accounting is an information framework that systematically integrates hydrological information from a range of data sources with other information on the economy and

[1] https://seea.un.org

[2] https://sdgs.un.org/conferences/water2023

[3] https://documents-dds-ny.un.org/doc/UNDOC/GEN/N18/460/07/PDF/N1846007.pdf?OpenElement

environment. Water accounting is part of a broader accounting view that encompasses the relationship between people, the economy and the environment. Such accounting is known by several names, including natural capital accounting, ecosystem accounting, environmental-economic accounting and, in the corporate sphere, sustainability or environment and social governance (ESG) reporting.

There are several water accounting frameworks. The focus on the SEEA is because it has been adopted over time via United Nations (UN) processes as an international statistical standard. The SEEA has several components, including the:

- SEEA Central Framework (UN et al., 2014)
- SEEA Ecosystem Accounting (UN et al., 2021)
- SEEA Water (UN, 2012a)

The SEEA is an extension of the System of National Accounts (SNA) (EC et al., 2009). The SNA is used by virtually every country in the world for economic management and policy, and its best-known indicator is Gross Domestic Product (GDP). The main features of the SNA and SEEA are described in more detail in Chapter 2.

Other water accounting frameworks are in use (Godfrey and Chalmers, 2012), for example Water Accounting Plus[4] (WA+) and are referenced within the document. In general, these frameworks are aligned to different parts of the SEEA Water and use similar data sources and methods (Vardon et al., 2012). Corporate water accounting is also used by businesses outside of the water supply industry to inform organisational decisions, identifying, for example, their dependence on water (Christ and Burritt, 2018).

The distinguishing features of SEEA Water are that:

- it sets water within a broader set of environmental and ecosystem accounts which integrates with the SNA (Chapter 2);
- water valuation is in accordance with agreed concepts and methods that are coherent with the SNA (Chapter 3);
- it has been internationally agreed and standardised via UN processes (Chapter 4); and
- it is the most used water accounting framework in the world (Chapter 5).

There are also other water information systems that have much in common with the SEEA, or other water accounting systems with some of these features, but none have all of these features.

Whichever water accounting or water information framework is used, the compilation of data relies on the expertise, data sources and methods from a range of professions and agencies. This includes hydrologists, economists, statisticians and accountants, and institutions of government for water management, hydrology, economics, statistics, central planning, agriculture and energy (especially where hydroelectricity is imported). Non-government research institutions, like universities, also have a role to play (Bagstad et al., 2021).

[4]https://wateraccounting.un-ihe.org/

Water accounting, through the consistent application of concepts and the related definitions and classifications, provides a fully integrated information resource. This supports transparency about the connections between water, the broader environment and the economy. This, in turn, allows for comparisons between different industries and natural resources, over time and between places. Accounts reveal how changes in, for example, water availability in one part of the economy or environment, may affect other parts of the economy or environment. Such information is needed for effective water governance and management. SEEA also enables comparisons between countries to be made.

1.2 Aims and structure of report

The aim of this report is to increase awareness and understanding of water accounting and how it may be implemented and used in decision-making for water economics, water management and governance. This report also provides the impetus for the greater uptake and use of water accounting, and will encourage the collection of the basic environmental and economic data that underpin the accounts.

To increase awareness and understanding of water accounting, this report:

- outlines the main features of water accounting;
- reviews existing water accounts to determine current practices (e.g. institutional arrangements, data sources and methods used for account production);
- distils lessons from current practices, and examines the strengths and weaknesses of water accounts for use in water-related decision-making;
- investigates the opportunities and challenges for wider development and use of water accounts for water economics and governance; and
- identifies the steps towards best practice water accounting.

The report has nine chapters and five annexes:

1. Introduction
2. National and environmental accounting
3. Water valuation in SNA
4. SEEA-based water accounting
5. Water accounting review
6. Country examples
7. Realising the potential of water accounting
8. Lessons and best practice
9. References

Annex 1. Glossary of water accounting

Annex 2. List of water accounting tables

Annex 3. Full water supply and use account

Annex 4. Database metadata

Annex 5. List of countries and regions producing water accounts

Each chapter has multiple sections.

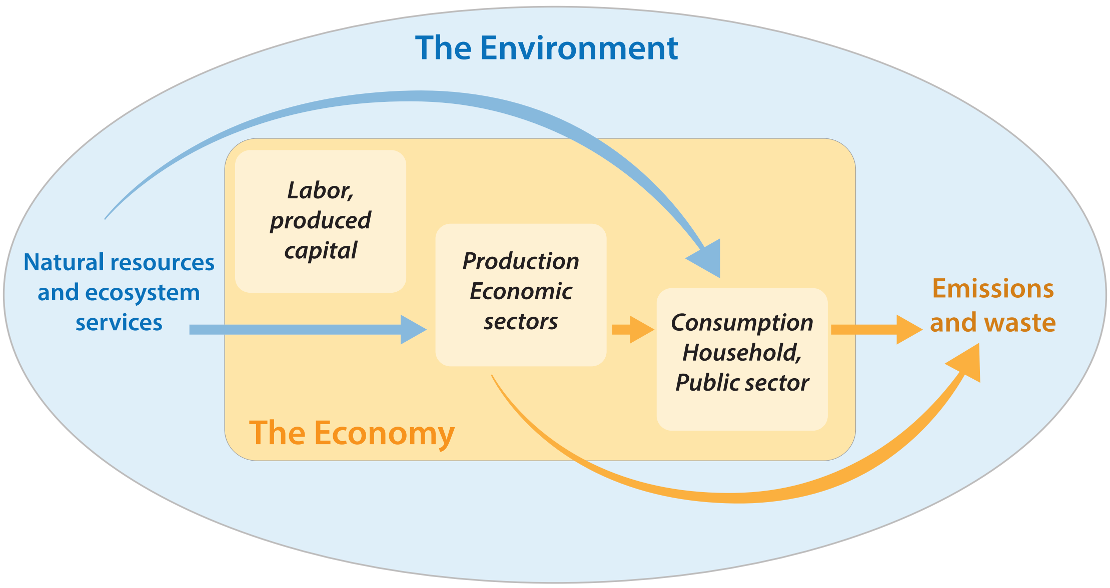
2 National economic and environmental accounting

2.1 The System of National Accounts (SNA) and SEEA

Water accounts are one group of environmental-economic accounts that sit within the SEEA, which in turns links to the SNA (EC et al., 2009). The SNA is the framework used in macro-economic statistics throughout the world for more than 50 years, and from which the accounting identity Gross Domestic Product (GDP) is derived (Coyle, 2015).

In general, the SEEA shows the interactions of the economy with the environment. Figure 2.1 shows the extraction of natural resources and use of ecosystem services by the economy, and the returns of emissions and waste. The economy is as defined by the SNA.

Figure 2.1 The environmental and economic context for accounting



Source: After World Bank (2021)

2.2 Industries, sectors and products in the SNA

Within the economy, as defined by the SNA, a range of activities take place – the production and consumption of various goods and services, and capital formation. The economy is composed of economic units which are classified to industries (e.g. agriculture, mining, water supply, manufacturing, education, health, etc.), using the International Standard Industry Classification (ISIC),[5] and sectors (e.g. private, public and households[6]).

[5]https://unstats.un.org/unsd/publication/seriesm/seriesm_4rev4e.pdf

[6]The official sector classification used in the SNA is financial corporations, non-financial corporations, government, not-for-profit institutions supporting households, and households.

The classification to industry is based on the production of goods and services which are classified according to the Central Product Classification (CPC).[7] For example, if rice is produced by an economic unit (e.g. a farm) then it is classified to the agricultural industry and, assuming it is privately owned, the private sector. The rice may then be consumed by another economic unit, which could be a household (a sector), or be used in the production process of another unit. For example, the rice may be sold to a restaurant, which is an economic unit classified to the food and beverage service industry, and the meal produced by the restaurant is consumed by a household (a sector). In this, there is a chain of supply and use, with goods and services, production, consumption and accumulation, and the industries and sectors are defined, and transactions recorded, using standardised definitions and classifications.

Key industries, products and sectors for water accounting are:

- Water collection, treatment and supply (ISIC division 36), the main supplier of the product "Natural Water" (CPC 1800), often shortened to the water supply industry;
- Wastewater treatment (ISIC division 37), often referred to as the sewerage industry
- Agriculture (ISIC division 01), usually the biggest consumer[8] (but not user) of water within the economy;
- Energy (ISIC division 35), a key user of the product "Natural Water" (CPC 1800), both for hydropower as well as for cooling in thermal power plants. Where it occurs, hydropower is usually the biggest user (but not consumer) of water;
- Households (a sector), key users of the product "Natural Water" (CPC 1800) supplied by the water supply industry (ISIC division 36).

2.3 SEEA goes beyond SNA

The SEEA extends beyond the SNA to cover natural resources and the ecosystem services used in the economy, as well as the wastes, emissions and other return flows to the environment from the economy. For example, the SEEA records flows of water, timber and minerals (indeed all natural resources), and ecosystem services (e.g. climate regulation, water purification, cultural services), into the economy, and the return of CO_2 emissions and water from the economy to the environment. Expenditure on environmental protection and resource management is also recorded.

While the scope of the SEEA is large, no country implements the entire system. Thus, while there should be comprehensive coverage, in practice, most countries compile only a selection of the environmental accounts linked to the SNA.

The strength of the SEEA stems from its consistent application of definitions and classifications for stocks, flows and economic activity across different types of environmental assets and different environmental dimensions (e.g. across water, ecosystems, CO_2 emissions and energy). In this way, integrated information on the economy and environment is provided and enables the analysis of different scenarios, for example, how the development of the economy affects the environment, or how the degradation of the environment will affect

[7]https://unstats.un.org/unsd/classifications/unsdclassifications/cpcv21.pdf

[8]In the SEAA context, water consumption is all the water used by industries, which may be directly extracted from the environment or supplied by the water supply industry, less all of that leaves the industry, which may be discharged to sewerage or directly to the environment.

the economy. This in turn enables the development and application of better policies that consider the links between the environment and the economy.

While the SNA defines the economy and designates the economic units and their classification, the SEEA defines and classifies the environment. Key classifications in the SEEA cover:

- Environmental assets
- Natural resource flows
- Ecosystem assets
- Ecosystem service flows

Environmental assets and natural resource flows are defined and classified in the SEEA-Central Framework, while ecosystem assets and ecosystem service flows are defined in the SEEA-Ecosystem Accounting.

2.4 Stocks and flows

Two key concepts essential to the SEEA are stocks and flows, which can be measured in physical (e.g. m^3, litres, acre-feet) or monetary (e.g. $, €, ¥) units.

Stocks are the quantity of a particular product or natural resource at a point in time. Assets are usually associated with stocks that have economic values. In the SNA, natural resource stocks are recorded in balance sheets in monetary terms. In the SEEA stocks are recorded in the asset accounts in physical terms (e.g. the volume of minerals in the ground) and monetary terms. The stocks at the beginning of a period are called the opening stocks, and those at the end of the period (start time plus one year) are called closing stocks. The difference between opening and closing stocks is the result of flows (additions and subtractions) to the stocks. Stocks and changes in stocks are recorded in asset accounts. These accounts are described for water in Chapter 4.

Flows are the quantity that is added or subtracted from a stock during a specific period (e.g. a year). Flows are also recorded in supply and use tables. These show the supply of a particular natural resource to industries, for example, timber from a natural forest to the forestry industry (ISIC 02). The flows are related to particular stocks and are also shown in the asset accounts. So, in the asset account, the removal of the timber would be shown as a reduction to the stock, but the reduction is not attributed to an industry. An example of integrated accounts for water assets and supply and use is provided in Chapter 4.

2.5 Accounting and First Nations

How the values of First Nations can be expressed in environmental accounts, and how First Nations might be able to use environmental accounting, are two questions that have received little attention in the SEEA (Normyle et al., 2022a). Water plays a significant role in the culture of First Nations, with water the second most common component addressed in studies of Indigenous people (Manero et al., 2022). To date, no water accounts have been developed with First Nations, nor for the use of water accounts by First Nations and their representative organisations. Nevertheless, SEEA-based accounts have been developed for specific areas (Normyle et al., 2022b) and the Indigenous Estate in Australia (Barnett et al., 2022).

3 Water valuation in SNA and SEEA

3.1 Introduction

The valuation of the environment, both the stocks and flows of natural resources like water, and its relation to SNA and SEEA, are described by Obst et al. (2016). This chapter provides an overview of the different conceptions of value, namely exchange and welfare values, how exchange values are different from market prices, and how values apply to different water stocks and flows recorded in the water accounts (which are described in Chapter 4). Chapter 12 of SEEA Ecosystem Accounting provides a detailed description of how exchange and welfare values are related.

In the SNA, "*market prices are the amounts of money that willing purchasers pay to acquire goods, services or assets from willing sellers*" (EC et al., 2009, para 3.119). In many cases, there is not a market transaction, but a market price is estimated. For example, in the case of public education, the users of the education service do not directly pay for that service, but the value of these services is estimated via the cost of production, and a transaction between households and government is imputed. Cost of production is based on the value of the capital and goods and services used in its production, which are, in the case of education, the school buildings, pay for teachers and administrative staff, cost of energy (e.g. for lighting and temperature control), and other goods (e.g. books).

National accounts value water in the same way that they value all other assets and products using the concept of exchange values and the SNA – "*Exchange values are the values at which goods, services, labour or assets are in fact exchanged or else could be exchanged for cash"* (2008 SNA, para. 3.118). For most entries in the SNA, exchange values are measured using data from observed transactions involving market prices. The 2008 SNA notes there are cases where observed exchange values do not represent market prices, for example in situations of transfer and concessional pricing (2008 SNA, para 3.131-3.134). This is usually the case for water.

This situation arises because of several characteristics (After: UN, 2012a; Easter et al., 1997; Young, 1996; Grafton et al., 2020):

- Water is a heavily regulated product for which the price charged (if any) often bears little relation to its economic value or even the cost of supply. This situation is sometimes severe in water-scarce developing countries where water may be supplied to some users at no charge. Administered prices occur, in part, because the natural characteristics of water inhibit the emergence of competitive markets that establish economic value;
- Water supply often has the characteristics of a natural monopoly because water storage and distribution are subject to economies of scale;
- Where and when water is scarce, water is rationed, or there are restrictions on particular types of uses (e.g. parks and gardens are not permitted to use water);
-

- Property rights, essential for competitive markets, are often absent and not always easy to define when the uses of water exhibit characteristics of a public good (e.g. flood mitigation), a collective good (e.g. 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 those in the local area;
- Large amounts of water are abstracted for own use by industries other than those under ISIC Division 36 (water collection, treatment and supply), such as agriculture, mining and energy. Abstraction for own use is not recorded as an intermediate input of water; hence, the use of water is underestimated and the value of water's contribution, for example, to agriculture, is not explicit but accrues to the operating surplus of agriculture.

Observed exchange values of water, and in particular the product "Natural Water" (CPC 1800),[9] are not a representation of "true" exchange values, and hence are an inadequate indicator of water's economic value. As such, alternative valuation methods are needed, if the objective is to maximise the economic value obtained from water use from investments in the water sector and to assess issues of equity and environmental sustainability (GWP 2000).

The valuation of water using exchange values is useful for many policy areas (UN et al., 2014), for example, to assess efficiency in the development and allocation of water resources. Efficient and equitable allocation of water requires considering the value of water used by competing end-users in the current generation, the current value of water supply and sanitation assets, the allocation of resources and the degree to which wastes discharged into water are treated, and other activities that affect water quality (e.g. dissolved nutrients runoff from agricultural land). Such valuation can also be useful in setting water pricing policy (e.g. where water is supplied at cost of production) and in the design of economic instruments to achieve better use of water resources. Economic instruments for water management include property rights, tradable water markets, taxes on water depletion and pollution, and subsidies for water demand management.

Accounts for water-related environmental protection and resource management expenditure can also be used to judge the efficiency of expenditure on water quality maintenance and catchment restoration activity (Lange, 1997).

3.2 Water valuation methods and the SEEA

The World Water Development Report notes that water "valuation is only of use if the decision-making process in question is based on a fair assessment of values", and that "valuation of water infrastructure is about good governance" (UNESCO, 2021:3).

This report recognises the multiple values of water and the difficulties of water valuation. The report also identifies fours aspects of water value – hydrologic infrastructure (e.g. dams, water and sewerage pipes), economic uses (e.g. drinking water, cooling water, irrigation water, manufacture of food and beverages, etc.), cultural uses (e.g. significant water bodies or water-dependent places), and value to the environment (this is the extent and condition of ecosystems and the ecoservices they provide).

[9] The Central Product Classification classifies and codes all production in the economy. See https://unstats.un.org/unsd/classifications/Econ/cpc.

The concept of exchange values can be applied to the four aspects, and they are recognised in different parts of the SNA and SEEA. The value of hydrological infrastructure and the value of economic uses are in the scope of the SNA, but while these values are included, they are hidden and cannot directly be derived from the national accounts. The SEEA Water provides the methodology to identify separately and report these values. The cultural values and values to the environment of water are within the scope of SEEA Ecosystem Accounting and can be measured using methods consistent with exchange values (UN, 2022). Non-monetary metrics can also be used to assess change in value, for example and decline in the physical condition of ecosystems (e.g. declines in water quality) can be interpreted as loss of environment value.

Values can be determined for water flows or stocks (assets). The asset value of water is often calculated via the net present value approach, which is based on the depreciated values of future flows. Water assets may also be valued via the licencing and trade of water rights.

Within the SNA and SEEA, the valuation of water flows included in the water accounting is usually related to:

- Water as an intermediate input to production (e.g. to agriculture)
- Water as a final consumer good (e.g. use by households)
- Water that underpins financial assets (e.g. tradable water rights)
- Water-related ecosystem services (e.g. water purification and water regulation) and the 'sink' function of the environment (e.g. for wastewater).

These flows of water can be related to economic production and consumption within the economy as defined by the SNA, or those flows of benefits to people but outside the SNA definition of the economy.[10] Ecosystem services may be used within and outside of the economy as defined by the SNA. The SEEA notes that there is no consensus on water valuation methods and does not make recommendations about methods suitable for valuation in water accounts beyond those used for the SNA (UN et al., 2021: para. 8.4). While there is no consensus, there are more than two decades of attempts to value water in accordance with the concept of exchange value. For example, Lange (1997) made comparison of user fees, costs of delivery and the economic contribution of water to different sectors of the economy, as a first step toward estimating the opportunity cost of water.

There is also a long history of water pricing and valuation, with many reviews of water value (e.g. Hirshleifer et al., 1960; Hanemann, 1997; Olmstead and Stavins, 2009; OECD, 2010; EPA, 2017; Siikamäki et al., 2021; Metcalfe, 2022) as well as databases of studies on ecosystem services and environmental valuation[11] containing studies on water. The consistency of these methods with the principle of exchange value needs to be investigated, but many of the methods used are likely to be consistent with exchange values.

[10] Depending on the source and user of water, and the use in the economy, some ecosystem services are already counted in the SNA, in particular, water abstracted from an artificial reservoir by a water supplier (Vardon, 2022).

[11] E.g. Environmental Valuation Reference Inventory (https://www.evri.ca/) and Ecosystem Services Valuation Database (https://www.esvd.info/home)

The SEEA Ecosystem Accounting considers the relationship of exchange values to environmental valuation methods, and recommends the following valuation methods, in the order of preference (UN, et al. 2021: in para. 9.23).

- Methods where the price for the ecosystem service is directly observable
- Methods where the price for the ecosystem service is obtained from markets for similar goods and services
- Methods where the price for the ecosystem service is embodied in a market transaction
- Methods where the price for the ecosystem services is based on revealed expenditures (costs) for related goods and services
- Methods where the price for the ecosystem service is based on expected expenditures or markets.

Methods specifically for monetary valuation of the water-related ecosystem services are also outlined by NCAVES and MAIA (2022). These include water provisioning, water filtration, water regulation and peak flow mitigation services.

For the water provisioning service, four methods are provided:

- *Resource rent or residual method*. Payments made for water supply are made for irrigation, household, and industrial uses. These payments are for the water, its transport and treatment. The transport and treatment costs (including labour and capital costs) can be deducted from the total payment with the residual value being the value of the water. It is usual for water to be provided 'at cost', that is, the payments made reflect only the capital and running costs and no payment is made for the water. In many cases, water is provided to use at less than cost. This results in zero or negative resource rents, implying no value (e.g. Obst et al., 2016).
- *Productivity change*. This is done using partial and general equilibrium models and looking at the impacts of a reduction in the supply of water to the output in different sectors of the economy (e.g. Calzadilla et al., 2013; Roson and Damania, 2016).
- *Replacement cost methods*, where a source of water is valued based on the cost of obtaining the water from the next lowest cost source (adjusted for water quality) (e.g. Edens and Graveland, 2014; Keith et al., 2017). An example would be using the cost of providing water through desalination.
- *Value of water rights*, where they are separately identified (from land values) and trading in water rights takes place such that a market is established. These rights are financial assets (Comisari and Vardon, 2013).

For the water filtration service two methods are suggested:

- *Replacement cost method.* This is the capital (i.e. infrastructure) and operational costs of purifying water to the same level of water quality (e.g. La Notte et al., 2012; Schenau et al., 2022).
- *Avoided damage costs.* This is the reduction in water purification and treatment costs that arises from having the ecosystem service.

The damage to human health from water pollution is another potential approach that has been used in accounting (e.g. Angeles and Peskin, 1998) and might also be useful and in accordance with the notion of exchange values (i.e. it is a type of avoided loss).

Water regulation and peak flow (or flood) mitigation services are not provided by water but by certain ecosystems. These services are, for example, provided by upland and liner vegetation, and the value of this benefit can be calculated using avoided loss (Kramer et al., 1997).

3.3 Double counting water value

When deriving values for water accounts and water-related ecosystem services, care must be taken to avoid double counting if the value of water is included as part of a total value of a country's assets. For example, the value of water as an intermediate input is already included in the SNA, although it is rarely explicitly identified, for example:

- For industries purchasing water from the Water collection, treatment and supply industry (ISIC 36), the water value in the SNA is included in three components of an industry's production costs – the service charge paid, any additional current and capital costs (purchases of equipment, energy, labour and other inputs) incurred by a company for the treatment, storage or transport of water, and industry value added where any residual water value accrues.
- For industries abstracting water for own use, the value of water is split between the costs incurred for the abstraction, transport, treatment or storage of water, and the industry's value added.
- For households, water value in the SNA includes the portion paid to water utilities or incurred by self-providers (e.g. the costs of people operating their own dams, wells, pumps).

Similarly, for ecosystem services the value of water-related ecosystem services may be embedded in the value of other ecosystem services, for example, in the value of agricultural commodities, timber and non-timber forest products that all require water for production.

The SNA includes "Water associated with land" as part of the asset "land" and relates to "any inland waters (reservoirs, lakes, rivers, etc.) over which ownership rights can be exercised and that can, therefore, be the subject of transactions between institutional units" (2008 SNA, para. 10.175.). While not specifically mentioned, soil water is also part of land in the context of the 2008 SNA, and soil water can only be accessed via land, for example, by the growing of rain-fed crops (Comisari and Vardon, 2012).

4 SEEA-based water accounting

4.1 Introduction

This chapter provides an overview of SEEA-based water accounting, including a brief history, its scope, key concepts, the main types of accounts, and the data sources and methods typically used to compile accounts. This chapter is an introduction to SEEA-based water accounting and is not intended to be a detailed reference for the production or use of water accounts. References to a variety of information sources are included within this chapter for those interested in more detail.

The SEEA consolidates the experiences and practices of countries and international organisations in the field of water accounts. The first UN environmental-economic accounting guidance was produced in 1993 and updated in 2003 (UN et al., 2014). The SEEA Water (UN, 2012a) consolidated experiences of countries with water accounting and was adopted as an interim international statistical standard in March 2007,[12] pending the finalisation on the SEEA Central Framework which occurred in 2012 (UN et al., 2014).

Two features distinguish SEEA Water from other water information systems that it directly links: (1) Water information to the information in the SNA and (2) Water information to the environmental and ecological information in the SEEA Central Framework and SEEA Ecosystem Accounting.

Through the shared concepts, structures, definitions and classifications with the SNA and broader SEEA framework, these linkages provide the means to integrate environmental-economic analysis. This helps to overcome the tendency to divide analysis and management along disciplinary lines, that is, where analyses of economic and environmental issues are carried out independently of one another. This allows for multidisciplinary research and management (e.g. Brandt et al., 2013).

This chapter provides an overview of the SEEA Water, including the terminology, main concepts and features of the system, the types of accounts, and a brief synopsis of the data sources and methods to compile water accounts.

4.2 Terminology and definitions

The terminology used in SEEA Water was developed by an Electronic Discussion Group (EDG) and is presented as a glossary in Annex 1 of this report (SEEA Water: para. 1.67). The glossary is needed as water accounting is multidisciplinary, spanning many fields, including hydrology, economics, environmental sciences and national accounting. The terminology was an agreement of the EDG, and at the time was considered the best alignment of the terminology of each field. The EDG considered many sources, including the International Glossary of Hydrology[13] (WMO, 2012), the FAO's Global Information System on Water and Agriculture

[12] See section 37/108 of the Report of the 38th Session of the UN Statistical Commission.

[13] https://library.wmo.int/index.php?lvl=notice_display&id=7394#.Y3Fwe3ZxWUk

of Aquastat[14], the UN Glossary of Environmental Statistics[15], and the SNA and SEEA glossaries. It should be noted that some of the glossaries have been updated since the adoption of SEEA Water in 2007.

The glossary is important because some terms, such as "water use" and "water consumption", mean different things in different contexts. The glossary enables different communities, countries, and international organisations to understand how their particular definitions relate to those in the SEEA. Over time, understanding should increase and the terminologies and related definitions should become better aligned.

4.3 Scope of water accounting

The scope of water accounting is presented in Figure 4.1. This figure is a simplified presentation of the physical stocks and flows of water within the hydrological system, which is a part of the environment, and the economy, and the interactions between the two. Many of the flows, and in particular those within the economy and between the economy and the inland water resource system, have matching monetary flows.

The inland water resource system of a territory (e.g. a nation or river basin) is composed of all water resources in the territory (surface water, groundwater and soil water) and the natural flows between them. The economy of a territory is defined by the SNA and consists of resident water users who: extract water for production and consumption purposes; put in place the infrastructure to store, treat, distribute and discharge water; and discharge water back to the environment.

Not shown in Figure 4.1, but within the scope of water accounting, are the discharge of pollutants, water quality, spending on resource management and environmental protection and water-related ecosystem services (e.g. water supply, water purification and water flow regulation services). Again, some of the physical aspects of water accounting have associated monetary values. Conversely, the monetary accounts for resource management and environmental protection have associated physical actions (e.g. installation of water treatment plants, water quality monitoring systems and catchment management).

The SEEA Water provides information on the:

- Stocks and flows of water resources within the environment.
- Pressures on the environment from the economy, including the volume of water extraction and wastewater returned to the environment.
- The supply and use of water and in production process and by households.
- The reuse of water within the economy.
- The costs of collection, purification, distribution and treatment of water and financing of these costs (e.g. charges to the users of water supply and sanitation services).
- Payment of permits for access to extract water from the environment or for the discharge of wastewater to the environment.
- The hydraulic stock in place, as well as investments in hydraulic infrastructure.

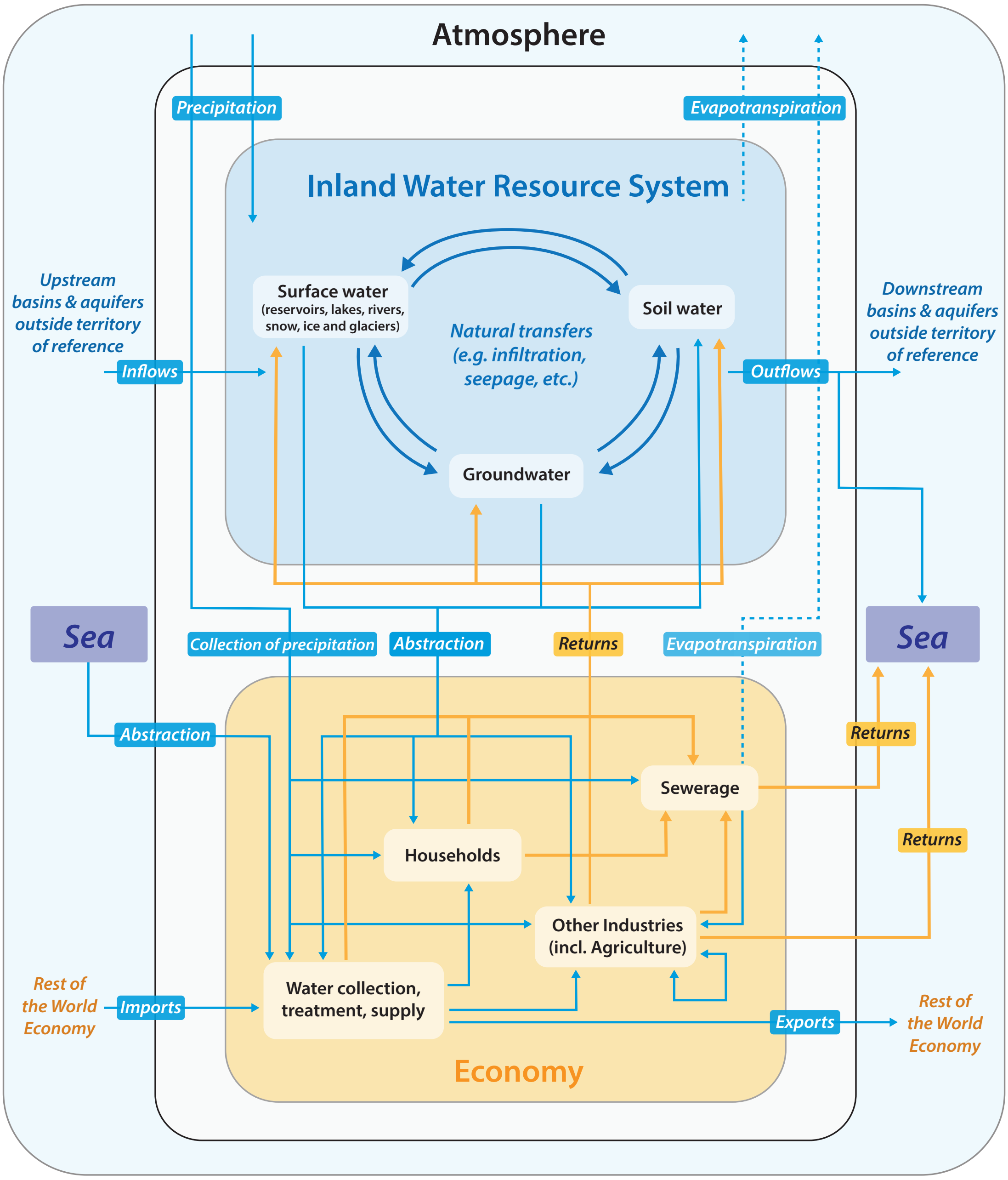
[14] https://www.fao.org/aquastat/en/databases/glossary/

[15] https://unstats.un.org/unsd/environmentgl/

- Water quality and water pollution.
- The economic valuation of water resources.

The inland water resource assets classes are surface water, groundwater and soil water. Surface water is further disaggregated and includes artificial reservoirs, lakes, rivers, snow, ice and glaciers. Changes in water stocks are due to flows of water within the environment (for example between surface water and groundwater) or flows between the economy and the environment (for example river water used for irrigation). Changes in stocks can also result from increased knowledge regarding stocks (for example the discovery of new aquifers or the reassessment of the volume of already identified groundwater resources).

Figure 4.1 The scope of water accounting



Source: After SEEA Water (UN, 2012a)

Beyond the scope of water accounting are the damages caused by water (e.g. by floods). Some of these damages would be recorded in the balance sheet of the national accounts as a reduction in the value of produced capital (e.g. houses, bridges and roads) and the damage to the environment would be recorded as a decline in ecosystem condition accounts. The ecosystem services of water flow regulation and river flood mitigation services are also included in ecosystem accounting, but these services are provided by upstream and riparian vegetation which can moderate run-off, slow water flows, and contribute to maintenance of riverbanks (e.g. by preventing their erosion) that provide a physical barrier to high water levels.

4.4 Types of water accounts

The SEEA describes three general types of accounts:

- Supply and use tables in physical and monetary terms, showing flows of natural inputs, ecosystem services products and residuals
- Asset accounts for individual environmental (including ecosystems) assets in physical and monetary terms, showing the stock of environmental assets at the beginning and the end of each accounting period and the changes in the stock
- Accounts recording transactions about economic activities undertaken for environmental purposes.

The SEEA Water identifies 22 different types of standard water accounting tables, 14 supplementary tables and five indicator tables (Annex 2). The main types of water accounts compiled are:

- Physical asset accounts
- Physical flow accounts – supply and use tables
- Monetary supply and use tables
- Water emissions accounts
- Ecosystem accounts containing water-related ecosystem services

Physical water asset accounts show stocks of water contained in the inland water resources by class of asset and how they change from one time period to the next. The water asset account is very closely aligned with a water balance (Vardon et al., 2012). The stocks of water recorded in the accounts may be low in some classes of water assets. For example, the stock level of a river is measured as the volume of the active riverbed determined based on the geographical profile of the riverbed and the water level, which is usually very small compared with the total stock of water resources for a nation or the annual flow of water in rivers. It is also the case that not all water resources are relevant in accounts, for example, in areas without snow, ice or glaciers, or groundwater. It is also the case that not all water resources within a particular class will be reported. For example, soil water may only be reported for the areas used for agriculture or forestry, and in such instances the scope of the reported estimate must be clear. Table 4.1 is a real example of a water asset account from Australia.

Physical water flow accounts describe flows of water encompassing the initial abstraction of water resources from the environment into the economy, to the water flows within the economy in the form of supply and use by industries and households, and finally, flows of water back to the environment. Such accounts are also known as water supply and use tables. Table 2.2 is a real example of a water flow account, again from Australia.

The top half of Table 4.2 is the supply table. It records the abstraction of the natural input of water from the environment, with environment shown in a column, according to the source of water, which is shown in the rows as surface water (52,766 ML), groundwater (1,254 ML) and rainwater tanks (1,100 ML). The use of the water from the environment is then recorded in the lower half of the table, against seven industries (i.e. agriculture, mining, manufacturing, etc.) and households in the columns. In this example, the water supply industry uses 49,958 ML of surface water from the environment which it then supplies to others as a product ("Natural Water" CPC 1800[16]) in the row labelled "distributed water" in the top half of the table. The distributed water is in turn shown as used by the seven industries and households in the lower half of the table. In this example (Table 4.2), agriculture is a very small user of water, which is atypical as agriculture is usually the largest user of water in many countries (Wada et al., 2013). However, the Canberra region is largely an urban region with regard to water use. Agriculture water use is often shown by the type of agricultural production. For example, the most recent Australian water accounts[17] divide agriculture into the industry classes: nursery and floriculture production; mushroom and vegetable growing; fruit and tree nut growing; sheep, beef, cattle grain growing and other livestock farming; dairy cattle farming; poultry farming; and, other crop growing.

Physical flow accounts can also show the supply and use of other types of water, for example, by water quality (e.g. potable or non-potable), and desalinated water. In the case where water is extracted from the oceans or seas for desalination, this is shown as an extraction from the sea of saline water, which is then converted to the product (e.g. potable water) which is then supplied to industries and households. It is also possible to show the supply and use of other water-related products, like bottled water and manufactured beverages (CPC 243, 244 respectively), although at present no country includes these products (and the relative volumes used are small). The flows of wastewater to the sewerage industry are also recorded.

Conceptually, the physical flow accounts record all flows back to the environment from the economy. In practice, some return flows, such as the unused portion of irrigated water that returns to groundwater or surface, are not recorded. This is mostly due to lack of data and the resources required to make estimates. This issue can be addressed, but if it is not then this has implications for the interpretation of the accounts and for determining water consumption (all water into the economy less all water out of the economy). It is also often difficult to split the flows to the sewers by type of industry and households, as the sewerage service industry generally does not record this information.

Monetary accounts for the supply and use of water are aligned with the physical flow accounts. They show the supply and use of water and sewerage service within the economy. As with the physical flow accounts, different types of water and water-related products can be recorded. Table 4.3 is a real example of a monetary supply and use table.

[16]https://unstats.un.org/unsd/classifications/Econ/cpc

[17]https://www.abs.gov.au/statistics/environment/environmental-management/water-account-australia/2020-21

A range of other monetary accounts are part of the SEEA Water. These include accounts for the:

- Expenditure on the protection and remediation of water resources (which are a subset of the environment protection and resource management expenditure accounts of the SEEA Central Framework).
- Financing of expenditure on the protection and remediation of water resources.

The SEEA Central Framework also includes accounts for environmental taxes and subsidies.

Emission accounts record the volume of water emitted by the economy, with or without water treatment. In this account, the water flows from different industries and sectors of the economy to the sewerage industry and directly to the environment are shown. Accounts can also include the amount of sewerage sludge and record the pollutants (e.g. N, P, K) added to water by economic activity - these emissions are expressed in terms of total weight (e.g. kilograms or tons) or concentration. The accounts cover: pollutants added to wastewater and collected in the sewerage network; pollutants added to wastewater discharged directly into water bodies; and non-point source emissions, such as emissions from urban run-off and agriculture.

Water quality or condition accounts show water by different quality classes for each type of water resource or show water quality indicators by type of water resource or individual water resources. A real example from Australia showing a range of water quality indicators for different surface water bodies is provided in Table 4.4. SEEA Ecosystem Accounting also provides a description of ecosystem condition indicators, with water quality being an indicator of overall ecosystem quality.

Tables 4.1 to 4.4 are an example of an integrated suite of accounts - physical assets, the supply and use of water in physical and monetary terms, and water quality tables for Australia (ABS and BoM, 2019). The example presented do not show all the categories in the SEEA water accounts. For example, snow, ice and glaciers do not occur in the region and so are not shown in the asset account in Table 2.1, while information on water from water tanks is included but is not shown in the SEEA Water asset account. These are cases of the standard tables being adapted to local circumstances.

Table 4.1 is related to Table 4.2. Table 4.1 is the physical water asset account. In this table the row "Abstractions/Drivers" records abstractions from surface water (52,766 ML) and groundwater (1,254 ML). These entries correspond exactly to the physical supply and use table (Table 4.2), with the supply of water from the environment from surface and groundwater shown in the first two rows. A series of flows is then recorded within the economy. Industries and households record water use. The water supply industry uses 49,958 ML of surface water and other industries use 1,524 ML, which means total use of surface water is 52,766 ML. The water abstracted by the water supply industry is then supplied to other water users in the economy. The 49,958 ML is transferred back to the supply table and shows the supply of distributed water by the water supply industry to other industries and households. Losses in distribution are attributed to the water supply industry, and in this case equals 5,127 ML. The flows of wastewater are also shown: industry and households supply 40,821 ML of waste-

Table 4.1 Asset Account for Water Resources, Canberra region, ML, 2016-17

	Surface water						
	Reservoirs (a)	Lakes (b)	Rivers	Subtotal surface water	Ground-water	Urban water system	Total Canberra region
Opening Stocks	235,971	39,324	5,416	280,711	na	966	281,677
Increases in stocks	347,995	196,573	1,336,144	1,880,713	4,079	90,779	1,975,571
Returns from the economy	-	-	36,971	36,971	4,079	40,821	81,871
Precipitation	9,776	5,080	6,184	21,041		-	21,041
Flood return	-	-	2,190	2,190			2,190
Runoff	94,161	22,269	566,467	682,897			682,897
Inflows							
from upstream territories			262,309	262,309	na	-	262,309
from other resources in the territory	244,058	169,224	462,023	875,305	na	49,958	925,263
Decreases in stocks	341,723	195,009	1,294,648	1,831,380	1,254	87,731	1,920,364
Abstraction/Diversions	49,958	na	2,808	52,766	1,254		54,020
Evaporation	15,230	9,521	6,332	31,083		na	31,083
Overbank flow	-	-	53,617	53,617			53,617
Outflows							
to downstream territories			818,608	818,608	na	-	818,608
to other resources in the territory	276,535	185,488	413,282	875,305	na	87,731	963,036
Other changes in volume	-3,343	-1,719	-45,980	-51,042	-2,825	-3,048	-56,915
Net change	2,929	-154	-4,484	-1,709	na	-	-1,709
Closing Stocks	238,900	39,170	932	279,002	na	966	279,968

Source: ABS and BoM (2019)

Table 4.2 Physical water supply and use table for the Canberra region, Australia, ML, 2016–17

	Industry								Households	Environment	Total
	Agricul-ture	Mining	Manufac-turing	Energy	Water supply	Sewerage	Other industries (a)	Industry Total			
Natural inputs (flows from the environment to the economy)											
Surface water										52,766	52,766
Groundwater										1,254	1,254
Rainwater tanks										1,100	1,100
Subtotal natural inputs										55,120	55,120
Products (flows within the economy)											
Distributed water	-	-	-	-	49,958	-	-	49,958	-		49,958
Reused water	-	-	-	-	-	3,392	-	3,392	-		3,392
Wastewater	87	12	375	-	115	-	9,256	9,845	30,976		40,821
Subtotal products	87	12	375	-	50,073	3,392	9,256	63,195	30,976		94,171
Return flows (flows from the economy to the environment)											
Surface water	-	np	np	-	-	36,929	42	36,971	-		36,971
Groundwater	-	np	np	-	4,079	-	-	4,079	-		4,079
Subtotal return flows	-	np	np	-	4,079	36,929	42	41,050	-		41,050
Total supply	87	12	375	-	54,152	40,321	9,297	104,245	30,976	55,120	190,341
Physical Use table (ML)											

	Industry								Households	Environment	Total
	Agricul-ture	Mining	Manufac-turing	Energy	Water supply	Sewerage	Other industries (a)	Industry Total			
Natural inputs (flows from the environment to the economy)											
Surface water	np	742	np	-	49,958	-	1,524	52,766	-		52,766
Groundwater	np	4	np	-	-	-	1,120	1,201	53		1,254
Rainwater tanks	na	na	na	na	na	na	na	na	1,100		1,100
Subtotal natural inputs	615	746	3	-	49,958	-	2,644	53,967	1,153		55,120
Products (flows within the economy)											
Distributed water	96	13	np	np	5,127	-	10,194	15,843	34,115		49,958
Reused water	-	np	np	np	-	3,298	np	3,392	-		3,392
Wastewater	-	np	-	np	-	40,821	np	40,821	-		40,821
Subtotal products	96	np	414	np	5,127	44,119	10,287	60,056	34,115		94,171
Return flows (flows from the economy to the environment)											
Surface water										36,971	36,971
Groundwater										4,079	4,079
Subtotal return flows										41,050	41,050
Total use	711	760	417	-	55,085	44,119	12,932	114,023	35,268	41,050	190,341
Total Consumption (Total Use less Total Supply)	624	748	41	-	933	3,798	3,634	9,778	4,292	-14,070	-

Source: ABS and BoM (2019)

Table 4.3 Monetary water supply and use table for the Canberra region, Australia, AUD, 2016–17

	Industry								Taxes less subsidies on products, trade & transport margins	Households	Total
	Agriculture	Mining	Manufacturing	Energy	Water supply	Sewerage	Other industries (a)	Industry Total			
Valuation of natural inputs (Ecosystem service of water provisioning)											896.0
Supply of water and sewerage services ($m)											
Distributed water	-	-	-	-	175.6	-	-	175.6	0.4	-	176.0
Reused water	-	-	-	-	-	0.1	-	0.1	-	-	0.1
Total supply of water products	-	-	-	-	175.6	0.1	-	175.8	0.4	-	176.2
Sewerage Services	-	-	-	-	-	120.2	-	120.2	0.7	-	121.0
Total supply of water products and sewerage services	-	-	-	-	175.6	120.4	-	296.0	1.1	-	297.2
Intermediate consumption and final use ($m):											
Distributed water	-	-	0.4	-	0.2	-	51.0	51.6	-	124.5	176.0
Reused water	-	-	-	-	-	-	0.1	0.1	-	-	0.1
Total use of water products	-	-	0.4	-	0.2	-	51.1	51.7	-	124.5	176.2
Sewerage Services	-	-	-	-	-	34.2	-	34.2	-	86.8	121.0
Total use of water products and sewerage services	-	-	0.4	-	0.2	34.2	51.1	85.9	-	211.3	297.2

Source: ABS and BoM (2019)

Table 4.4 Water Quality Account, Canberra region, Catchment Health Indicator Program (CHIP) Score, 2013-14 to 2016-17

	2016-17									
	pH (a)	Conductivity	Turbidity	Phosphorus	Dissolved Oxygen	Nitrate	WQ Score	WB Score	RARC Score	CHIP Score
Lakes and Ponds										
Lake Ginninderra	1.0	4.0	1.0	1.0	5.0	1.0	2.2	3.0	4.0	3.1
Yerrabi Pond	2.0	4.0	1.0	1.0	4.0	2.0	2.3	3.0	4.0	3.1
Lake Tuggeranong	1.0	2.0	2.0	1.0	1.0	5.0	2.0	5.0	4.0	3.7
Lake Burley Griffin (b)	1.0	3.0	3.0	3.0	na	1.0	2.2	na	na	2.2
Rivers										
Murrumbidgee River	1.0	2.8	1.0	1.0	3.0	1.5	1.7	2.6	3.8	2.7
Molonglo River	1.0	4.0	1.3	1.3	3.7	1.3	2.1	3.2	4.0	3.1
Cotter River	2.0	1.0	1.0	1.0	1.0	1.0	1.2	2.0	3.0	2.1
Catchment										
Ginninderra	1.2	3.8	1.8	1.4	3.9	2.0	2.4	3.4	na	3.2
Molonglo	1.0	3.6	1.8	2.2	4.6	1.8	2.5	3.5	na	3.3
Southern region	1.3	2.1	1.3	1.1	3.0	1.4	1.7	3.1	na	2.8

Source: ABS and BoM (2019)

water to the sewerage industry for treatment, and the sewerage industry then discharges 36,929 ML of water back to the environment.

The physical supply and use account (Table 4.2) is directly related to the monetary supply and use account (Table 4.3). The value of the water abstracted from the environment is not shown and only the supply and use of distributed water (water supplied by water suppliers/utilities) is recorded. Here, the total value of the distributed water is AUD 176 million and sewerage disposal value is AUD 121 million. These values are the amounts paid by users to producers.

The water quality account (Table 4.4) shows individual surface water bodies (lakes, ponds and rivers) which is related to part of the water asset account (Table 4.1). The artificial reservoirs are not shown in the water quality account (4.4), while the water asset account does not show the stocks, abstractions and returns from and to individual surface water bodies. Such detail could be added.

Other accounts could be added to the series to strengthen the linkages between the economic and environmental information. Examples could be a water emissions account, showing the pollution load in water returns from different parts of the economy to the water resources, or an account of the ecosystem service of water filtration provided by the vegetation surrounding the artificial reservoirs. Accounts for the capital and operating costs of the water supply and sewerage industry would help to understand the extent to which the fees and charges for the use of distributed water and sewerage services cover the cost of the production of these services.

4.5 Data sources and methods

Water accounts rely on many data sources and methods. A detailed examination of the data sources and methods used is beyond the scope of this report. Readers are referred to the International Recommendations for Water Statistics (UN, 2012b). Since the publication of these recommendations, there have been advances in the use of remote sensing technologies, hydrological modelling (e.g. Karimi et al. 2013; Pedro-Monzonís et al., 2016a; Esen and Hein, 2020; Kind et al., 2020), and an increase in computer power that has resulted in the refinement and development of a range of tools for estimating various types of data needed for water accounting (e.g. WA+[18]).

In general, the data fall into two distinct categories: physical data on the environment (e.g. stocks and flows of water in the environment); and physical and monetary data regarding water and economic units (e.g. flows of water between the environment and the economy and flows of water within the economy, and the related financial information). The data sources and methods used to produce the information needed depends on a range of factors, including the institutional arrangements and level of human and financial resources available.

Data on the physical environment are usually collected through direct (scientific) observation by agencies responsible for hydrological and meteorological monitoring and research. Data from or about economic units (e.g. businesses and households) are usually collected by two basic means: accessing data collected for administrative purposes (e.g. tax, annual

[18]https://wateraccounting.un-ihe.org/welcome-water-accounting-plus-0

reports, water licensing registers, etc.); or by direct survey (e.g. by a national statistical office). In many cases, the original providers of the data and the original sources of the data are the same, namely, the economic units and the records kept by these units. Surveys are usually conducted by the national statistical system, while administrative data may be held by a range of government agencies and some industry associations, and individual companies may produce annual reports with relevant information.

4.6 Spatial outputs

Information for water management is required at many geographic levels, from local government areas to river basins, to the national and multinational levels. The choice of the spatial reference for the compilation of water accounts ultimately depends on the data needed by users and the resources available to data producers.

In general, four types of spatial boundaries are used in water accounts:

- *Physical boundaries associated with surface and groundwater*, for example, river basins or water catchments, and aquifers and other sub-surface boundaries including groundwater provinces, and groundwater management areas
- *Administrative regions*, for example, local, state/provincial and national governments
- *Water service areas*
- *Accounting catchments*, which are hybrid areas representing the best possible match of the three other types of spatial boundaries

For physical boundaries, it is internationally recognised that river basins are the most appropriate spatial reference for IWRM, for example in the World Water Assessment Programme (2009) and the European Water Framework Directive (European Commission 2000). This is because the people and economic activities within a river basin will have an impact on the quantity and quality of water in the basin, and also the water available in a basin will affect the people and economic activities that rely on this water. As such, river basins are suggested to be the most appropriate for compiling water accounts in SEEA Water. Nevertheless, in areas where groundwater is an important source of water, aquifers may also be appropriate for compiling water statistics.

Administrative regions usually correspond to a level of government, for example local, state/provincial, or national. Administrative regions are usually responsible for planning and economic policies within their jurisdiction, noting that different regions are likely to have different laws, regulations, institutional arrangements and management practices relating to water.

Water suppliers or sewerage service providers, which may be government or non-government businesses, will often have service areas that are related to the physical infrastructure, which they own or operate to supply water or sewerage services. For example, a particular water supplier may supply water to more than one city or town, and these may be in two different river basins or administrative areas (for example, two different local government areas).

Accounting areas are an artificial construct of characteristics of the administrative regions and river basins where there is a mismatch of physical, administrative and water service areas (which is often the case). Accounting areas are used to provide the best possible match of economic, environmental and social data, which use a variety of spatial references.

In practice, an accounting area is usually an administrative region, composed of all or parts of several river basins, or a river basin composed of all or parts of several administrative regions.[19] Usually, whole administrative regions are added together to form the nearest approximation of a river basin, or vice versa.[20] In defining accounting areas, it is necessary to compare river basins and administrative boundaries to determine the best possible match based on practical considerations of data availability and data collection.

4.7 Time periods

When integrating or collecting water data, the reference periods for the water data must align. In environmental statistics, the calendar year is often the reference period, while for economic statistics it is usually the financial year. For water statistics, countries may use a hydrological year. A hydrological year is a 12-month period such that the overall changes in storage are minimal and carry over is reduced to a minimum.[21] Financial and hydrological years may be the same as or different to calendar years.

It is often the case that water accounts are developed for the period used in the national accounts, which is usually a financial year. This allows direct temporal comparability between economic and environmental aspects of water statistics. Many water statistics, like precipitation and other meteorological and hydrological data, are compiled more frequently (e.g. weekly or monthly) than economic statistics, and hence they can usually be more easily adapted to financial years than economic statistics can be adapted to hydrological or calendar years.

4.8 Ecosystem accounting and water

In the SEEA, environmental assets are considered from two perspectives. In the SEEA Central Framework, the focus is on individual components of the environment that provide materials and space to all economic activities. In the case of water, this would be water resources (surface water, groundwater, or soil water). The focus is on material benefits from the direct use of environmental assets as natural inputs for the economy by enterprises and households. SEEA Ecosystem Accounting encompasses the same environmental assets but focuses on the interactions between individual environmental assets within ecosystems, and a broader set of material and non-material benefits that accrue to the economy and other human activity from flows of ecosystem services.

In SEEA Ecosystem Accounting a distinction is made between ecosystem services (the contributions of ecosystems to benefits used in economic and other human activity), abiotic flows (contributions to benefits from the environment that are not underpinned by, or reliant on, ecological characteristics and processes), and spatial functions, which are the benefits that

[19]After SEEAW para. 2.90.

[20]See Edens et al. (2007).

[21]See UNESCO/WMO, International Glossary of Hydrology.

arise from the provision of space. These different contributions may be described in physical terms (for example, how much water is extracted) and monetary terms. SEEA provides detailed guidelines on how and with which methodologies these contributions may be valued in a way that is fully consistent with values as reported in the SNA (see Chapter 3).

The SEEA Ecosystem Accounting covers water ecosystems, several water-related ecosystem services, and water quality indicators that contribute to the assessment of ecosystem condition. The water ecosystem assets (e.g. artificial reservoirs[22], lakes, rivers and streams, snow, ice and glaciers and groundwater) correspond to those described in the SEEA Central Framework and SEEA Water but may also include other water related ecosystem types, such as wetlands. Soil water is not included as a separate asset in ecosystem accounting. Water quality and water availability are used as indicators of ecosystem condition.

The SEEA Ecosystem Accounting reference list includes several water-related ecosystem services including:

- Water supply
- Water purification (retention and breakdown of nutrients and other pollutants, e.g. as provided by the vegetation in water catchments)
- Water flow regulation
- River flood mitigation services (this is the riparian vegetation which provides structure and a physical barrier to high water levels)
- Nursery population habitat (e.g. for harvested fish)
- Recreation-related services (e.g. canoeing on a river)
- Visual amenity (e.g. views of a river or snow, ice and glaciers)
- Spiritual, artistic and symbolic services (e.g. the Ganges River)

The ecosystem service of water supply is one of the most reported ecosystem services (e.g. Keith et al., 2017; Ouyang et al., 2020). There is also the potential for double counting the value of some water-related ecosystem services, and in particular water purification and water supply (Vardon et al., 2019a).

There are also overlaps in the coverage of the SEEA Water and SEEA Ecosystem Accounting, and a different term can be used for the same flow recorded in each system (Vardon, 2022). For example, the water supply service in SEEA Ecosystem Accounting is equivalent to the abstraction of water in SEEA Water.

4.9 Water accounting and SDG 6

The Sustainable Development Goals (SDG)[23] are a universal call to action to end poverty, protect the planet and ensure that all people enjoy peace and prosperity. SDG 6 is to "*Ensure availability and sustainable management of water and sanitation for all*". The SEEA can support six indicators for SDG 6, including:

[22]Human-created ecosystems, like urban settlements and agricultural landscapes, are all included in the SEEA Ecosystem Accounting typology.

[23]https://sdgs.un.org/goals

- Proportion of wastewater safely treated
- Proportion of bodies of water with good ambient water quality
- Change in water-use efficiency over time
- Level of water stress: freshwater withdrawal as a proportion of available freshwater resources
- Change in the extent of water-related ecosystems over time
- Water- and sanitation-related official development assistance that is part of a government-coordinated spending plan

Constructing all of these indicators would require data from several of types from the SEEA Water, the SEEA Central Framework, the SEEA Ecosystem Accounting. The SEEA-based accounts in combination with the SNA also can been used to produce a range of other indicators. An example from the Philippines is presented later in the report (Section 6.6).

The advantage of SEEA-based indicators is that the water information can be linked to other economic, social and environmental information, enabling, for example, integrated land and water management (IWRM) (Meijer et al., 2020), and linked to SDGs 8 and 12, respectively on sustainable economic growth and sustainable consumption and production.

4.10 Water accounting and 'water budgets'

Water budgets are a tool for quantifying the flows of water into and out of a hydrological system. They record all water stored and exchanged on the land surface (rivers, lakes), subsurface (aquifer, groundwater) and atmosphere (precipitation, evaporation) (e.g. Healy et al., 2007). In a water budget, the rate of change of water stored is balanced by the quantity and rate at which water flows into and out of a hydrologically defined area. A water budget closely resembles the physical water asset account (see Table 4.1).

By linking a water budget, which is largely equivalent to the physical water asset account, to the physical and monetary supply and tables (Tables 4.2 and 4.3, respectively), the amount of water abstracted and returned by human activity can be better understood. The SEEA Water can record in greater detail the amount of water abstracted and returned by different industries and sectors. This enables water managers to allocate the available water to different users and understand the impacts on both the hydrological and economic systems of changes in water availability, water use and expected water demand (e.g. through increased population or the growth of large water-using industries).

5 Water accounting review

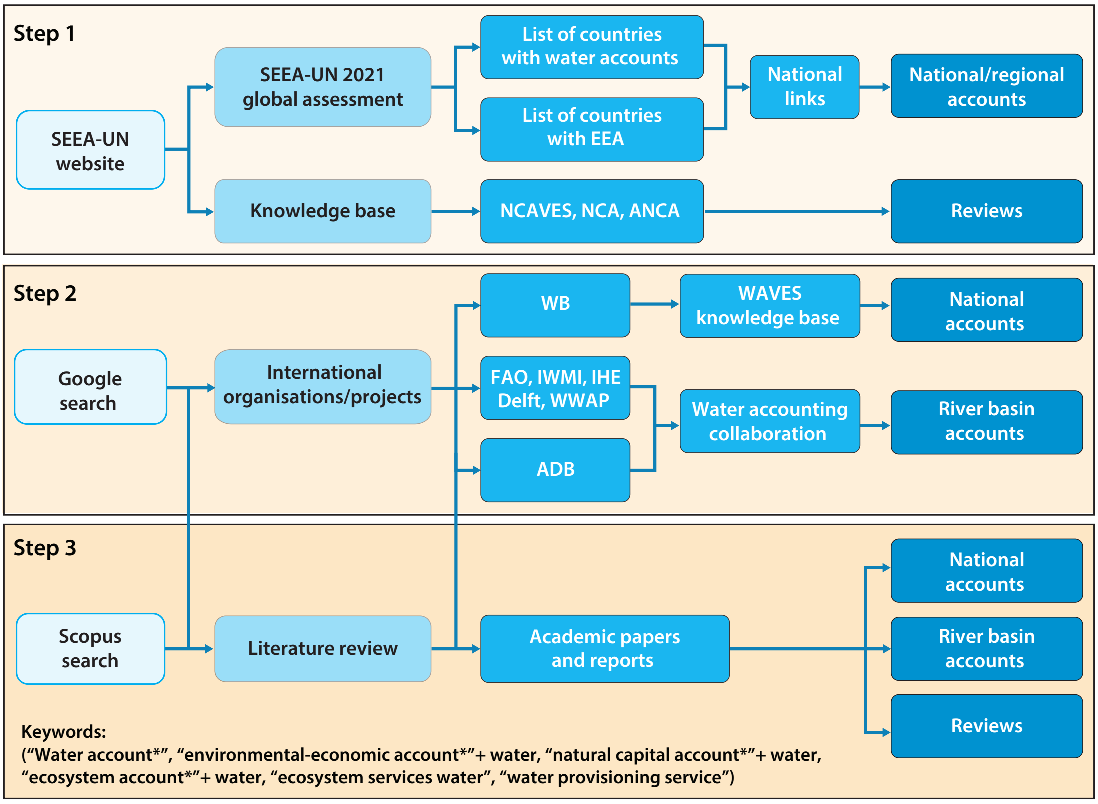
5.1 Introduction

This chapter provides a global review of water accounting to establish the extent to which water accounting is undertaken, and to summarise key features of the accounts. It presents the data sources and methods, and then the results. The review follows reviews of water accounts or environmental accounting more generally (e.g. Bagstad et al., 2020; Salminen et al., 2018; Smith, 2020; World Bank, 2021). The scope of this water accounting review covers all water accounting systems (not just SEEA) and the academic literature, and not just the accounts published by governments.

5.2 Data sources and methods

This review drew from existing protocols for systematic literature reviews (e.g. Moher et al., 2009; Woodcock et al., 2014; Sarkis-Onofre et al., 2021). A three-step process was employed to scan and find the water accounts (Figure 5.1).

Figure 5.1 Search pathways for water account review



The first step was a search of the UN SEEA website[24] and results of the 2021 Global Assessment (which collected a wealth of information on the status and progress of implementation of the SEEA in countries). From this, a list of countries with water accounts was made. Following the links provided on the SEEA website, or by searching the websites of responding institutions, the water accounts were accessed and downloaded. A similar search was expanded to other countries in the list which reported having environmental or ecosystem accounts, but not specifically water accounts.

Some countries' websites were easier to navigate because they had separate themes on water accounts or environmental accounts, while others were more difficult due to language barriers or because water accounts were embedded in various modules and in different titles. In addition, the knowledge base in the SEEA-UN website was searched for related literature and project documents supported by the UN, including the "Natural Capital Accounting and Valuation of Ecosystem Services" (NCAVES), the Enhance Natural Capital Accounting Policy Uptake and Relevance (EnhaNCA), and Advancing Natural Capital Accounting (ANCA) projects.

Step two was a Google search for initiatives of other international organisations. This led to the knowledge base of Wealth Accounting and the Valuation of Ecosystem Services (WAVES) – a World Bank-led global partnership – and various water accounting initiatives led by the Asian Development Bank (ADB), the Food and Agriculture Organization (FAO) in cooperation with the World Water Assessment Programme (WWAP), the International Water Management Institute (IWMI) and the IHE Delft Institute for Water Education (IHE Delft). While the WAVES knowledge base provides access to project-based national water accounts, the others focus more on water accounts for river basins. The Google search also helped the review to find water accounts of some countries or regions, especially those having a highly visible webpage for water accounts, such as Australia and Europe.

The final and third step was a systematic search in Scopus database and Google Scholar to find water accounts and reviewed documents from academic and other sources. Scopus was selected as the largest global database of published documents (Kilonzi and Ota, 2019) ecosystem science domain has made tremendous progress in the study of ecosystem services, but debates on neglected cultural ecosystem services (CES). The keywords used in the search were: "water account*", "environmental account*"+water; "environmental and economic account*"+water; "economic-environmental account*"+water, "natural capital account*"+water, "ecosystem account*"+water, "ecosystem services"+water, "water provisioning service", "SEEA"+ water", "SEEA"+ecosystem. No other restrictions were set. As a result, a total of more than 1800 journals and documents of all types were found, of which approximately 200 had the key wording "water account*" in the title. These were scanned for both the main text and the references to find water accounts.

After the water accounts were identified, a database was developed using Microsoft Access to store and classify the accounts. The database was structured into eight groups connected to each other by a unique letter account code as follows:

(i) *General information*: publishing agency, institutionalised status, search strategy, sources of water account and reviewed documents with links

[24] www.seea.un.org

(ii) *Boundaries and methodology*: type of water accounts, adopted framework and methodology, and spatial boundaries

(iii) *Sector and industry coverage*: industries covered by ISIC classification, typical sector split shown in agriculture, energy and mining industry, and agricultural commodities covered

(iv) *Timeframe*: the publishing year, reference year, length of the time series and gaps

(v) *Physical scope*: the recording of some key physical indicators including import and export of water, water sources, losses, evaporation, flows of water within the economy, return of water and wastewater, types of produced water assets and split shown for treated and untreated water for water treatment plants, wastewater treatment plants and desalination plants

(vi) *Economic scope*: the recording of some key economic indicators including running cost of water treatment, wastewater treatment and desalination, value of produced water assets, and other economic information such as value of irrigated agriculture, rain-fed agriculture, hydroelectricity, etc.

(vii) *Region and income level*: the classification of countries by regions and income level follows the World Bank's classification 2022–2023 (World Bank, 2022). Accordingly, countries are divided among income groups according to 2022 Gross National Income (GNI) per capita.

(viii) *Water stress*: the classification of water stress follows the World Resources Institute' categories based on the ratio of total water withdrawals to available renewable surface and groundwater supplies (WRI, 2019)

Annex 4 contains the database metadata.

5.3 Results of review

A total of 271 individual water accounts were identified, produced by 78 countries and regions which are listed in Annex 5. The summaries of different aspects of the accounts below reflect the fact that some countries have several editions of particular accounts, more than one government agency produces water accounts, and that the accounts are produced by organisations outside of government (international agencies and research institutions). For example, Australia, has two national government agencies and two different state governments producing water accounts, in addition to academic publications of water accounts and ecosystem accounts containing water-related ecosystem services. Because of these overlaps, the summary information has different sample sizes for different aspects of the accounts.

The number of accounts produced has increased over time (Figure 5.2). The earliest water account identified was in 1991 in the Philippines, for water emissions (pollution) accounts.

Accounts have been produced for all regions of the world. The largest percentage of accounts have been produced in Europe and Central Asia (31%), and by high-, upper middle- or lower middle- income countries (33%, 31% and 32%, respectively) (Figure 5.3). Accounts were produced for all levels of water stress, with Middle East and North Africa, and South Asia regions having the highest number of accounts, produced in countries of extreme water stress (n=15 and 9, respectively) (Figure 5.4).

Accounts were published by a range of agencies and in academic journals (Figure 5.5). Many accounts are collaborative exercises, so while they are published by one agency, one or more other agencies were involved in their production. For the purpose of this review, in cases where there is joint publication the account is included in the publication category of each of the agencies involved.

The most common publishers of water accounts were academic journals (52%) and national statistical offices (32%) (Figure 5.5). The production and publication of many SEEA-based water accounts has been sponsored by international agencies, notably the World Bank

Figure 5.2 Cumulative number of water accounts produced

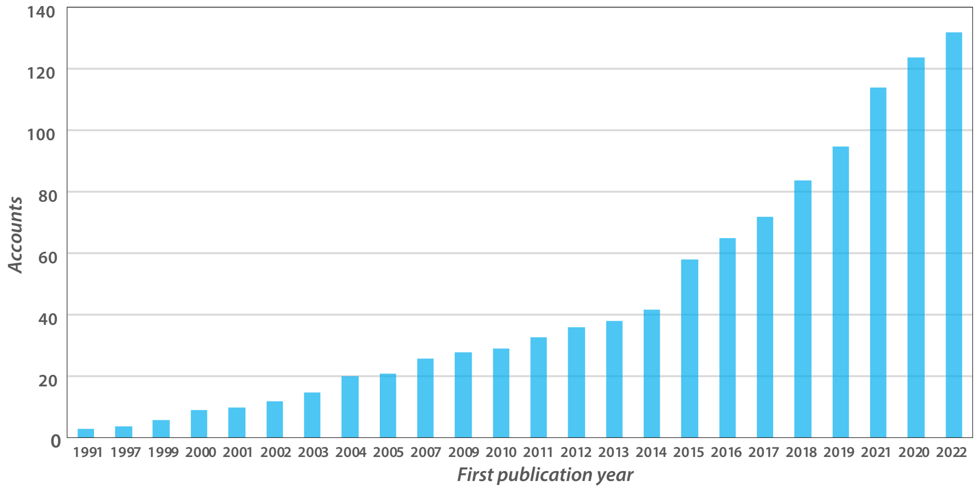
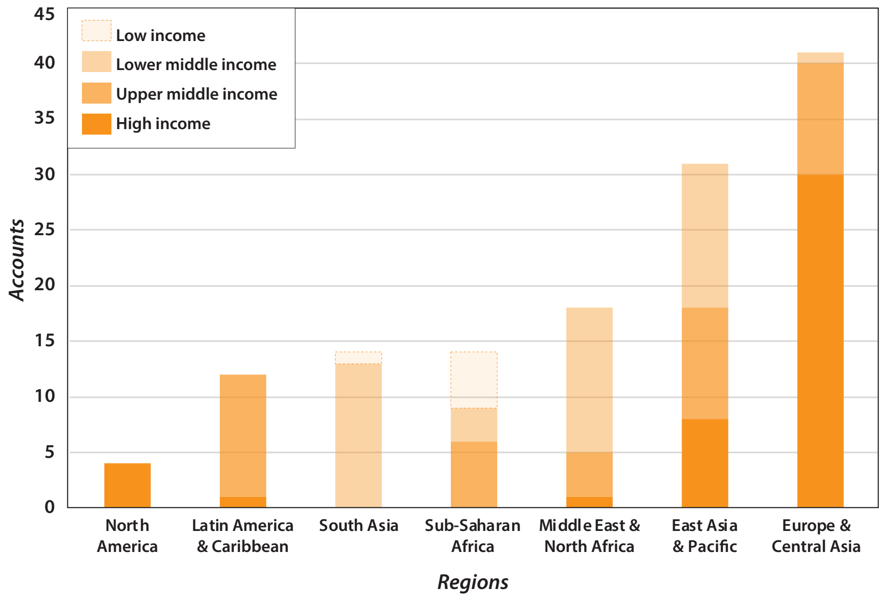


Figure 5.3 Number of accounts produced by region and income level



through the WAVES[25] and GPS[26] programs, and the UN through NCAVES[27], with 27 accounts published by international agencies.

Many accounts (n=106) were one-off exercises, with several countries not establishing an ongoing program of account production (Figure 5.6). Only 17 accounts are in annual production, and 13 of these are from national statistical offices (Figure 5.6). Only 9 water accounts

[25]https://www.wavespartnership.org/en

[26]https://www.worldbank.org/en/programs/global-program-on-sustainability

[27]https://seea.un.org/home/Natural-Capital-Accounting-Project

Figure 5.4 Number of accounts by region and categories of water stress

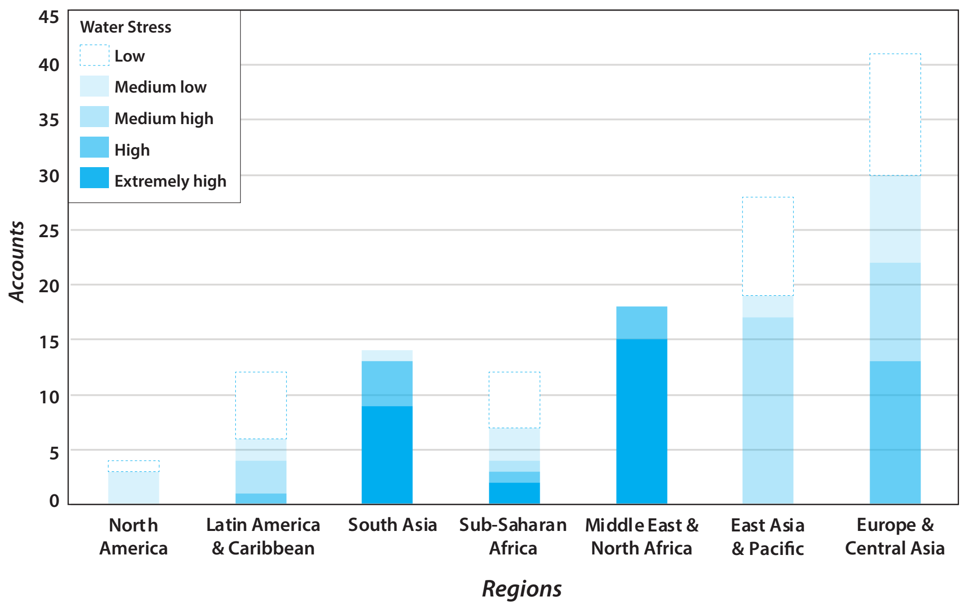
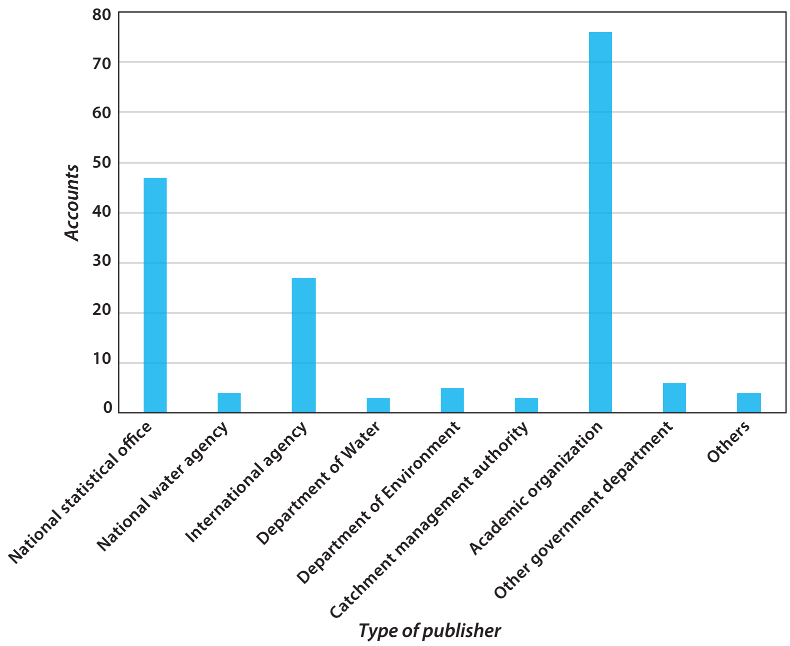


Figure 5.5 Water accounts by type of publisher



have been published more than 10 times, while 27 countries have a time series greater than 10 years (Figure 5.7).

The SEEA was the most common water accounting framework in use, being used in 55% of all accounts produced, mostly by national statistical offices and academic organisations (Figure 5.8), and in 70% of countries (Figure 5.9).

Physical supply and use tables were the most common type of account produced (n=83), closely followed by physical asset accounts (n=51) (Figure 5.10). Fifteen countries produced monetary supply and use tables, and two countries produced monetary asset accounts. The

Figure 5.6 Accounts by publication frequency

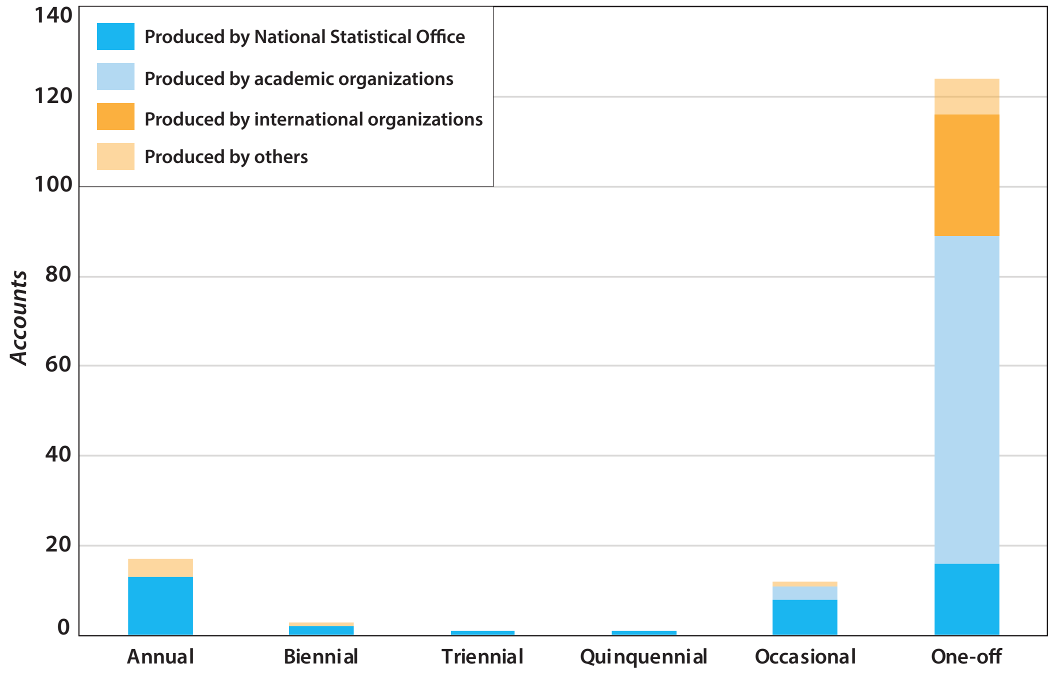


Figure 5.7 Number of countries with water accounts by time series

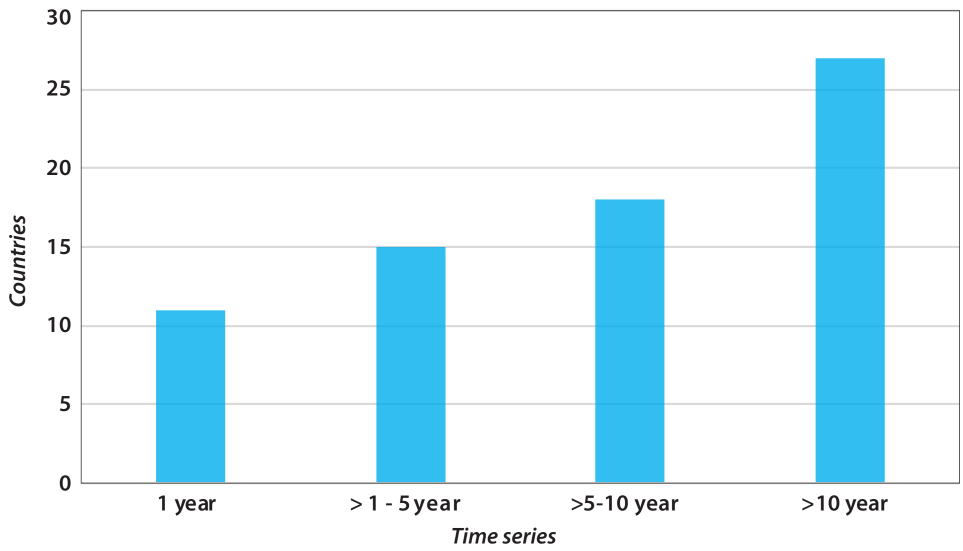


Figure 5.8 Number of accounts using each water accounting framework

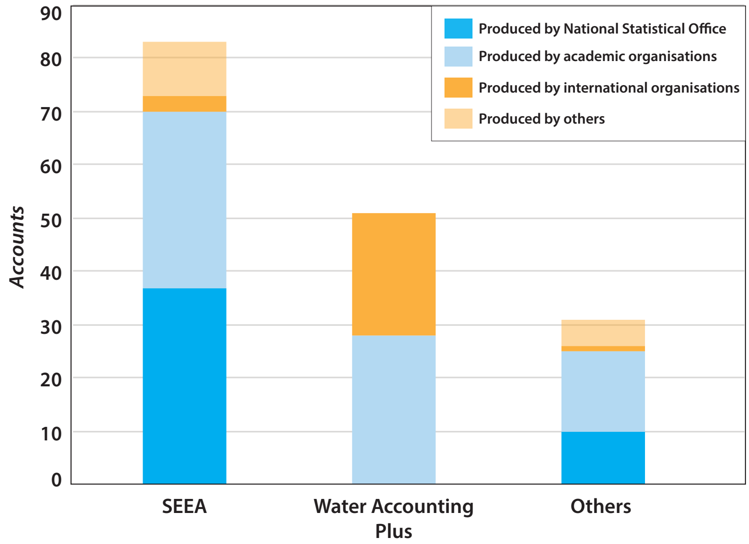


Figure 5.9 Number of countries using each accounting framework

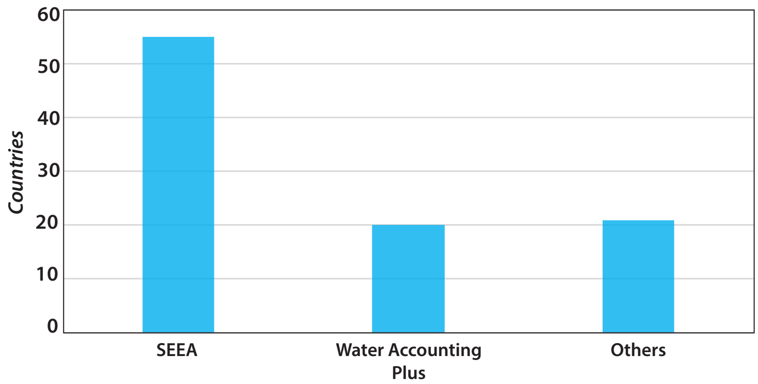
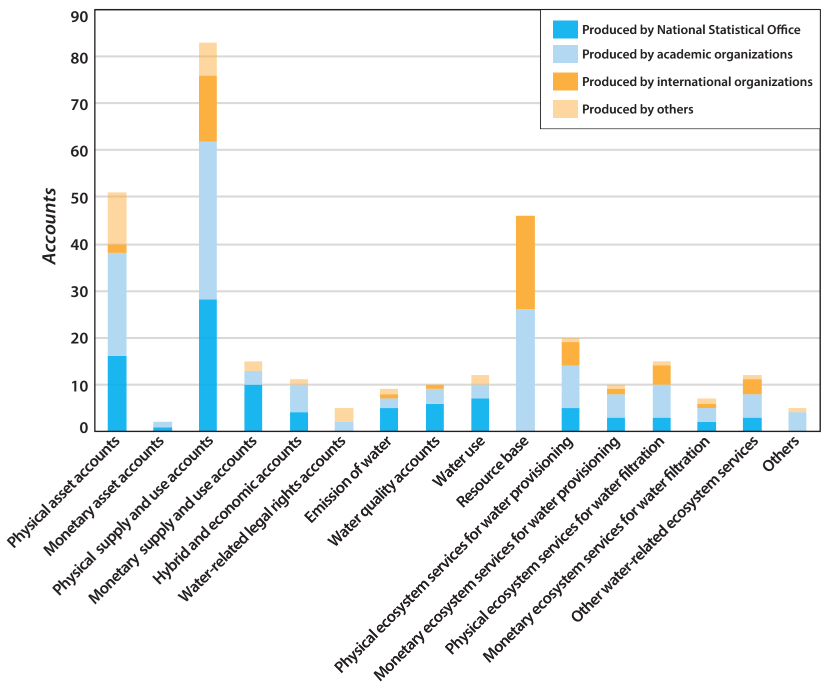


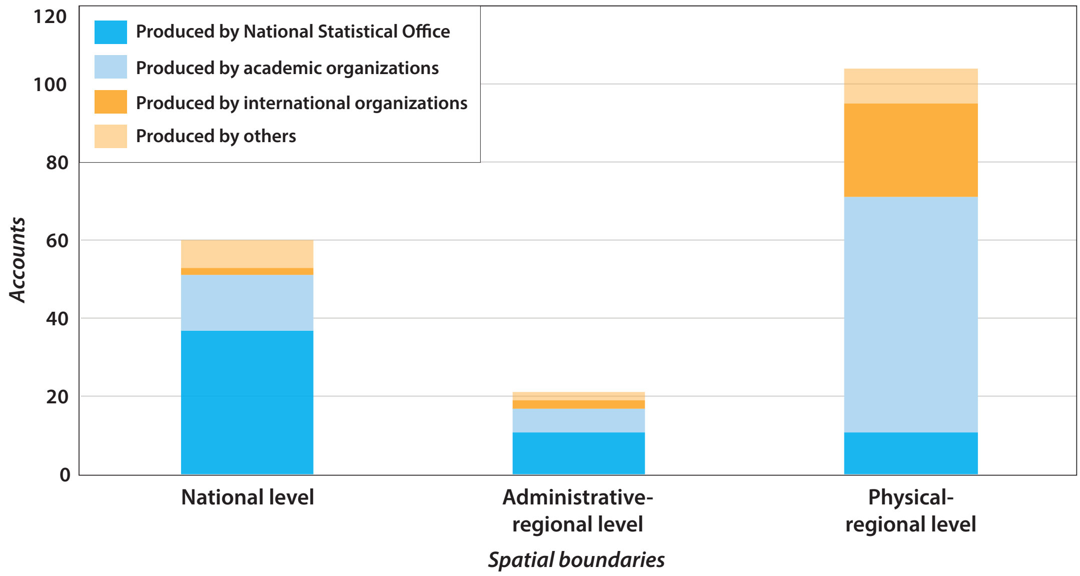
Figure 5.10 Types of accounts produced



number of accounts with the ecosystem services of water provision (n=30), water filtration services (n=22), and other water-related ecosystem services (n=12), is not an accurate reflection of the amount of account work done in this space, with the salient word "water" absent from the title, abstract, or keywords of many articles that produce accounts for multiple ecosystem services.

Most water accounts (n=104) produced were at regional level based on physical boundaries, mostly river basins or other hydrologically defined areas (Figure 5.11). The majority of accounts at the river basin scale were in the academic literature, with the national level accounts (n=60) mostly published by national statistical offices (n=37) (Figure 5.11).

Figure 5.11 Water accounts by spatial output and publisher



The level of detail in water accounts varied in terms of the number of industries, water resources and water recorded. The number of industries ranged from four (e.g. water supply, agriculture, other industries and households), to more than 30, including subdivisions of the agricultural industry by, for example crop types (Figure 5.12). Agriculture was the industry most often recorded (n=106), and the "other" category was also high (n=90) as this category is used to represent all industries other than the 20 ISICv4 industries or in accounts that do not use the ISIC classification. The water supply industry was explicit in just 57 accounts. Water use by households[28] (or domestic) was reported in 52 accounts. Australia, Denmark, Guatemala, Namibia, Colombia, Finland, Guatemala and The Netherlands had the greatest number of industries or subdivisions of industries (mostly agriculture). Surface water and groundwater were the most common water resources recorded, with surface water often split between reservoirs, rivers and streams, lakes and snow, ice and glaciers (Figure 5.13). Soil water (e.g. the water used in rainfed agriculture), was recorded. Evaporation (n=83) and return flows (n=78), were the most recorded flows (Figure 5.14).

[28]In the SNA and SEEA households are a sector, not an industry

Figure 5.12 Number of water accounts and the number of times industries and sectors appear

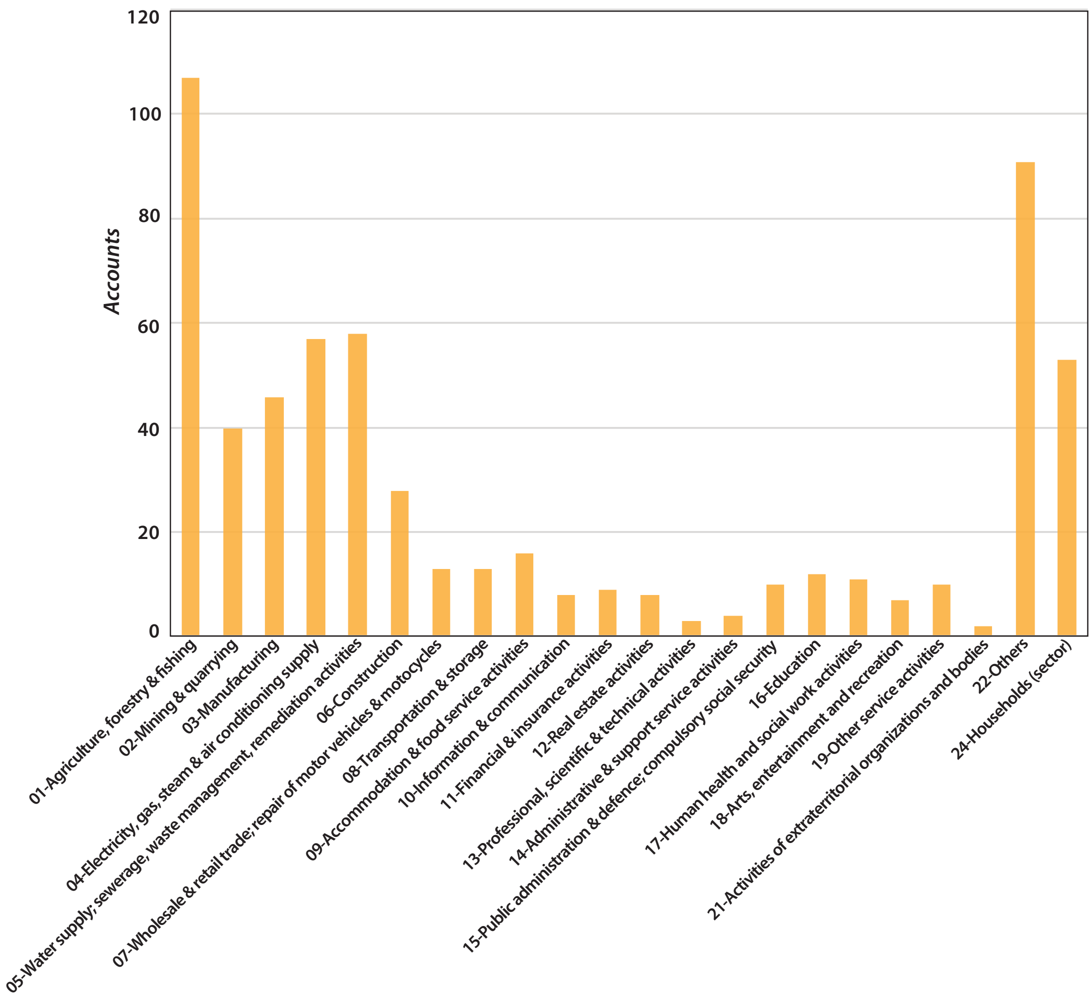
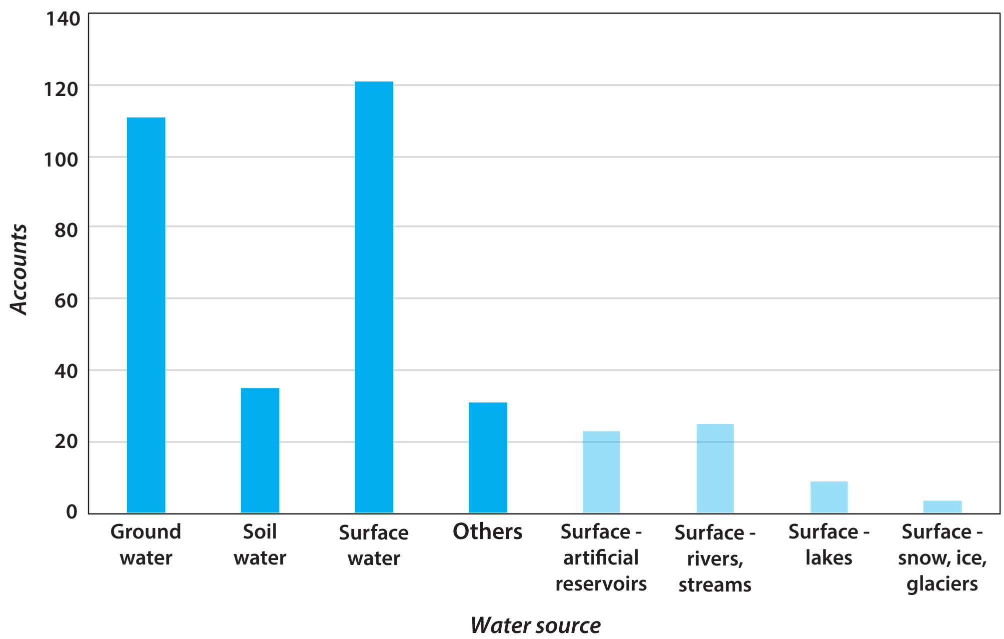


Figure 5.13 Number of water accounts including water resources



Historically, most accounts were published as printed documents, made available on the web via a PDF file (n=121), and several accounts have both a PDF file and downloadable tables (n=18). Use of a PDF is still the case for low- and middle-income countries producing accounts, like Botswana, while high-income countries like Australia and the Netherlands have dispensed with printed and PDF documents and the text is now entirely online with downloadable tables (n=26) (Figure 5.15).

Figure 5.14 Number of accounts including water flows

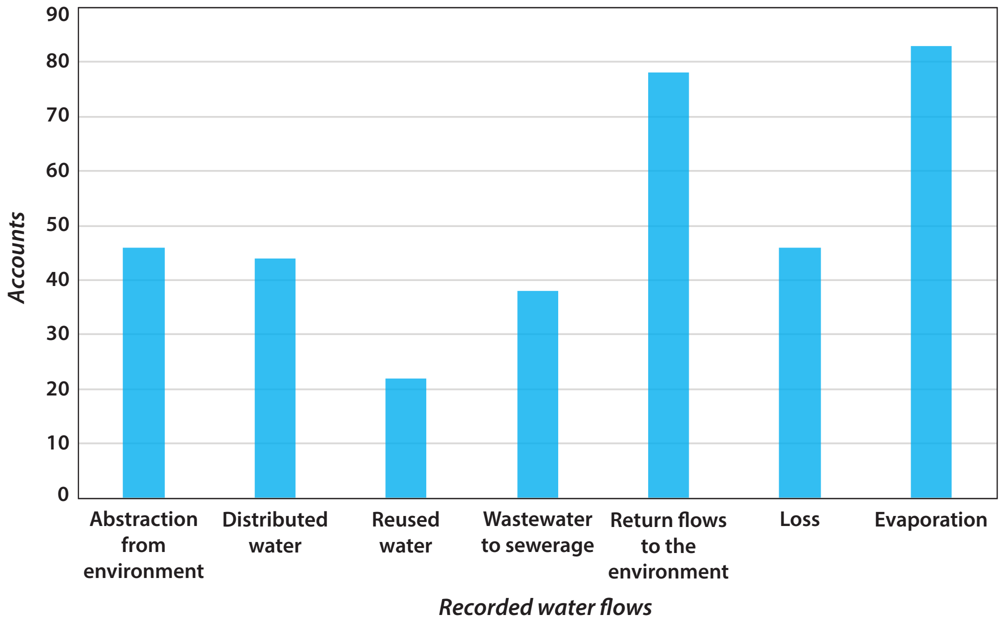
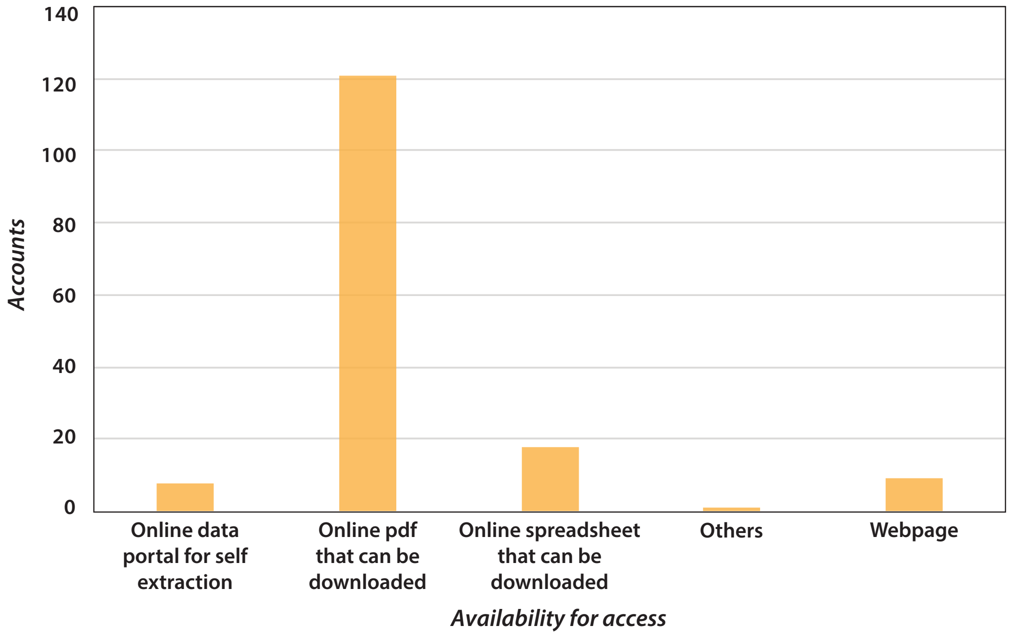


Figure 5.15 Water accounts access



6 Country examples

Water accounts have been developed around the world in a variety of contexts. This chapter presents a selection of case studies to highlight the ways in which water accounting has developed and been used in countries. For example: in areas of high or low water stress; in large, small, high- or low-income countries, and; with differing levels of capacity and data availability.

6.1 European Water Framework Directive

The European Water Framework Directive (WFD) was adopted in 2000 and is an information framework for water, enabling data analysis and assessment of current or possible interventions to effectively manage water resources in the European Union. Member States are required to develop River Basin Management Plans which include a range of biological and economic information at the catchment level, intended assess the status of inland waters and to develop programs of measures to reduce pressure and to improve the health of such ecosystems (Santos et al., 2021; Carvalho et al., 2019).

The WFD has increased demand for integrated hydro-economic information at the level of river basins for decision-making. The use of the framework, and a lack of interdisciplinary approaches, have led to water management actions that have, to date, yielded poor results (Souliotis and Voulvoulis, 2021).

The Netherlands is one of the leading implementers of SEEA-based accounting and has more than two-decades of experience with water accounting. It was one of the first nations to use the SEEA Water to meet the needs of the WFD, and also the demand for integrated hydro-economic information (Schenau and ten Ham, 2005). The Netherlands accounts provide information about the interactions between the physical water system and the economy at national and river basin scales (Brouwer et al., 2005). This includes the development of physical and monetary flow accounts[29] and emission accounts[30] and valuation (Edens and Gravland, 2014). The water accounts include physical data on water use and wastewater supply, as well as economic data on production, value added and employment (van Berkel et al., 2022).

One of the major challenges in the compilation of the accounts in the Netherlands (and elsewhere) is matching the available data across spatial scales. The Dutch have also produced ecosystem accounts including water-related ecosystem services, including water purification, at a fine level of spatial detail.[31] Data from the water accounts and System of National Accounts are used by the Ministry of infrastructure and Water Management to report on the WFD for the Netherlands every three years.

[29] https://www.cbs.nl/en-gb/figures/detail/82883ENG?q=environmental%20accounts

[30] https://www.cbs.nl/en-gb/our-services/methods/surveys/brief-survey-description/environmental-accounts-emissions-to-water-origin-and-destination

[31] https://www.cbs.nl/nl-nl/publicatie/2021/22/natuurlijk-kapitaalrekeningen-nederland-2013-2018

The SEEA Water has also been tested at the subnation level for WFD reporting in Spain for the Guadalquivir river basin. Borrego-Marín et al. (2016) and Gutiérrez-Martín et al. (2017) found that the SEEA Water methodology satisfies the requirements for the economic characterisation set out in Articles 5 and 9 of the WFD, and in particular to estimate cost-recovery for water supply. Gutiérrez-Martín et al. (2017) also concluded that using the SEEA Water would increase the comparability of information and knowledge-sharing between regions and countries.

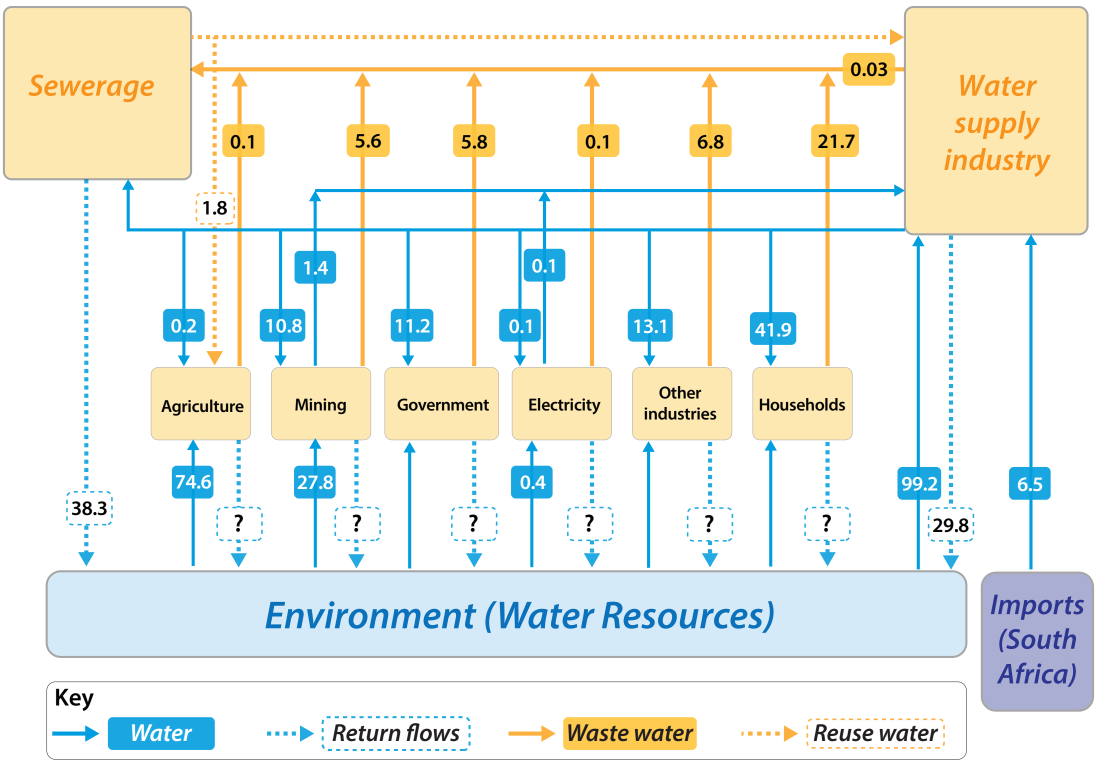
To test if ecosystem accounting can meet the requirements of the WFD, Souliotis and Voulvoulis (2021) examined the Evrotas River Basin in Greece and the Broadland Rivers catchment in England to determine the asset value of two ecosystem services, and associated these with changes in water condition due to policy instruments. They found that the asset value of water for residential consumption and recreational purposes fluctuates from year to year, influenced by current and future uses. They concluded that water management should consider both current and emerging pressures when designing interventions to manage water resources sustainably, and that ecosystem accounting could aid such considerations.

6.2 Botswana country experience

Botswana is one of a small group of countries in southern Africa, including Namibia and South Africa, that has produced and used water accounts over many years (Lange et al., 2007). More recently, Zambia has begun the production of accounts (GRZ, 2020).

The accounts produced in Botswana (e.g. DWS, 2021) show the available water resources, their abstraction and utilisation, by industry and sector, as well as returns of wastewater via the sewerage network (Figure 6.1). The value of water sales by the water supply industry is

Figure 6.1 Physical supply and use of water in Botswana 2018-19 (million m³)



Source: After DWS (2021)

also included in the accounts. The volume of non-revenue water is also recorded. Information of the return flows from several industries is not recorded in the accounts and is indicated in Figure 6.1 as "?". The absence of this information means that water consumption – all water entering an industry, less all water returning to the environment – cannot be reliably calculated.

In Botswana's accounts, the water used by the agricultural industry is split in several ways, showing use in irrigation by different types of livestock and in horticulture. An estimate of the water used by wildlife was also made, given the importance of wildlife for tourism (Vardon et al., 2017). Indicators are derived by combining the water accounts with other information, for example industry value added[32] per m^3 of water use, and GDP per capita per m^3 of water use. Return flows of water to the environment are only captured for the water supply industry, meaning that "true" water consumption as defined in SEEA Water (and hydrology) is not able to be calculated.

Setlhogile et al. (2017) noted that water accounting needs to be better integrated in the national development planning of Botswana to better inform decision-making on water allocation, water efficiency, water infrastructure and expansion of non-conventional water resources, as well as water costs and savings opportunities. They noted that water accounts reveal a range of opportunities for the implementation of Botswana's IWRM-water efficiency plan and water demand management efforts. Examples include increasing freshwater use efficiency by using non-potable water for industries that do not require potable water, and encouraging on-site water recycling and re-use.

The accounts also reveal a growing share of surface water abstraction, which alleviates pressure on well fields, most of which currently have unsustainable withdrawal levels (Setlhogile et al., 2017). Self-providers abstract more than 50% of water resources (DWS, 2021) but policy and water management are focused on the water service provider, pointing to the need for additional management of self-providers (Setlhogile et al., 2017).

Data availability and data access are ongoing issues for Botswana. Pule and Galegane (2017) note that the production of accounts helped to identify data gaps and deficiencies that are being addressed. They also note that account production had led to greater collaboration between different parts of government and the research community. Going forward, the inclusion of information on water rights should improve the information within the water accounts and make them more useful for water policy and IWRM (Kelebang, 2021).

6.3 Colombia water accounts for setting water fees

The Government of Colombia updated water use fees in 2016. The fee is used to fund the management of water resources by national and regional authorities. As part of the decision-making process, the National Planning Department (DNP, 2016) built a social accounting matrix using the national water accounts (DANE and IDEAM, 2016) to estimate the economic impacts of increasing the minimum fees (Alvarez et al. 2016). The matrix was used to model the impacts of different fee increases on industries. Seven industries were included in the matrix: agriculture, electricity, mining, industry and commerce, services, others (use of water), others (without information), plus "environmental government". The inclusion of "environ-

[32]Industry value add is the contribution of each industry to GDP.

mental government" allowed investigations of the use of the Water Use Fee to fund improvements to the environment via government. According to the law, the fees must be used for improving environmental conditions and water quality.

It has been proposed to establish a different minimum Water Use Fee for different industries based on cost of production (COP): 0.8 COP to 3.0 COP per m^3 for agriculture, and 0.8 COP to 10.0 COP per m^3 for other industries. To test the impact of different fees on industries, a Computable General Equilibrium Model for Water was developed, with the Social Accounting Matrix the main data input.

Both the analysis and water accounts were used in discussions leading up to the decision to increase water fees, and to inform discussions between the government and the agriculture industry (Romero et al., 2017). The representatives of the agriculture industry argued that an increase of Water Use Fee would lead to the bankruptcy of some farmers, and that saving water would require high investments in technology. The analysis was used to counter these arguments and show that the fee increase was unlikely to bankrupt farmers.

The Colombia experience shows that accounts in combination with analytical tools can have direct input to government decision-making processes. Regular updating of the water accounts has occurred since then (e.g. DANE, 2022), and will allow ongoing analysis of the impact of water use fees on the economy.

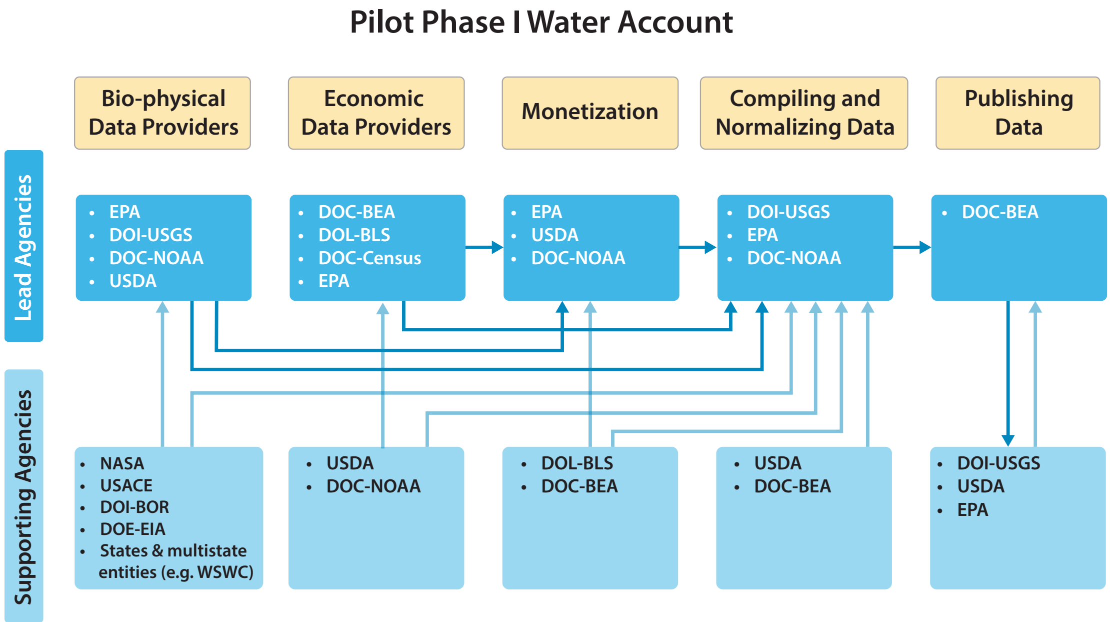
6.4 Developing water accounting in the United States

The United States recently released a draft strategy for the implementation of environmental economic accounting for the nation (USDC, 2022). The strategy had a phased implementation plan with water accounts part of the first phase. A feature of the water accounting plan was the large number of organisations involved in the production of the accounts (Figure 6.2), which emphasises that collaboration and cooperation are essential for the production and use of accounts in decision-making processes.

This emphasis is unsurprising as the US draft accounting strategy has built on many years of work involving collaboration between government and research institutions, identifying data and developing methodologies to compile accounts. This collaboration resulted in the production of experimental national- and state-level water accounts for the United States (Bagstad et al., 2020). Four types of water accounts were produced: (1) physical supply and use, (2) productivity, (3) quality and (4) emissions. Water use and emissions were attributed to 10 industries and sectors, while emission accounts were attributed to 15. The inclusion of a water emission account is a noticeable feature because few other countries have compiled this type of account. Among many other things, the accounts showed a decline in the total use of water in 44 states, although an increase in the use of groundwater in 21.

The experimental water account was the first research in the US to integrate the physical water data and economic data from the SNA, and it demonstrated that accounts could be produced with available data. While the study highlighted many data gaps and deficiencies, it also recognised that these could be addressed over time, and already more data has been identified that will improve the quality of the accounts and their usefulness for decision-making.

Figure 6.2 Implementation plan for water accounts in the United States



Source: USDC, 2022

6.5 Australia: An opportunity requiring resources

There is considerable pressure on water resources in many parts of Australia, and water abstraction for irrigated agriculture is a major pressure (Green and Moggridge, 2022). To assist the management and governance of water, water accounts are written into law via the Water Act 2007.[33]

Australia has a long history of collecting water resource data and has produced water accounts dating back to 1996 (Vardon et al., 2007). Since 2008–09, two national government agencies have produced water accounts; the Australian Bureau of Statistics[34] (ABS) and the Bureau of Meteorology[35] (BoM). The ABS uses the SEEA, while the BoM uses a framework developed by the Water Accounting Standards Board (2014). The BoM water account can be aligned with the SEEA Water Account and is produced for 11 regions of Australia, while the ABS produces national SEEA physical and monetary supply and use tables (Vardon et al., 2012). Both agencies produce annual water accounts. The two accounts were integrated as a one-off case study (ABS and BoM 2019) and some of the tables from this are used as an example in Section 4.3.

The current ABS annual accounts do not include the use of soil water by rainfed agriculture, nor the value or volume of water trades. Soil water was included in the ABS accounts from 2011–12 to 2016–17[36] and water trading for 2004–05.[37] BoM reports the volume and value of water entitlements trade but not as part of the water accounts.[38]

[33]See part 7 Water information of Water Act 2007. https://www.legislation.gov.au/Details/C2021C00539

[34]See https://www.abs.gov.au/statistics/environment/environmental-management/water-account-australia

[35]See http://www.bom.gov.au/water/nwa/2021/

[36]https://www.abs.gov.au/AUSSTATS/abs@.nsf/DetailsPage/4610.02013-14?OpenDocument

[37]https://www.abs.gov.au/ausstats/abs@.nsf/PrimaryMainFeatures/4610.0.55.003?OpenDocument

[38]http://www.bom.gov.au/water/dashboards/#/water-markets/national/state/at

A review of Australia water reforms by the Productivity Commission (2021) found: "*Water accounting is generally providing practical, credible and reliable information, but there is room for improvement. Public demand for information and timely provision of it has increased over time*." The Commission also recommended that more system integrity was required, in part to strengthen water accounting which would provide credible information and support robust institutional processes. This would help ensure that: water rights holders are operating appropriately; water systems are being managed to best effect; it would improve understanding of potential risks and planning for the future.

Improved management of the Murray-Darling Basin, where a large proportion of Australia's agricultural activity takes place, needs improved water accounting (Grafton, 2019). This includes a governance process that allows management actions to be modified and updated based on new information, understanding and decision-making processes that include explicit consideration of natural and anthropogenic risks, as well as incorporating a genuine participatory process involving all relevant stakeholders, not just irrigators who have dominated the processes to date. Neither of these improvements guarantees the success of water reform, be it in Australia or elsewhere, but they are necessary for delivering cost-effective water reform that is in the public interest.

Australia has clearly recognised the potential of water accounting for water management and governance, and is regularly producing water accounts. The challenge now is to improve the scope and coverage of water accounts and to integrate them into decision-making processes. The challenge is also to regularly produce fully integrated water accounting, covering the economic and hydrological aspect of water.

6.6 The pioneering Philippines

The Philippines has an abundance of water resources but there is growing demand for water due to population increases and economic demands, particularly in some areas (PSA, 2020). The depletion and degradation of water resources has been a concern for many years (SEPO, 2011).

The global review of water accounting (Chapter 5) found that in 1991 the Philippines was one of first countries to begin water account production. This was via the Environmental and Natural Resources Accounting Project (ENRAP) (Angeles and Peskin, 1998). This, and subsequent projects, have resulted in a long time series of water accounts, from 1988 to 1998 for physical and monetary assets, and physical supply and use tables from 2010 to 2020. Regional level ecosystem accounts, including accounts for water quality and water supply for the Laguna de Bay Basin, which contains the largest inland water body in the Philippines, have also been prepared, spanning the years 2001 to 2014 (LBTWG, 2016).

The Water Accounts of the Philippines (PSA, 2020) have been used to compute two indicators for SDG 6 on water and sanitation, namely SDG 6.4.1 Change in Water Use Efficiency (WUE) and SDG 6.4.2 Level of Water Stress (LWS).

WUE is defined as the value added of a given major sector divided by the volume of water used.[39] The three major sectors are defined as:

[39] https://www.fao.org/sustainable-development-goals/indicators/641/en/

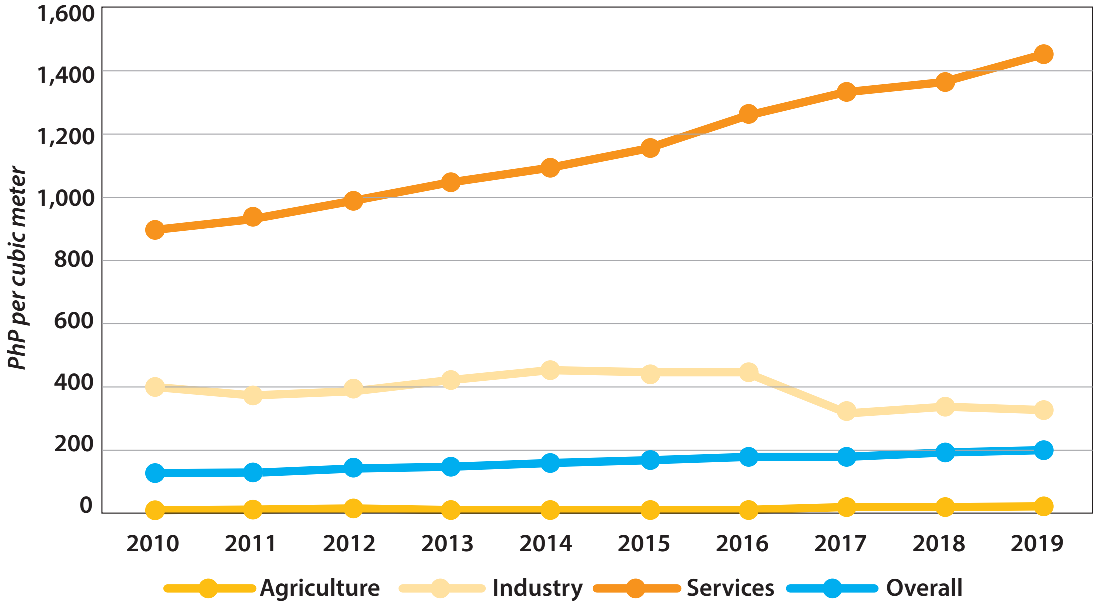
- *Agriculture*, which comprises irrigated agriculture; forestry; fishing
- *"MIMEC"*, which includes mining and quarrying; manufacturing; electricity, gas, steam and air-conditioning supply; construction
- *Services*, which covers all service sectors

The Philippines calculated three sectoral efficiencies and the overall water efficiency of the nation using the SEEA Water physical supply and use tables, and the valued added from the SNA (Figure 6.3).

The LWS[40] is defined as freshwater withdrawal as a proportion of available freshwater resources. It is computed as the ratio between total freshwater withdrawn by all major sectors and the total renewable freshwater resources, after considering environmental water requirements. This information comes from the SEEA Water supplementary physical asset account (the supplementary account includes a line item for abstraction "of which sustainable"). The results are in Figure 6.4.

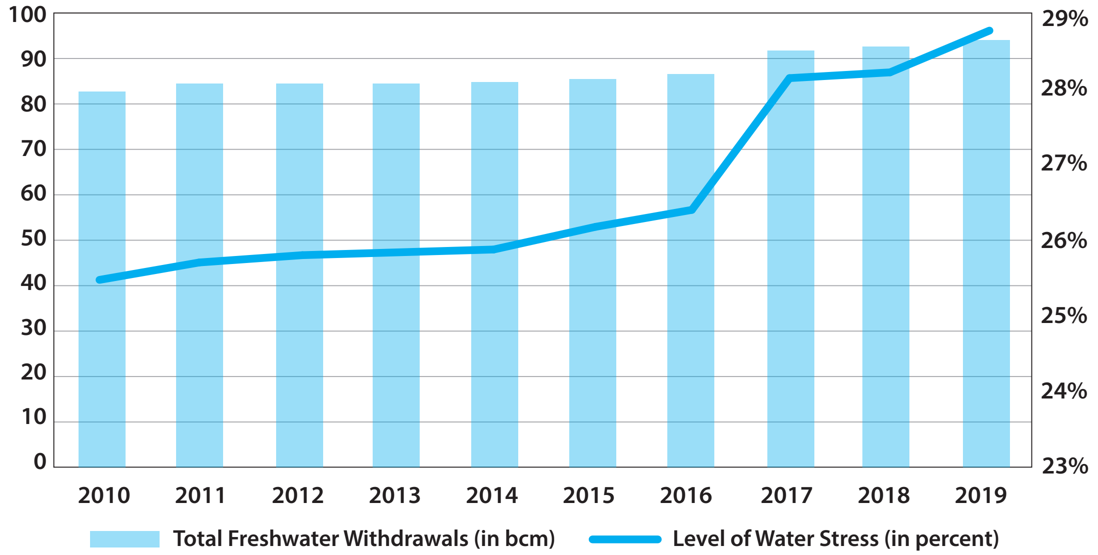
[40]https://www.fao.org/sustainable-development-goals/indicators/642/en/

Figure 6.3 The Philippines water use efficiency by major industry, 2010–2019



Source: PSA (2020)

Figure 6.4 The Philippines level of water stress, 2010-2019



Source: PSA (2020)

7 Realising the potential of water accounting

7.1 Introduction

Realising the potential of water accounting for water governance and management requires an understanding of the strengths and weaknesses of water accounting, as well as the challenges and opportunities for water accounting.

7.2 Strengths and weaknesses of water accounting

The strength of water accounting is that it provides a framework for integrating a wide range of water-related data with other information on the environment and economy. However, this conceptual strength underlines a weakness, because much of the data needed to underpin the accounts remains a key challenge (see Section 7.4). This results in few types of water accounts being produced, under-coverage of water resources (i.e. surface, ground and soil water), and low levels of industry detail. The advantage of accounting is that it makes clear the data gaps and deficiencies that can be addressed (Salminen et al., 2018).

A key data weakness is that although water consumption is reported in many accounts, there is usually a qualification: while the amount of water abstracted from the environment and the water user from the water supply industry are usually known, the flows discharged by industries and sectors to the sewerage network, or directly to the environment, are not known, due to a lack of data. Thus, the accounts generally report water consumption based on the incomplete data, so there is a chance that readers will incorrectly interpret the data. This concern is supported by Weckström et al. (2020) who found that a lack of data meant that the consumptive use of water cannot be reliably calculated at large scale for many industries.

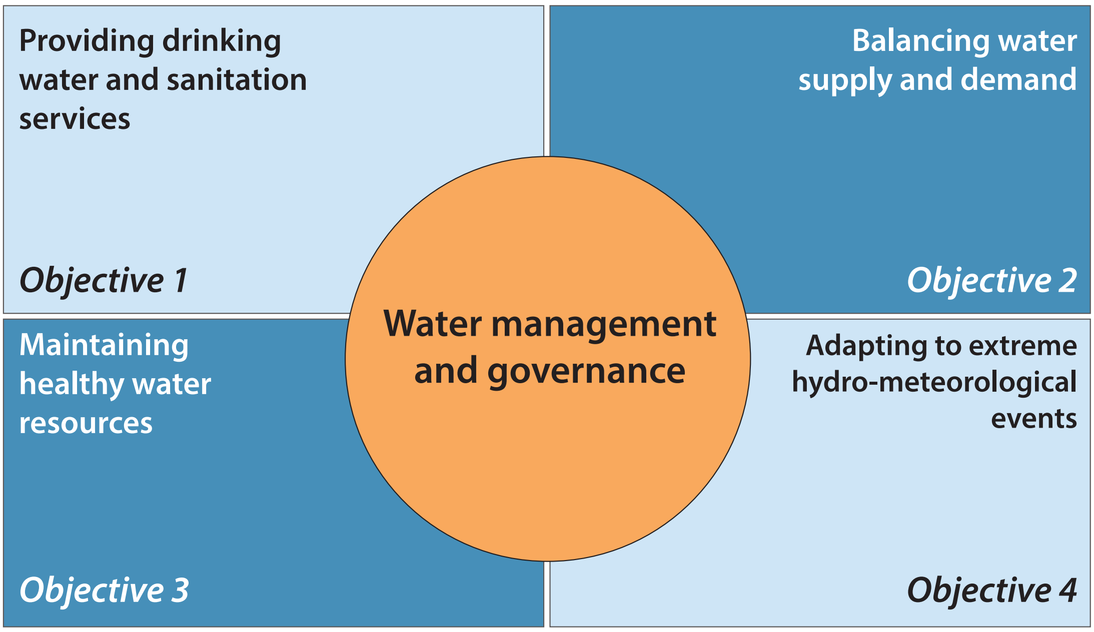
There is often a stop-start pattern in the production of water accounts. The Philippines started producing accounts in the 1990s (Angeles and Peskin, 1998), but there was long gap from these to the latest accounts (PSA, 2020). Similarly, while Namibia has a time series, albeit incomplete, and which dates to 1980 (Lange, 1997), there was little activity until well into the 2000s (MET, 2015), and since then they have not been repeated. This pattern is a weakness that points to a lack of capacity, resources and high-level commitment by government, which are all key factors of success in the production of natural capital accounts (World Bank, 2021).

7.3 Opportunities for water management and governance

SEEA is recognised as providing a conceptual framework for organising hydrological and economic information to support integrated water resource management (IWRM) and integrated land management (ILM).[41, 42] Unfortunately, this recognition has not yet translated into the regular production and use of water accounts.

The opportunities to use water accounts are many and varied. The emphasis of water management and governance in countries and regions depends on the specific characteristics of each society, and the environment in which the water occurs. While there are differences, there are four basic objectives of water management and governance, which can be grouped into four areas (Figure 7.1).

Figure 7.1 Broad grouping of water management and governance objectives



After: UNESCO-WWAP and UNSD 2011

[41]See paragraph 22 of the Report of the Committee of Experts on Environmental-Economic Accounting, 38th Session of the Statistical Commission.

[42]For example, in the conclusions of the *Data for All* sessions of the 5th World Water Forum, and an OECD workshop *Improving the information base to better guide water resource management decision-making,* on improving water information.

Objective 1 of *providing drinking water and sanitation services*, refers to all the governance arrangements that ensure that the population has access to safe drinking water, and a means of disposing excreta. Water and sanitation services are provided to population centres through water supply and sewerage networks, and are operated by water utilities. Many communities and households, especially in low- and middle-income countries, must provide their own water and sewerage services as they are not connected to these networks.

Objective 2 of *balancing water supply and demand*, refers to all the governance arrangements for water allocation to balance the demands for water by society with the physical availability of water. Water demand and water availability change over time and within and between different areas of society without compromising the needs of future generations and of the environment.

Objective 3 of *maintaining healthy water resources*, refers to all the policies aiming to preserve the quality of water resources and the aquatic ecosystems.

Objective 4 of *adapting to extreme hydro-meteorological events*, refers to all the governance arrangements aiming to reduce the negative effects of droughts and floods on people, the economy (and especially agricultural production) and the environment.

Each of these objectives can be linked to different types of water accounts, and examples can be found in several countries (Table 7.1).

7.3.1 Water accounting and the SDGs

Water accounting directly addresses SDG 6. The Philippines has used water accounting to construct some of the indicators related to SDG 6 (see Section 6.6). While the drinking water and sanitation targets are aligned with Objective 1, the indicators for meeting these targets do not directly emerge from the accounts. Nevertheless, the information from the accounts can be used for the governance and management of water to help achieve the objective, examining the amount available to be supplied and the amount used by households, as well as the cost of supplying the water and the price paid for the water (the prices paid for water do not usually reflect the cost of production). Analyses using the data from water accounts can be used to estimate the cost of providing water to additional households, and to forecast future demand.

7.4 Meeting the challenges for water accounting

There are two types of challenge in water accounting. The first is the technical challenge of *producing* accounts, including data limitations and moving from experimental to regular and ongoing production of accounts. The second is *using* accounting in water management and policy, a challenge of awareness and understanding. This second type of challenge can be framed as an opportunity, as seen in Section 5.3, and how to meet this challenge and realise the opportunity is the focus of this section.

7.4.1 Technical challenges

Valuation of water that is not exchanged in markets is an ongoing conceptual and practical challenge. The use of exchange values is embedded in the SNA and SEEA. Some exchange values are observable, however because of the characteristics of water and water markets

Table 7.1 Links between natural capital accounts and key water policy areas and concepts

Policy area	Key concept	
	Full cost recovery	**Integrated water resource management**
Providing drinking water and sanitation services	• Physical and monetary water supply and use tables • SNA accounts (emphasis of the water supply and sewerage industries) • Environment protection expenditure accounts • Water asset accounts	• Physical and monetary water supply and use tables • Land cover and land use accounts
Managing water supply and demand	• Physical and monetary water supply and use tables • Water asset accounts • Land cover and land use accounts • SNA accounts (emphasis on the water supply and sewerage industries)	• Land cover and land use accounts • Physical and monetary water supply and use tables • Water asset accounts
Maintaining healthy water resources	• Physical and monetary water supply and use tables (emphasis on return flows and operation on sewerage collection and treatment) • Land cover and land use accounts • Water quality accounts • Environment protection expenditure accounts	• Land cover and land use accounts • Physical and monetary water supply and use tables • Water asset accounts
Adapting to extreme hydro-meteorological events	• Land cover accounts • Water asset accounts • Environment protection expenditure accounts • Ecosystem service accounts (for flood protection and regulation of water flows)	• Land cover accounts • Water asset accounts • Environment protection expenditure accounts • Ecosystem service accounts (for flood protection and regulation of water flows)

Source: After Vardon et al. (2018)

(Chapter 3) this is not a "true" reflection of value. This is recognised in the SEEA (UN et al., 2021), and a range of alternative methods have been used in accounting, for example replacement cost (Edens and Graveland, 2014; 2013; Keith et al., 2017). Moreover, many existing water valuation methods are consistent with exchange values.

After valuation, the two most common factors impeding the production of water accounts are (1) data availability and (2) data quality (Vardon et al., 2012). Countries often have some of the data needed for the water accounts, but no country has access to all the data needed to produce the full suite of water accounts: physical and monetary supply-use tables, asset accounts, environmental protection expenditure related to water, water quality and emissions to water. Consequently, those producing accounts rely on a range of estimation methods to populate different parts of the water accounts. In some cases, data may exist but the agency or agencies producing the accounts may not be able to access the data for legal, administrative, or technical reasons.

Based on the Finnish experience of water account compilation, Salminen et al. (2018) provided a detailed analysis of data quality issues. They identify two potential sources of error in the estimates of water use. The first is poor data coverage of some industries resulting in unreliable estimates of the total water supply and use for these industries. The second source of error is for industries with high coverage where the total amounts of water are likely correct but cannot be reliably allocated to different sources of water (e.g. self-abstracted vs. mains water or between industries).

In the analysis of data under coverage, Salminen et al. (2018) compared the water use and data coverage for the 195 industries of the Finnish economy. Nine out of ten of the industries with very high-water use (>380 million m^3 per annum) had good data coverage, representing 75–90% of the economic activity of these industries, while half of the industries with very limited data were industries with low or negligible water use (<38,000 m^3 per annum). Six industries with medium water use (38,000 to 4.2 million m^3 per annum) and one of high-water use were identified as priorities for additional data collection: metal product and machinery repair, trade and repair of motor vehicles, wholesale trade excluding food and beverages, transportation supporting activities, religious organisations, beauty treatment and restaurants. Salminen et al. (2018) suggested that additional surveys could provide the coverage needed to provide more accurate data for these industries.

The misallocation of water supply and use is particularly relevant for the water supply and agricultural industries. Misallocation can be due to the source of water (i.e. surface water, groundwater, or soil water) or to industry and sector.

For the water supply industry, the total water supply is likely correct because that industry usually has good data coverage, as has been quantified for Finland (Salminen et al., 2018). Further, while total supply of the distributed water ("Natural Water" CPC 1800) is usually known, its use by industries and households may not be. That is, while the overall water balance is not affected (i.e. total supply equals total use of distributed water), the amount used by each industry or sector may be incorrect. Water suppliers typically have registers of customers. If the customers are coded to a particular type of industry or sector, then it is usually at a high level, for example, residential, commercial and agricultural. The databases of customers may be upgraded and include more codes of customers or samples of customers used to estimate uses, as has been done Botswana where the Water Utilities Corporation uses 10 customer codes (DWS, 2021).

The suppliers of water for irrigated agriculture may not know the commodities for which the water is used, or of the water used for agriculture production how much is from distributed water, self-abstracted water and soil moisture. Estimates of total agricultural use can be made through information on the area used for agricultural production and the water use coefficients for crops (e.g. for CropWat[43]) and livestock (e.g. WA+[44]). If agricultural production is rain-fed agriculture, then all water use can be assigned to soil water. When irrigated, then the amount of distributed water applied can be deducted and the residual assigned to soil water. All of this requires assumptions, and the accuracy of estimates is ultimately difficult to determine. Measurement is also required to estimate water consumption, which is less than the water used.

Accuracy is often the focus of data quality in water accounting; however accuracy is just one of several dimensions of data quality. Data quality frameworks are available from a range of sources. For example, the Australian Bureau of Statistics (ABS, 2009), Eurostat (2005), IMF (2012), OECD (2012), Statistics Canada (2002), and Clarke et al. (2011). The frameworks

[43]https://www.fao.org/land-water/databases-and-software/cropwat/en/

[44]https://wateraccounting.un-ihe.org/welcome-water-accounting-plus-0

from national statistical offices and international organisations are all similar, and in general describe six dimensions of data quality:

1. **Relevance** is how well the data meet the needs of users in terms of the concept(s) measured, and the population(s) represented
2. **Accuracy** refers to the degree to which the data correctly describe the phenomenon they were designed to measure
3. **Timeliness** is the delay between the reference period (the time to which the data pertain) and the date at which the data become available (i.e. the release date)
4. **Accessibility** is the ease of access to data by users, including the ease with which the existence of information can be ascertained, as well as the suitability of the form or medium through which information can be accessed
5. **Interpretability** is the availability of information to help provide insight into the data
6. **Coherence** is the internal consistency of a statistical collection, product, or release, as well as its comparability with other sources of information, within a broad analytical framework and over time

Of these, the key challenges for water accounting are *relevance*, *coherence* and *timeliness*.

For relevance, accounts are often limited in scope, not including all water resources and using highly aggregated industry classifications, valuation is uncommon, and accounts are irregularly produced. Such factors mean that accounts' relevance to decision makers is limited.

Coherence with other information sources is not always evident. Non-SEEA water accounting cannot be directly linked to the information from the SNA, nor other types of environmental accounts, for example due to the use of different definitions or classifications. A key reason for using SEEA is to have a coherent and integrated information system. Lack of coherence also means the water accounts are less relevant.

For timeliness, the review of water accounting (Chapter 4) found that most water accounts were published well after the reference period. If accounts are to be built into decision-making processes, then they will need to present current (timely) information on a frequent basis (e.g. annually). Lack of timeliness again means the water accounts are less relevant.

7.4.2 Challenge of awareness and understanding

A key driver of this report is to raise awareness and understanding of water accounting. That is, decision makers need to know how water accounting is relevant to their needs. This starts with a mapping of their needs, which is framed as an opportunity in Section 7.3.

Improved communication of what accounting is, and how it can be used, is one way to meet this challenge. At one level is briefing senior officials and providing summaries for policy makers. This informs the decision makers but needs to be complemented by material for civil society, and by engagement with the research and analytical community, requiring a range of communication materials. This is also related to the education pathway for water accounting. Environmental accounting is taught in a few universities[45], either as a stand-alone course or

[45]The Australian National University currently includes modules on environmental accounting in several undergraduate and postgraduate courses, as well as a specialist professional development course (see https://fennerschool.anu.edu.au/introduction-environmental-accounting)

included with other subjects, like natural resource economics, environmental management, public or sustainability reporting. Some online material is available,[46] and the WAVES and NCAVES programs both developed a suite of material and knowledge platforms, which were used in the review (see Section 5.2).

There is need for acceptance and use of water accounting in research analysis. The water accounts reveal what has happened, how water was used by whom, and what were the economic and environmental outcomes. Decision makers need to have options assessed, which means that the accounts alone are not enough. The information must be interpreted and analysed. The data from water can and have been used for modelling and scenario forecasting (e.g. Lenzen and Foran, 2001; Wittwer, 2012; Pedro-Monzonís et al., 2016b; Baneerje et al., 2019).

The research and analytical communities have a key role to play in raising the awareness and understanding of water accounting, through using the accounts in research designed to inform water management and policy. Such research needs to be encouraged and promoted within agencies specifically responsible for water management and policy, as well as central agencies responsible for overall environmental and economic management and policy.

8 Lessons and best practice

8.1 Lessons

For more than 30 years, the water accounting community has grown, and the number of accounts being prepared and the number of people and organisations actively preparing accounts is increasing. The community is diverse, with accountants, economists, hydrologists, statisticians and others working together to create many accounts in many different contexts. Yet the community, while diverse and increasing in size, remains small.

Our report highlights that production of water accounts is possible. Production requires goodwill and cooperation between agencies and professions, and when this occurs data gaps and deficiencies, and the difficulties of valuation in alignment with exchange values, can be overcome. Experience has shown that water accounts are produced in a range of socioeconomic and environmental circumstances, for low- to high-income countries (e.g. Zambia and The Netherlands), in places of different water scarcity (e.g. Botswana and The Philippines), and at different spatial scales, from river basins (e.g. Colombia) and small island states (e.g. Palau) to large countries (e.g. Australia). Accounts have different levels of economic (e.g. number of industries) and hydrological (e.g. number of water sources and water flows) information recorded.

While there is increasing water accounting activity, in most cases it has remained in an experimental phase, with short time series and irregular (stop-start) or one-off production. Ongoing water accounts production occurs only in a handful of countries. Water valuation beyond exchange value is still contentious. Many existing water valuation methods align with exchange values, and examples of valuation are increasing.

[46] https://seea.un.org/content/seea-e-learning-resources

There is recognition that water accounting is useful, and there are examples of water accounting uses, but such use is not common and has yet to be embedded in the decision-making processes of water management and governance. This lack of embedding is related to several factors, including the irregular and experimental nature of most accounts.

The lack of embedding in decision-making can be distilled to two interrelated problems:

- Decision makers have little awareness or understanding of water accounts and rely on existing water data sources.
- Water accounts take resources and time to produce and are often seen as a threat to existing water data providers, which can often lead to competition rather than collaboration. The problem is often exacerbated by misunderstandings on technical matters between different disciplines and agencies.

To overcome these problems the process of account production is key. There are three general models of account production, and each model has its strengths and weaknesses:

- *Production led by statistical agencies*. This generally ensures close linking with other SEEA-based accounts, the SNA and associated economic data, with a strong emphasis on integration and a focus on ongoing account production. A downside is that accounts will often take several years to produce and require substantial capacity building and technical inputs and data from a range of water and research institutions, and this in an environment that is usually separated from account users and their needs.
- *Production led by government agencies* concerned with water, natural resources or environmental management and policy. In this model, the accounts are produced to suit the needs of a particular agency. This ensures linkages to policy analysis and resource management but can mean that water accounts are produced in a silo and not easily integrated into other types of SEEA accounts or the SNA.
- *Production led by research agencies* (e.g. universities). In these projects, the accounts are generally produced relatively quickly (12–18 months) and use the latest knowledge and information. Interpretation and analysis are prominent, but there is no view to ongoing production as there is in government agencies.

The *raison d'être* for water accounting is integration of information for decision-making. Taking the strengths of each production model should lead to better outcomes, with more and better-quality data, easier integration of information, relevant, regular and timely accounts and embedding in decision-making.

General factors of success for developing and using environmental-economic accounting programs are identified by the World Bank (2021) and Ruijs et al. (2019) (Table 8.1). The keys to success are:

- **Mandate**: Continuing high-level support for developing and using environmental-economic accounting is essential. Champions are needed, and without ongoing high-level support accounting can be stuck in an experimental phase for years and be unable to reach its potential.

- **Engagement and communication**: Few people are aware of environmental accounting, and even fewer understand the information accounts contain or how it can be used. Communication is needed to engage stakeholders, ensure that the accounts are visible and understood, and target specific audiences.
- **Policy relevance**: Environmental-economic accounts must be relevant to environmental policy and management. For relevance, accounts need to be tailored, meeting the needs of specific areas, which may be from local through to national, particular industries, or groups within society (e.g. rural poor).
- **Cooperation and coordination**: A process is needed effectively to organise environmental-economic accounting producers, users and quality assurers. This has strategic and technical aspects, with high-level groups providing the former, and formal working groups and a broader community of practice addressing technical aspects. Both the strategic and technical areas are needed for developing and using accounts, ensuring accounts' ongoing production and use, and for embedding accounts in decision-making.
- **Continuous improvement**: Data are seldom complete or perfect, but accounts can usually be produced. Accounts can be improved over time, both in terms of increasing data quality and in the policy relevance.

These five factors lead to credibility and trust in the accounts, and in turn the decisions based on their information. The policy relevance is generally missing from most accounting programs (Vardon et al., 2016).

8.2 Towards best practice

A key to water accounting success is cooperation and collaboration within and between data providers and decision makers, and so best practice must support cooperation and collaboration. This is achieved through processes that ensure the mutual understanding and respect of knowledge, and the clear articulation of the aims and objectives of water accounting initiatives. That is it needs to go beyond that of account production and be part of decision-making about water.

Best practice involves establishing water accounting processes aligned with the 10 principles for making environmental accounts fit for policy (Table 8.1). The approach aligns with the process outlined by Batchelor et al. (2016) in Figure 8.1, i.e. focused on the biophysical data. The application of a principles-based process is necessary as each region or country has a unique set of stakeholders and institutional arrangements for water governance and management that sits within a broader socioeconomic framework and environmental context.

For the technical aspects of account production and use, best practices are more easily identified. Indicators that a country is moving towards best practice are presented in Table 8.2.

The experience of the past three decades has shown what can be done and how water accounting can be improved. It has enabled best practices to be identified. Progress towards best practice can be made with high-level support, allocation of sufficient resources, and by recognising the usefulness of water accounting.

Table 8.1 Ten principles for making environmental accounts fit for policy

Comprehensive:	
1. Inclusive	Acknowledging the diverse stakeholders concerned with decisions affecting natural capital, responding to their information demands, respecting different notions of value, and using appropriate means of engagement.
2. Collaborative	Linking the producers of environmental accounts the users of environmental accounts for policy analysis, and the policy makers using the environmental accounts' results, and building their mutual understanding, trust and ability to work together.
3. Holistic	Adopting a comprehensive, multi/interdisciplinary approach to the economic and environmental dimensions of natural capital, and to their complex links with policy and practice.
Purposeful:	
4. Decision-centred	Providing relevant and timely information for indicator development and policy analysis to improve and implement decisions with implications for natural capital.
5. Demand-led	Providing information demanded or needed by decision makers at specific levels.
Trustworthy:	
6. Transparent and open	Enabling and encouraging public access and use of environmental accounts, with clear communication of the results and their interpretation, including limitations of the data sources, methods and/or coverage.
7. Credible	Compiling, assessing and streamlining data from all available sources, and deploying objective and consistent science and methodologies.
Mainstreamed:	
8. Enduring	With adequate, predictable resourcing over time; continuous application and availability; and building increasingly rich time series of data.
9. Continuously improving	Learning focused, networked across practitioners and users, testing new approaches, and evolving systems to better manage uncertainty, embrace innovation, and take advantage of emerging opportunities.
10. Embedded	Environmental account production and use becoming part of the machinery of government and business, building capacity, improving institutional integration for sustainable development, and incorporating environmental accounts' use in procedures and decision-support mechanisms.

Source: Ruijs et al. (2019)

Figure 8.1 Water accounting process

1. Detailed water accounting planning

- For the first iterative cycle, finalise planning activities started in the inception phase. For subsequent iterative cycles take account of lessons from previous cycle(s) of water accounting and auditing e.g. modify/adapt domains, strategies, methodologies etc;
- Stakeholder dialogue and concerted action leading to prioritisation of next cycle of activities assessments and analysis;
- Agreement on expected outputs of next cycle of activities.

2. Biophysical information acquisition and management

- Combined biophysical and societal information needs assessment;
- Identification of secondary information sources for currenet cycle. If relevant, planning and implementing a programme of primary information collection;
- Information acquisition, processing and quality control;
- Storage and sharing (e.g. data, metadata, maps, reports, photographs, etc).

3. Targeted biophysical assessments

- Plan and implement targeted assessments of current status of and trends in, for example: water resources depletion; land management systems; water supply; storage and treatment; infrastructure etc;
- Compare/triangulate findings/outputs against information from independent sources;
- Share and discuss outputs/findings of each assessment with stakeholders. Resolve differences of opinion and take account of feedback.

4. Multi-scalar analysis and modelling of water flows, fluxes and stocks

- Use outputs from targeted assessments as a basis for selecting, setting up, calibrating and validating hydrological models;
- Use empirical data collected and models to support e.g. multi-scalar fractional and water balance analysis;
- Produce, tabulate and map multi-scalar estimates of water flows, fluxes and stocks under different conditions;
- Consolidate, share and discuss findings and outputs with stakeholders.

Source: Batchelor et al. (2016)

Table 8.2 Indicators of progress towards best practice water accounting

Aspect	Indicator
Process	Processes are established for: • stakeholder engagement • data exchange between agencies • data management • capacity building • continuous improvement • analysis of accounts, their use in decision-making processes and tools
Relevance	Accounts are built into decision-making process. For example: • water allocation • water price setting • water investment decisions • water policies • catchment management planning
Frequency	Accounts are produced annually to a pre-determined schedule
Timeliness	The accounts are available within a year of the reference period (e.g. if the data are for 2021, the account should be available by end of 2022)
Ongoing	Accounts have ongoing resourcing
Coherence	Accounts use SEEA-based classifications and standards enabling the integration production of different types of water accounts and for water accounts to be integrated with other SEEA and SNA accounts
Accuracy	Accounts are of sufficient accuracy to inform decision-making. Quantitative and qualitive measures of accuracy are equally appropriate
Accessibility	Accounts: • are easily discoverable • are available online • provide summary descriptions (not just tables)
Interpretability	Accounts are accompanied by methodological and other material that enable the information to be understood
Comprehensive	Account should be produced for: • physical supply and use • physical assets • monetary supply and use • emissions • quality • water related environment protection expenditure
Water resource coverage	Accounts should include: • all forms of surface water, groundwater and soil water • where applicable, desalinated and reuse water • the product “Natural Water” (CPC 1800) • where applicable, “Bottled Water” (CPC 243)

Aspect	Indicator
Industry and sector coverage	Accounts should separately identify the main water suppliers and users, including: • households • water supply industry • agriculture (split by major commodities) • mining • manufacturing • energy (with hydroelectric power generation separately identified) • service industries (health, education, etc.)
Spatial coverage	Scalable accounts. Coverage can be built up from regional level accounts to national or multinational, or vice versa
Valuation	Is done in accordance with the concept of exchange values
Integration	Water accounts are integrated with other accounts and information (e.g. SNA, land accounts, ecosystem accounts

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Annex 1 SEEA Water Glossary

Source: SEEA Water (UN, 2012a)

Abstraction: The amount of water that is removed from any source, either permanently or temporarily, in a given period of time for final consumption and production activities. Water used for hydroelectric power generation is also considered to be abstraction. Total water abstraction can be broken down according to the type of source, such as water resources and other sources, and the type of use. (EDG)

Abstraction for distribution: Water abstracted for the purpose of its distribution. (EDG)

Abstraction for own use: Water abstracted for own use. However, once water is used, it can be delivered to another user for reuse or for treatment. (EDG)

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

Actual final consumption of general government: The value of the government's total final consumption expenditure less its expenditure on individual goods or services provided as social transfers in kind to households. It is thus the value of the expenditures that the government incurs on collective services. (Based on 2008 SNA, paras. 9.103)

Actual final consumption of households: The value of the consumption of goods and services acquired by individual households, including expenditures on non-market goods or services sold at prices that are not economically significant, and the value of expenditures provided by government and NPISHs. (2008 SNA, para. 9.81)

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

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

Brackish water: Water with a salinity content between that of freshwater and marine water. (EDG)

Catchment (synonym: river basin): An area having a common outlet for its surface run-off. (UNESCO/WMO International Glossary of Hydrology, 2nd ed., 1992)

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

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

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

Emission to water: Direct release of a pollutant into water, as well as its indirect release by transfer to an off-site wastewater treatment plant. (Based on the European Commission, 2000)

Evapotranspiration: The quantity of water transferred from the soil to the atmosphere by evaporation and plant transpiration. (EDG)

Exports: Water that exits the territory of reference through mains or other forms of infrastructure. (EDG)

Final consumption expenditure of households: The expenditure, including imputed expenditure, incurred by resident households on individual consumption goods and services, including those sold at prices that are not economically significant. (2008 SNA, para. 9.94)

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

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

Gross capital formation: The total value of the gross fixed capital formation, changes in inventories and acquisitions less disposal of valuables for a unit or sector. (2008 SNA, para. 10.31)

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

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

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

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

Imports: Water that enters the territory of reference through mains or other forms of infrastructure. (EDG) Inflow: Water that flows into a stream, lake, reservoir, container, basin, aquifer system, etc. It includes inflows from other territories/countries and inflows from other resources within the territory. (EDG)

Intermediate consumption: The value of the goods and services consumed as inputs by a process of production, excluding fixed assets, the consumption of which is recorded as consumption of fixed capital; the goods or services may be either transformed or used up by the production process. (Based on 2008 SNA, para 6.213)

Irrigation water: Water artificially applied to land for agricultural purposes. (UNESCO/ WMO International Glossary of Hydrology, 2nd ed., 1992)

Lake: A generally large body of standing water occupying a depression in the Earth's surface. (EDG)

Mine water (synonym: mining water use): Water used for the extraction of naturally occurring minerals including coal, ores, petroleum, and natural gas. It includes water associated with quarrying, dewatering, milling and other on-site activities carried out as part of mining. Excludes water used for processing, such as smelting and refining, or slurry pipeline (industrial water use). (USGS, available from http://pubs.usgs.gov/chapter11/chapter11M.html)

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

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

Outflow: Flow of water out of a stream, lake, reservoir, container, basin, aquifer system, etc. It includes outflows to other territories/countries, to the sea and to other resources within the territory. (EDG)

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

Point source of pollution: Emissions for which the geographical location of the discharge of the wastewater is clearly identified, for example, emissions from wastewater treatment plants, power plants and other industrial establishments.

Population equivalents: One population equivalent (p.e.) means the organic biodegradable load having a five-day biochemical oxygen demand (BOD5) of 60g of oxygen per day. (OECD/ Eurostat joint questionnaire on inland water).

Potential evapotranspiration: The maximum quantity of water capable of being evaporated in a given climate from a continuous stretch of vegetation covering the whole ground well supplied with water. It thus includes evaporation from the soil and transpiration from the vegetation of a specified region in a given time interval, expressed as depth. (EDG)

Precipitation: The total volume of atmospheric wet precipitation, such as rain, snow, and hail, on a territory in a given period of time. (EDG)

Recycled water: The reuse of water within the same industry or establishment (on site). (EDG)

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

Rivers and streams: Bodies of water flowing continuously or periodically in a channel. (EDG)

River basin (see also catchment): An area having a common outlet for its surface run-off. (EDG)

Run-off: The part of precipitation in each country/territory and period of time that appears as stream flow. (EDG)

Sewage sludge: The accumulated settled solids separated from various types of water, either moist or mixed with a liquid component, as a result of natural or artificial processes. (OECD/Eurostat joint questionnaire on inland water)

Social transfers in kind: Individual goods and services provided as transfers in kind to individual households by government units (including social security funds) and NPISHs, whether purchased on the market or produced as non-market output by government units or NPISHs; the items included are: (a) social security benefits and reimbursements; (b) other social security benefits in kind; (c) social assistance benefits in kind; and (d) transfers of individual non-market goods or services. (Based on 2008 SNA, para 8.141)

Soil water: Water suspended in the uppermost belt of soil, or in the zone of aeration near the ground surface that can be discharged into the atmosphere by evapotranspiration. (EDG)

Standard river unit (SRU): A river stretch of one kilometre with a water flow of one cubic meter per second. (SEEA-2003, para. 8.128)

Supply of water to other economic units: The amount of water that is supplied by one economic unit to another and recorded net of losses in distribution. (EDG)

Surface water: Water which flows over, or is stored on, the ground surface. It includes artificial reservoirs, lakes, rivers and streams, glaciers, snow, and ice. (EDG)

Trade margin: The difference between the actual or imputed price realised on a good purchased for resale (either wholesale or retail) and the price that would have to be paid by the distributor to replace the good at the time it is sold or otherwise disposed of. (2008 SNA, para 6.146)

Transboundary waters: Surface or groundwaters which mark, cross or are located on boundaries between two or more States; wherever transboundary waters flow directly into the sea, these transboundary waters end at a straight line across their respective mouths between points on the low-water line of the banks. (UNECE, 1992, available from http://www.unece.org/env/water/pdf/watercon.pdf)

Transport margin: Transport charges payable separately by the purchaser in taking delivery of goods at the required time and place. (2008 SNA, para. 6.141)

Urban run-off: That portion of precipitation on urban areas that does not naturally percolate into the ground or evaporate, but flows via overland flow, underflow, or channels, or is piped into a defined surface water channel or a constructed infiltration facility.

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

Wastewater: Water which is of no further immediate value to the purpose for which it was used, or in the pursuit of which it was produced, because of its quality, quantity, or time of occurrence. However, wastewater from one user can be a potential supply of water to a user elsewhere. It includes discharges of cooling water. (EDG)

Watercourse: A natural or constructed channel through or along which water may flow. (UNESCO/WMO International Glossary of Hydrology, 2nd ed., 1992)

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

Water consumption: That part of water use which is not distributed to other economic units and does not return to the environment (to water resources, sea and ocean) because during use it has been incorporated into products or consumed by households or livestock. It is calculated as the difference between total use and total supply; thus, it may include losses due to evaporation occurring in distribution and apparent losses due to illegal tapping as well as malfunctioning metering. (EDG)

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

Water returns: Water that is returned into the environment by an economic unit during a given period after use. Returns can be classified according to the receiving media (water resources and sea water) and to the type of water, such as treated water and cooling water). (EDG)

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

Water supply to the environment: see water returns.

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

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

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

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

Annex 2 List of water accounting tables

Source: SEEA Water (UN, 2012a)

1 Standard tables

A1 1. Standard physical supply and use tables for water
  J. Supply (physical units)
  K. Use (physical units)

A1 2. Emission accounts tables
  A. Gross and net emissions table (physical units)
  B. Emissions by ISIC division 37 table (physical units)

A1.3. Hybrid supply and use tables
  A. Hybrid supply table (physical and monetary units)
  B. Hybrid use table (physical and monetary units)

A1.4. Hybrid account table for supply and use of water (physical and monetary units)

A1.5. Hybrid account table for water supply and sewerage for own use (physical and monetary units)

A1.6. Government account table for water-related collective consumption services

A1.7. National expenditure account tables
  A. For wastewater management (monetary units)
  B. For water management and exploitation (monetary units)

A1.8. Financing account tables
  A. For wastewater management (monetary units)
  B. For water management and exploitation (monetary units)

A1.9. Asset account table (physical units)

2 Supplementary tables

A2.1. Supplementary information to the physical supply and use tables (and expansion of the standard physical supply and use, listed above)
- A. Physical use table (physical units)
- B. Physical supply table (physical units)

A2.1. Supplementary information to the physical supply and use tables
- A. Physical use table
- B. Physical supply table

A2.2. Matrix of flows of water within the economy

A2.3. Supplementary information to the emission accounts
- A. Gross and net emissions
- B. Emissions by ISIC division 37
- C. Sludge indicators

A2.4. Supplementary information to hybrid and economic accounts.
- A. Economic accounts—supplementary information
- B. National expenditure accounts for the protection and remediation of soil, groundwater, and surface water
- C. Financing accounts for the protection and remediation of soil, groundwater, and surface water

A2.5. Supplementary information to the asset accounts
- A. Matrix of flows between water resources

A2.6. Quality accounts

A2.7. Supplementary information to the water accounts: social indicators

3 Indicator tables

A3.1. Selected indicators of water resource availability and pressure on water derived from water accounts

A3.2. Selected indicators of water intensity and water productivity

A3.3. Indicators of opportunities to increase effective water supply

A3.4. Indicators of costs and price of water and wastewater treatment services

A3.5. Indicators of selected challenge areas from the United Nations World Water Development Report 2

Annex 3 Full water supply and use account

Source: SEEA Central Framework (UN, 2014); Grey cells are null by definition

Physical supply table for water	Abstraction of water; Production of water; Generation of return flows							Flows from the rest of the world		
	Agriculture, forestry and fishing	Mining & quarrying, Manufac-turing and Construction	Electricity, gas, steam and air conditioning supply	Water collec-tion, treat-ment and supply	Sewerage	Other indus-tries	Households	Imports	Flows from the Environ-ment	Total supply
(I) Sources of abstracted water										
Inland water resources										
Surface water									440.6	440.6
Groundwater									476.3	476.3
Soil water									50.0	50.0
Total									966.9	966.9
Other water sources										
Precipitation									101.0	101.0
Sea water									101.1	101.1
Total									202.1	202.1
Total supply abstracted water									1169.0	1169.0
(II) Abstracted water										
For distribution				378.2						378.2
For own-use	108.4	114.6	404.2	13.9	100.1	2.3				743.5
(III) Wastewater and reused water										
Wastewater										
Wastewater to treatment	17.9	117.6	5.6	1.4	0	49.1	235.5			427.1

Physical supply table for water	Abstraction of water; Production of water; Generation of return flows							Flows from the rest of the world		
	Agriculture, forestry and fishing	Mining & quarrying, Manufacturing and Construction	Electricity, gas, steam and air conditioning supply	Water collection, treatment and supply	Sewerage	Other industries	Households	Imports	Flows from the Environment	Total supply
Own treatment										0.0
Reused water										
For distribution					42.7					42.7
For own use		10.0								10.0
Total	17.9	127.6	5.6	1.4	42.7	49.1	235.5			479.8
(IV) Return flows of water										
To inland water resources										
Surface water			300.0		52.5	0.2	0.5			353.2
Ground water	65.0	23.5		47.3	175.0	0.5	4.1			315.4
Soil water										
Total	65.0	23.5	300.0	47.3	227.5	0.7	4.6			668.6
To other sources		5.9	100.0		256.3		0.2			362.4
Total return flows	65.0	29.4	400.0	47.3	483.8	0.7	4.8			1031.0
of which: Losses in distribution				47.3						47.3
(V) Evaporation of abstracted water, transpiration and water incorporated into products										
Evaporation of abstracted water	29.5	38.3	2.5	1.8	0.7	3.6	10.0			86.4
Transpiration	40.2	1.2								41.4
Water incorporated into products	6.5	3.7								10.2
TOTAL SUPPLY	**267.5**	**314.8**	**812.3**	**442.6**	**627.3**	**55.7**	**250.3**		**1169**	**3939.5**

Physical use table for water

	Abstraction of water; Intermediate consumption; Return flows						Final consumption		Flows to the rest of the world		
	Agriculture, forestry and fishing	Mining & quarrying, Manufacturing and Construction	Electricity, gas, steam and air conditioning supply	Water collection, treatment and supply	Sewerage	Other industries	Households	Accumulation	Exports	Flows from the Environment	Total use
(I) Sources of abstracted water											
Inland water resources											
Surface water	55.3	79.7	301.0	4.5	0.1						440.6
Groundwater	3.1	34.8	3.2	432.9		2.3					476.3
Soil water	50.0										50.0
Total	108.4	114.5	304.2	437.4	0.1	2.3					966.9
Other water sources											
Precipitation				1.0	100.0						101.0
Sea water			100.0	1.1							101.1
Total	0.0	0.0	100.0	2.1	100.0	0.0					202.1
Total supply abstracted water	108.4	114.5	404.2	439.5	100.1	2.3					1169.0
(II) Abstracted water											
Distributed water	38.7	45	3.9	0.0	0.0	51.1	239.5				378.2
Own-use	108.4	114.6	404.2	3.1	100.1	2.3	10.8				743.5

	Abstraction of water; Intermediate consumption; Return flows						Final consumption		Flows to the rest of the world		
	Agriculture, forestry and fishing	Mining & quarrying, Manufacturing and Construction	Electricity, gas, steam and air conditioning supply	Water collection, treatment and supply	Sewerage	Other industries	Households	Accumulation	Exports	Flows from the Environment	Total use
(III) Wastewater and reused water											
Wastewater											
Wastewater from other units					427.1						427.1
Own treatment											0.0
Reused water											
For distribution	2.0	40.7									42.7
For own use	10.0										10.0
Total	12.0	40.7	0.0	0.0	427.1	0.0	0.0	0.0		0.0	479.8
(IV) Return flows of water											
Returns of water to the environment											
To inland water resources										668.6	668.6
To other sources										362.4	362.4
Total return flows										1031.0	1031.0
(V) Evaporation of abstracted water, transpiration and water incorporated into products											
Evaporation of abstracted water										86.4	86.4
Transpiration										41.4	41.4
Water incorporated into products								10.2			10.2
TOTAL USE	**267.5**	**314.8**	**812.3**	**442.6**	**627.3**	**55.7**	**250.3**	**10.2**		**1158.8**	**3939.5**

Annex 4 Database metadata

#	Variable Name	Description
I	General information	
	Country_Code	ISO-3 letter country code
	Country_Name	Name of the country or the region in the world
	Account_Code	Unique letter code assigned to the water account
	Account_Label	Label of the water account
	Publisher	Name of agencies or academic journals who are engaged in the production of the water account
	Water_Type_of_publisher	Type of agency engaged in the production of the water account (National statistical office; National water; Scientific information agency; Economic information agency; International agency; Department of Water; Department of Environment; Other government department; Catchment management authority; Water supply industry; Academic organisation; Others)
	Responding_authority	Authorities/authors in charge and take lead in producing the water account
	Independence_status	Whether the account is published as a stand-alone water account or with other accounts (Yes/No)
	Included_in_what_accounts	The accounts that include the water account if the water account is not published independently
	Account_name_set_by_country	Water account named by the country/authors
	Insitutionalized_status	Whether water accounting has been institutionalised or still in project-based pilot (Yes/No). This is identified by the time series or if the water account is embedded in official statistical system
	Project_details	Some details of the project (if any) that support the construction of water account
	Applications	Some highlight applications of water account in practice
	Water_Source_of_account	Source from which the water account is found and accessed (Original source; UN survey site; WAVES Knowledge Centre; UN Knowledge base; Google search; Systematic Scopus search; Others)
	Source_of_account_details	Specify the source of the water account if it is not listed in the categories
	Water_Source_of_reviewed_document	Source from which the reviewed documents on the water account is found and accessed (Original source; UN survey site; WAVES Knowledge Centre; UN Knowledge base; Journal website; Google search; Others)
	Source_of_reviewed_document_details	Specify the source of reviewed documents if it is not listed in the categories
	Search_strategy	Describe how the water account is found (Original source; UN survey site; WAVES Knowledge Centre; UN Knowledge base; Scopus search; Google search; Others)
	Search_strategy_details	Specify other strategies if it is not listed in the categories
	Link	Links to the water account and reviewed documents

#	Variable Name	Description
	Availability	The form that the water account is available for access (Data portal for self-extraction; online pdf that can be downloaded; online spreadsheet that can be downloaded; webpage; others)
	Water_Compiled_account	Whether the water is found and compiled as claimed (Claimed and complied: the water account is claimed by the country itself or in reviewed documents and complied Not found: the water account is claimed in reviewed documents but not found yet)
	Water_Region_WB	Classification of countries by region (East Asia and Pacific, Europe and Central Asia, Latin America and Caribbean, Middle East and North Africa, North America, South Asia, Sub-Saharan Africa) (WB, 2022)
	Water_Income	Classification of countries by income level (WB, 2022): Countries are divided among income groups according to 2022 gross national income (GNI) per capita: low income, $1,085 or less; lower middle income, $1,086 to $4,255; upper middle income, $4,256 to $13,205; and high income, $13,206 or more.
	Water_Water_stress	Classification of countries by water stress categories based on the ratio of total water withdrawals to available renewable surface and groundwater supplies: Extremely high (>80%), High (40%-80%), Medium high (20%-40%), Medium low (10%-20%), Low (<10%) (WRI, 2019)
II	Boundaries and methodology	
	Application_of_SEEA_framework	Whether the water account adopts the SEEA framework and methodology (Yes/No)
	Application_of_SEEA_standard_methodology	Whether the water account is produced in SEEA standard tables (Yes/No)
	Year_of_SEEA_adoption	The year that the SEEA framework and methodology is adopted (publishing year)
	Other_framework/methodology	Other framework and methodology adopted
	Water_Account_types	Types of water account (Physical supply and use accounts; Monetary supply and use accounts; Physical asset accounts; Monetary asset accounts; Water-related legal rights accounts; Water quality accounts; Ecosystem services for water provisioning; Ecosystem services for water filtration; Other water-related ecosystem services; Hybrid and economic accounts; Emission of water; Others-Resource base; Others-Water use; Others)
	Spatial_boundary	The spatial level that the water account is produced (National level; Regional administrative level; Regional physical level/river catchment)
	Spatial_boundary_details	Details of regional level if any
	Consistency_spatial_boundary	Whether the water account's spatial boundary is consistent across types of accounts (Yes/No)
III	Industry coverage	
	Water_Industry_coverage	Categories of industries in the water account (ISIC classification)
	Water_Industry_coverage_details	Specify other industries that are not listed in the categories or further details for attention

#	Variable Name	Description
	Water_Sectoral_coverage	The sector split shown in the water account (Rain fed-irrigated agriculture; water supply-wastewater treatment; hydropower; mine dewatering)
	Water_Sectoral_coverage_details	Specify other sector split shown that are not listed in the categories or further details for attention
	Agricultural_water_use_shown_by_commodity	Whether the agricultural water use is shown by commodities (Yes/No)
	Water_Agricultural commodity	The agricultural commodities split shown in water account
	Agricultural_commodity_details	Specify other commodities split shown that are not listed in the categories or further details for attention
	Consistency_sector_coverage	Whether the industry coverage and sectoral split is consistent across accounts (Yes/No)
IV	Timeframe	
	Frequency	The frequency of publication of the water account
	Number_of_times_published	The number of publishing times
	Year_first_published	The first year of publication
	Year_last_published	The last year of publication
	First_reference_year	The first reference year
	Last_reference_year	The last reference year
	Number_of_gaps	The number of gaps in reference years
	Years_of_publication	List of years of publication
	Length	The length of the time series (difference between the last and the first reference year)
	Time lags	The difference between the last year of publication and the last reference year
	Consistency_time series	Whether the time series is consistent across accounts (Yes/No)
V	Physical scope	
	Water_Imports_and_exports_of_water	Imports and exports of water counted in the water account (Upstream flows (natural in-flows); Downstream flows (natural out-flows); Imports of produced water (piped in-flows); Exports of produced water (piped out-flows)
	Unit_of_imports_and_exports_of_water	Unit of imports and exports of water counted in the water account (By volume, by value in local currency)
	Water_Water_sources	Source of water in supply-use accounts and assets account (Surface water: Groundwater; Soil water; Surface-artificial reservoirs, Surface-lakes; Surface-rivers and streams; Surface-snow ice and glaciers; Others)
	Water_sources_details	Further details on water source that need attention

#	Variable Name	Description
	Water_Recording_of_losses	Type of losses recorded in the water account (by volume) (Evaporation from reservoirs and dams under control of water utilities; Leakage from pipes; Leakage from irrigation channels; Loss in distribution as a whole; Loss from pipes and irrigation channels attributed to water supply industry; Loss recorded as return flows to environment)
	Water_Recording_of_evaporation	Type of evaporation recorded in the water account (Evaporation generally; Evapotranspiration; Transpiration; Evaporation from water distribution system; Evaporation, evapotranspiration and water incorporated into products all together; Water incorporated into products)
	Water_Returns_of_water	Returns of water recorded in the water account (by volume) (To inland water resources, sea and ocean, environment generally, other sources)
	Water_Returns_of_wastewater	Returns of wastewater recorded in the water account (by volume) (To inland water resources, sea and ocean, environment generally, other sources)
	Water_Recording_of_flows	Flows of water in the supply and use table account (Abstraction from environment; Distributed water; Reused water; Wastewater to sewerage)
	Water_treatment_plants_(by treated/untreated)	Whether the data on water treatment plants split to treated and untreated water (by volume) (Yes/No)
	Wastewater_treatment_plants_(by treated/untreated)	Whether the data on wastewater treatment plants split to treated and untreated water (by volume) (Yes/No)
	Desalination_plants	Whether the data on desalination plants split to treated and untreated water (by volume) (Yes/No)
	Water_Produced_assets_type	Type of water produced assets that is counted by physical number
	Key_indicators	Some physical indicators that are produced in the accounts
VI	Economic scope	
	Running_cost_water_treatment	Whether the water account includes running cost of water treatment, either in total or split down to categories or both (in local currency)
	Running_cost_water_treatment_ categories	The cost categories of running cost of water treatment (if any)
	Running_cost_ wastewater_ treatment	Whether the water account includes running cost of wastewater treatment either in total or split down to categories or both (in local currency)
	Running_cost_ wastewater_ treatment_categories	The cost categories of running cost of wastewater treatment (if any)
	Running_cost_desalination	Whether the water account includes running cost of desalination either in total or split down to categories or both (in local currency)
	Running_cost_of_desalination_ categories	The cost categories of running cost of desalination (if any)
	Water_Assets_value	Type of water produced assets that are valued in local currency
	Water_Economic_information	Other types of economic information included in the water account (Value of irrigated agriculture; Value of rain-fed agriculture; Value of rain-fed and irrigated agriculture together; Value of hydroelectricity; Others)

Annex 5 List of countries and regions producing water accounts

Afghanistan
Africa
Armenia
Australia
Azerbaijan
Belarus
Bosnia and Herzegovina
Botswana
Brazil
Cambodia
Canada
Central Asia
China
Colombia
Costa Rica
Croatia
Denmark
Dominican Republic
Ecuador
Egypt
Ethiopia
Europe
Fiji
Finland
France
Germany
Greece
Guatemala
India
Indonesia
Iran
Ireland
Israel
Italy
Jordan
Kazakhstan
Lebanon
Luxembourg
Madagascar
Malaysia
Mauritius
Mexico
Middle East
Moldova
Mongolia
Namibia
Nepal
Netherlands
New Zealand
Nigeria
Norway
Pakistan
Palau
Palestine
Peru
Philippines
Russia
Rwanda
Samoa
South Africa
Spain
Sri Lanka
Sweden
Tajikistan
Tanzania
Thailand
Tunisia
Turkey
Uganda
United Kingdom
United States of America
Vietnam
Zambia
World

GLOBAL COMMISSION on the ECONOMICS OF WATER

The Global Commission on the Economics of Water (GCEW) redefines the way we value and govern water for the common good.

It presents the evidence and the pathways for changes in policy, business approaches and global collaboration to support climate and water justice, sustainability, and food-energy-water security.

The Commission is convened by the Government of the Netherlands and facilitated by the Organisation for Economic Co-operation and Development (OECD). It was launched in May 2022 with a two-year mandate.

The GCEW is executed by an independent and diverse group of eminent policy makers and researchers in fields that bring novel perspectives to water economics, aligning the planetary economy with sustainable water- resource management.

Its purpose is to make a significant and ambitious contribution to the global effort to spur change in the way societies govern, use and value water.

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