A full account of water:

Aligning water flow classifications, moving the production boundary, updating tables, adding water quality, towards values and valuation, and policy applications.

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Issue paper

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Questions to the London Group

1. Do you agree with recommendations?
2. What process would be needed to update SEEA-Water as proposed in Recommendation 9.

Summary of Recommendations

1. That concordance tables and diagrams for the definitions of water flows and assets in the SEEA-Water, SEEA-CF, and SEEA-EA are added to the Central Framework
2. Water in reservoirs should be treated as a produced asset
3. The water supply use tables in the Central Framework be updated to reflect water as a produced asset, and to accommodate this:
    a. The water supply industry is split into water distribution and water storage, and
    b. The product natural water (CPC 1800) is split into distributed water and stored water
    c. A column for inventory is added
4. That text is added to Central Framework, clarifying that losses in water distribution and, if accepted that water is a produced asset, losses from evaporation in reservoirs, be treated as use of natural water (CPC 1800) by the water storage industry (a sub-category of the water supply industry).
5. That physical and monetary supply use tables integrating the Central Framework and Ecosystem Accounting are developed along the lines suggested in this paper
6. That the water quality accounts from the SEEA-Water become part of the Central Framework.
7. That the methods from the SEEA Ecosystem Accounting be used to value water abstractions and water assets in the Central Framework.
8. That alternative representations of water values are recognised in the Central Framework update
9. That the SEEA-Water is updated, integrating the relevant parts of the Central Framework and Ecosystem accounting, more guidance on values and valuation, and with material on how water accounting can be used for water policy and management.

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1. Introduction

The paper is technical document produced for discussion at the 30th Meeting of the London Group on Environmental Accounting so that the group can develop a position paper for the planned update of the Central Framework in the System of Environmental-Economic Accounting (SEEA). The document also serves as a vehicle for engaging the broader water and ecosystem service communities on the planned update and to ensure that any updates are conceptually robust and that the information resulting from water accounting is useful for decision-making.

1.1 SEEA Central Framework update

The publication of the SEEA Ecosystem Accounting (SEEA-EA) and the 2025 update of the System of National Accounts (SNA), led to a proposal to update the SEEA Central Framework (SEEA-CF). This proposal was endorsed at the 55th Session of the UN Statistical Commission and an initial list of issues for prioritization is now available from the United Nations SEEA website dedicated to the update.

Of the 35 issues for prioritization, three are specific to water and several other broader issues that are relevant to water accounting. The issues specific to water accounting are:

- **D2. Inclusion of water quality accounts in the SEEA-CF.** Measurement of water quality is included within the SEEA-EA ecosystem condition accounts for freshwater bodies, but could also possibly be included as a separate account in the asset chapter of the updated SEEA-CF. More discussion is needed on if this needs to be done given that there is overlap with the SEEA-EA. There is already a water quality account in the SEEA-Water, which would provide a basis for inclusion.
- **D4 Consideration of water as a produced asset (e.g. water in artificial reservoirs).** This was also an issue during the SEEA-CF 2012 revision, which may need to be revisited. Currently the SEEA-CF does not consider water (such as in artificial reservoirs) as a produced asset, but instead only records production at the point the water is abstracted from a water body

(natural or artificial). Further discussion is needed on the appropriate recording, considering also the link to the SNA production boundary.

- **D7 Valuation of water.** There are multiple issues surrounding the valuation of water in the SEEA-CF. Firstly, the asset boundary of water in the SEEA-CF is very broad and includes, in principle, all inland bodies of water, not all of which are able to be valued. In addition, water prices are seldom "market" or "near market". Water is often provided free of charge or at prices which do not reflect the costs of providing the related services, thus leading to a non-positive resource rent. However, avoiding economic valuation of water beyond market prices hinders the ability of the accounts to answer policy questions.

Two of the more general issues directly affecting water accounting are:

- **B2. Further clarifying treatment of losses (e.g. energy, water).** There are a number of issues related to losses which are not fully described in the SEEA-CF, particularly on energy and water losses but also in the context of circular economy. Some papers which were drafted during the preparation of the SEEA-CF could be reviewed to see if we can clarify the terminology and conceptual issues. In addition, this could be looked at in the context of sub-national or regional accounts and links to ecosystem accounting.
- **B4. Inclusion of text on quarterly accounts.** In the last few years, countries and international organizations have begun to release air emission accounts on a quarterly basis. A short, general description on the importance of quarterly accounts (especially for air emission and water accounts) could be added in the SEEA-CF.

Other cross-cutting issues are also relevant to water accounting, include:

- **A1. Providing a broad overview of links between SEEA-CF and SEEA-EA.**
- **A4. How SEEA-CF accounts can be made spatially explicit.**
- **A6. Introduction of thematic accounts and strengthening the link to policy.**
- **A9. Consistency with the 2025 SNA revision issues**
- **B1. Description of PSUTs.**

- **B7. Inclusion of residual flows to ecosystem type, i.e. pressure account**
- **B9. Further guidance on recording own account production**

For the general issues understanding the links and overlaps between the SEEA-CF, SEEA-EA and SNA is important.

1.2 Aims of this paper

This paper's aims are primary to address the three issues specifically relating to water accounting in SEEA-CF update:

- **D2 Inclusion of water quality accounts in the SEEA-CF.**
- **D4 Consideration of water as a produced asset (e.g. water in artificial reservoirs).**
- **D7 Valuation of water.**

We will also examine the issue of water quality accounting, which is related to issue **B7 Inclusion of residual flows to ecosystem type.**

For these, we assess options and provide recommendations.

2. Water accounting

Increasing water scarcity around the globe is driving demand for more and better quality water information. Water accounting can address this demand. Since the adoption of the SEEA-Water in 2007 and the SEEA-CF in 2012, there have been advances in the understanding of water accounting that can improve the current water accounts. This, along with the recent adoption of SEEA-EA and the 2025 System of National Accounting 2021 update, means there is an opportunity to re-examine water accounting to provide coherence between the SEEA-CF, SEEA-Water, SEEA-EA and SNA and to ensure that information from the accounts is useful to decision-makers.

In addition to the SEEA, there are other water accounting frameworks in use around the world (Vardon et al. 2023). These include the Water Account+ (WA+) (Karmi et al., 2013; Molden and Sakthivadivel, 1999) and those developed by individual countries – both national and subnational, for example in Australia and California – and by water suppliers, other business, and in academia. In general, these frameworks can be mapped into SEEA (Vardon et al., 2012). As well as ensuring internal consistency within the different SEEA components and SNA, the process should increase understanding of SEEA-based water accounting in the wider world of water statistics. This should have a positive impact on the use of SEEA in decision-making, which has been limited (Vardon et al., 2016) but is growing (Clarke et al., 2023).

3. Terminology, definitions, and classifications

Accounting for the movement of water within the environment, between the environment and the economy, and within the economy is complex (Vardon et al., 2019). A range of terms are in use by the different disciplines involved in the production of water accounts. A glossary of terms developed by an expert working group is presented in the SEEA-Water. At the time it was considered the best alignment of the terminology of each field. The EDG considered many information sources, including the International Glossary of Hydrology[1], the FAO's Global Information System on Water and Agriculture of Aquastat[2], the UN Glossy of Environmental Statistics[3], and the SNA (EC et al., 2009) and 2003 SEEA precursor (UN et al., 2003) glossaries. Some of the glossaries have been updated since the adoption of SEEA-Water in 2007.

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

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

[3] https://unstats.un.org/unsd/environmentgl/#:~:text=The%20UNSD%20Glossary%20of%20Environment,development%20indicators%2C%20and%20environmental%20accounting.

Table 1 lists the definitions of water flows and water-related ES in the SNA, SEEA-CF, SEEA-Water, and SEEA-EA. The definitions of some water flows with the same terminology differ between the SEEA-Water and SEEA-CF (wastewater and reused water) and does not offer any commentary on the differences in definitions of flows between the two, nor in the definitions to other terms used in the accounts (e.g., water consumption) (Table 1). In the SEEA-CF water resources are not specifically defined, but water assets are defined (Table 2). SEEA-EA has many water-related ecosystem services, and SEEA-EA also recognises abiotic flows.

As well as being important for understanding the terminology used to describe flow, the distinction and classification of water flows as an ecosystem service, natural resource or product is important for water valuation.

The SEEA-CF includes natural resources abstracted from the environment, and the flows of the product natural water (CPC 1800). SEEA-EA distinguishes between ecosystem services and abiotic flows, which are contributions from the environment not underpinned by ecological processes. The description of treatment of water flows in SEEA-EA reflects the debate about to what extent water flows are underpinned by ecological processes. As a result, the classification of water flow is ambiguous. For instance, SEEA-EA Table 6.1 (p. 126) includes ecosystem provisioning services and abiotic flows, and water is given as an example of an abiotic flow. However, water supply is listed as a provisioning service in Table 6.3 (SEEA-EA, pp. 131-134), and water provisioning is a commonly recorded ecosystem service (Vardon et al., 2023). Paragraph 6.104 of SEEA-EA allows flexibility in treating water flows, either as an ecosystem service or as an abiotic flow, saying the treatment of flow should align with the Central Framework.

In Table 1 the product natural water (CPC 1800) is not divided by water quality, nor does it distinguish potable from non-potable water or recognise recycled water (i.e., treated or untreated water supplied for use by industry or households. The SEEA-Water physical supply and use tables do distinguish across these characteristics. Bottled waters (CPC 24410) have not been included in the PSUT, but they are of importance in many areas with low-quality distributed water or without access to distributed water, as is the case in many low- and middle-income countries.

Table 1. Definitions of water flows recorded in the SNA, SEEA-CF, SEEA-Water, and SEEA-EA

Abiotic flows as defined in SEEA-EA	
Abiotic flow	are contributions to benefits from the environment that are not underpinned by, or reliant on, ecological characteristics and processes. (SEEA-EA, para. 6.35)
Water supply-related ecosystem services defined in SEEA-EA	
Water supply service (water provisioning)	reflect the combined ecosystem contributions of water flow regulation, water purification, and other ecosystem services to the supply of water of appropriate quality to users for various uses including household consumption. (SEEA-EA, p. 131)
Water purification service (water quality regulation)	are the ecosystem contributions to the restoration and maintenance of the chemical condition of surface water and groundwater bodies through the breakdown or removal of nutrients and other pollutants by ecosystem components that mitigate the harmful effects of the pollutants on human use or health. (SEEA-EA, p. 132) This is a regulating service.
Water flow regulation services - Baseline flow maintenance	re the ecosystem contributions to the regulation of river flows and groundwater and late water tables. They are derived from the ability of ecosystems to absorb and store water, and gradually release water during dry seasons or periods through evapotranspiration and hence secure a regular flow of water. This may be recorded as a final or intermediate ecosystem service. (Table 6.3, p 132 SEEA-EA)
Water flow regulation – Peak flow mitigation	peak flow mitigation services will be supplied together with river flood mitigation services in providing the benefit of flood protection. This is a final ecosystem service. (Table 6.3, p 132-3 SEEA-EA)
Soil and sediment retention services (soil erosion control services)	are the ecosystem contributions, particularly the stabilising effects of vegetation, that reduce the loss of soil (and sediment) and support use of the environment (e.g., agricultural activity, water supply). This may be recorded as an intermediate or final service. (Table 6.3, p 132 SEEA-EA)
Other hydrological ecosystem services defined in SEEA-EA	
Flood control services – River flood mitigation	are the ecosystem contributions of riparian vegetation which provides structure and a physical barrier to high water levels and thus mitigates the impacts of floods on local communities. River flood mitigation services will be supplied together with peak flow mitigation services in providing the benefit of flood protection. This is a final ecosystem service. (Table 6.3, p 133 SEEA-EA)
Rainfall pattern regulation services	are ecosystem contributions of vegetation, in particular forests, in maintaining rainfall patterns through evapotranspiration at the sub-continental scale. Forests and other vegetation recycle moisture back to the atmosphere where it is available for the generation of rainfall. Rainfall in interior parts of continents fully depends upon this recycling. This may be a final or intermediate service. (Table 6.3, p 132 SEEA-EA)
Local (micro and meso) climate regulation services	are the ecosystem contributions to the regulation of ambient atmospheric conditions (including micro and mesoscale climates) through the presence of vegetation that improves the living conditions for people and supports economic production. Examples include the evaporative cooling provided by urban trees ('green space'), the role of urban water bodies ('blue space') and the contribution of trees in providing shade for humans and livestock. This may be a final or intermediate service. (Table 6.3, p 132 SEEA-EA)

Solid waste remediation services	are the ecosystem contributions to the transformation of organic or inorganic substances, through the action of micro-organisms, algae, plants and animals that mitigates their harmful effects. This is may be recorded as a final or intermediate service. (Table 6.3, p 132 SEEA-EA)
Biological control services	are the ecosystem contributions to the reduction in the incidence of species that may prevent or reduce the effects of pests on biomass production processes or other economic and human activity. This is may be recorded as a final or intermediate service. (Table 6.3, p 133 SEEA-EA)
Recreation-related services	are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use and enjoy the environment through direct, in-situ, physical and experiential interactions with the environment. This includes services to both locals and non-locals (i.e., visitors, including tourists). Recreation-related services may also be supplied to those undertaking recreational fishing and hunting. This is a final ecosystem service. (Table 6.3, p 133 SEEA-EA)
Visual amenity services	are the ecosystem contributions to local living conditions, in particular through the biophysical characteristics and qualities of ecosystems that provide sensory benefits, especially visual. This service combines with other ecosystem services, including recreation- related services and noise attenuation services to underpin amenity values. This is a final ecosystem service. (Table 6.3, p 133 SEEA-EA)
Education, scientific and research services	are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use the environment through intellectual interactions with the environment. This is a final ecosystem service. (Table 6.3, p 133 SEEA-EA)
Spiritual, artistic, symbolic services	are the ecosystem contributions, in particular through the biophysical characteristics and qualities of ecosystems, that are recognised by people for their cultural, historical, aesthetic, sacred or religious significance. These services may underpin people's cultural identity and may inspire people to express themselves through various artistic media. This is a final ecosystem service. (Table 6.3, p 133 SEEA-EA)
Water flows defined in SEEA Central Framework and SEEA-Water	
Water (natural resource)	Natural resources include all natural biological resources (including timber and aquatic resources), mineral and energy resources, soil resources and water resources. (SEEA Central Framework, paras 2.101, 5.18) Water abstraction is defined as the amount of water that is removed from any source, either permanently or temporarily, in a given period of time. (SEEA Central Framework, para 3.195)
Wastewater *SEEA-Water*	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)
Wastewater *SEEA-CF*	Wastewater is discarded water that is no longer required by the owner or user. (SEEA Central Framework, para 3.86)
Recycled water *SEEA-Water*	The reuse of water within the same industry or establishment (on site).
Reused water *SEEA-Water*	Wastewater delivered to a user for further use with or without prior treatment. Recycling within industrial sites is excluded. (EDG)

Reuse water *SEEA-CF*	Reused water is wastewater supplied to a user for further use with or without prior treatment, excluding the reuse (or recycling) of water within economic units. (3.207)
Water in the Central Product Classification (CPC)	
Natural water (CPC 1800)	This subclass includes: potable and non-potable water, suitable for further use, including: • treated water (e.g., from desalination plants, water treatment plants) • untreated water (e.g., obtained directly from natural sources) This subclass also includes: • used water suitable for further use This subclass does not include: • sea water, cf. 16200 • steam and hot water, cf. 17300 • mineral waters containing added carbon dioxide, cf. 24410 • waters individually bottled as beverages, cf. 24410 • distilled water, cf. 34250 • sewage and other wastewater, i.e. water not suitable for further use, cf. 39990 (CPC, p. 197)
Bottled waters, not sweetened or flavoured (CPC 24410)	This subclass includes waters individually bottled as beverages, including: • aerated (carbonated) waters • mineral waters (natural or artificial) This subclass does not include: - ice and snow, cf. 17400 - natural water (i.e. non-bottled), cf. 18000 - sweetened or flavoured water, cf. 24490

Understanding how the SEEA-CF and SEEA-EA align requires understanding the final and intermediate use of ecosystem services (Vardon 2022). Final ES are "*those ecosystem services in which the user of the service is an economic unit*". Intermediate ES are "*those ecosystem services in which the user of the ecosystem services is an ecosystem asset and where there is a connection to the supply of final ecosystem services*." (SEEA-EA, p.124). Accounting for final and intermediate use of ES means the chains of ES flows that results in benefits to people are recognised and that ES values are not double counted.

The definition of the final ecosystem service of water supply in the SEEA-EA corresponds to the definition of water resource abstraction in the SEEA-CF (Vardon 2022). Water can also be treated as an abiotic flow in the SEEA-EA. These are three different names for the same flow water abstracted from the environment (SEEA-CF) or ecosystem (SEEA-EA).

Table 2. Comparison of the asset classifications in SEEA-CF, SEEA-Water and SEEA-EA

SEEA Central Framework and SEEA-Water	**SEEA Ecosystem Accounting**	**Notes for determining the scope and definitions of water assets for valuation**
Surface water • Rivers and streams • Lakes • Artificial reservoirs[4] • Snow, ice and glaciers	Freshwater • F1 Rivers and streams • F2 Lakes • F3 Artificial reservoirs • T6 Polar-alpine (cryogenic)	Direct correspondence between SEEA-Water, SEEA Central Framework and SEEA Ecosystem Accounting
Groundwater	• SF1 Subterranean freshwater • SF1 Anthropocentric subterranean freshwater • FM1 Semi-confined transitional waters	SEEA Ecosystem Accounting sub-divides groundwater into three classes. In the SEEA-Water and SEEA Central Framework, groundwater includes all these sources and could be similarly divided.
Soil water	• Water use in rainfed agricultural and cultivated forest ecosystems	The SEEA-Water and Central Framework only identifies soil water, which is found in all ecosystem types with soil. However, in practice the use of soil water is only estimated for rain-fed agricultural ecosystems. The use of soil water can be shown by the ecosystem types used in the SEEA Ecosystem Accounting.
	Transitional • TF1 Palustrine wetlands • MFT1 Brackish tidal systems	The SEEA-Water and Central Framework does not explicitly recognize these assets although water assets consist "*of fresh and brackish water in inland water bodies, including groundwater and soil water"* (SEEA Central Framework para 5.474) and these would likely be recorded as abstractions from surface water (i.e. lakes)
Seas and oceans	Marine • M1 Marine shelf • M2 Pelagic ocean waters • M3 Deep sea floors	The SEEA-Water included seas and oceans as a source of water for desalinization and cooling water as well as receiving return flows from the economy and river outflows. The ocean accounts described in SEEA Ecosystem Accounting do not consider marine ecosystems as a possible source of water.

[4] Artificial reservoirs include all human-built water storages, from rainwater collection and small farm dams through to large artificial reservoirs (e.g., Hoover Dam, Kariba Dam, and Bhakra Nangal Dam)

In all cases water abstraction is recorded from assets which have the same or similar names. Table 2 compares the asset classifications in SEEA but does not show the SNA classification that describes water resources as consisting "*of surface and groundwater resources used for extraction to the extent that their scarcity leads to the enforcement of ownership or use rights, market valuation and some measure of economic control*" (SNA, para. 10.184) and the SNA defines water as a non-produced asset, an issue discussed in Section 4. The asset classifications in SEEA-CF, SEEA-Water, and SEEA-EA are similar but have some minor differences (see Table 2). The classification of surface water assets directly aligns. The classification of groundwater assets and oceans and seas is more detailed in SEEA-EA. A key difference is that the SEEA-Water and SEEA-CF include soil water ("green water"), whereas this is not explicitly included in the assets in SEEA-EA.

Because of the varying terminology, confusion and misunderstanding are occurring. To overcome these problems, a concordance table and matching diagrams should be developed and included in the SEEA-CF update. The table should at a minimum cover the SNA and SEEA terms and definitions and could be extended to cover the terminology used in the broader water and ecosystem service communities. This could take the form of an updated glossary.

10. Recommendation 1. That concordance tables and diagrams for the definitions of water flows and assets in the SEEA-Water, SEEA-CF, and SEEA-EA are added to the Central Framework

4. Water as a produced asset

Treating reservoir water as a produced asset was proposed by Nagy et al. (2009) in the development of the SEEA-CF and was accepted in the related outcome paper (Obst, 2010). However, this treatment was ultimately rejected to maintain consistency with the SNA.

4.1. Produced vs. Non-Produced Assets

Paragraph 10.8 of the SNA defines: "*An asset is a store of value representing a benefit or series of benefits accruing to the economic owner by holding or using the entity over a period of time. It is a means of carrying forward value from one accounting period to another. All assets in the SNA are economic assets.*"

The SNA identifies financial and non-financial assets. Two categories of non-financial assets are recognised: produced assets and non- produced assets. "*Produced assets are non-financial assets that have come into existence as outputs from production processes that fall within the production boundary of the SNA*" and "*Non-produced assets are non-financial assets that have come into existence in ways other than through processes of production*" (SNA, para. 10.9).

SNA paragraph 6.2 defines: "*Production is an activity, carried out under the responsibility, control and management of an institutional unit, that uses inputs of labour, capital, and goods and services to produce outputs of goods and services*."

SNA paragraph 10.12 defines inventories as "*produced assets that consist of goods and services, which came into existence in the current period or in an earlier period, and that are held for sale, use in production or other use at a later date.*"

4.2. Current treatment of Water in Reservoirs

Under the current SNA and SEEA, water in artificial reservoirs is a non-produced asset. This classification assumes that, while the infrastructure (e.g., the dam) is a produced asset, and that labour and other goods and services are used for the operation of the reservoir, the water itself remains a natural resource, simply occurring in reservoir. In effect this is no different to a lake used for water supply.

4.3 Arguments for Reclassification as a Produced Asset

The traditional classification of reservoir water as a non-produced asset does not fully capture the realities of water management in artificial reservoirs. For the water to occur in reservoirs substantial human intervention is required to create, manage, and maintain the water in the reservoirs. This intervention displaces the water in time and space. This intervention includes the construction of dam walls and ongoing operational activities for water regulation (e.g. for hydro-electricity), quality control, flowed distribution (e.g., via pipes).

Having reservoir waters involves the inputs of capital, labour and other goods and services, to produce another product, natural water CPC 1800, which aligns with the definitions of production, produced assets and inventories in the SNA (paras., 6.2, 10.9, and 10.12, respectively).

Treating water in reservoirs as a produced asset and inventory more accurately reflects the economic activities associated with its management; without the dam and its management, there would be no water to distribute at a later date. Impounding the water also means that the water, the natural resource or final ecosystem service of water supply (as well as other water-flow dependent downstream ecosystem services, such as recreation) is not available to potential water users downstream of reservoirs.

The treatment of reservoir water as a produced asset and inventory aligns with the different treatment of plantation forests and natural forests used for timber production. Trees in plantation forests are treated as produced, with timber production recorded annually, while trees in natural forests that are ultimately harvested are treated as non-produced and timber production recorded at the time of felling. In this analogy, water in lakes and rivers would be non-produced assets (akin to natural forests), a reservoir water, produced assets (akin to plantation forest).

4.4 Implications of reclassification for accounts

Reclassifying reservoir water as a produced asset has implications for the physical supply and use tables. It will expand the accounting tables, requiring the additions to inventory to be added to the water supply and use table. It would also require the recording of losses from this inventory, such as those due to evaporation, which can be significant. These losses are in addition to losses in distribution (e.g., through burst and leaky pipes). The text on water losses in para. 3.212 of the

SEEA-CF does provide detailed guidance on the accounting of these losses, but by convention are recorded as a use by the water supply industry.

The water asset accounts already separately distinguish the additions and reductions to artificial reservoirs. Adding water to artificial reservoirs would mean the inclusion of water on the national balance sheet.

Rainwater collection by households is a probably a produced asset. If reservoir water is treated as a produced asset, then the same logical and treatment would apply to households. This would be own-account house production of "natural water" (CPC 1800).

Water banking and managed aquifer recharge, the process of injecting surface water into sub-surface water or ground water, would mean the water injected would be treated as produced water. In this case the water injected is likely to already have been in the economy. The decision needed would be is this a return to the environment or is it the storage of the product "natural water" CPC 1800 in a natural aquifer?

Recommendation 2. Water in reservoirs should be treated as a produced asset.

Recommendation 3. The water supply use tables in the Central Framework be updated to reflect water as a produced asset, and to accommodate this:

a. **The water supply industry is split into water distribution and water storage**
b. **The product natural water (CPC 1800) is split into distributed water and stored water**
c. **A column for inventory is added**

Recommendation 4. That text is added to Central Framework, clarifying that losses in water distribution and, if accepted that water is a produced asset, losses from evaporation in reservoirs, be treated as use of natural water (CPC 1800) by the water storage industry (a sub-category of the water supply industry).

5 Integrated accounting tables

The design of accounts and selection of accounting treatments should be relevant to decision-making (Vardon et al., 2016). This section presents supply and use tables integrating the Central Framework and Ecosystem Accounting. Two alternative accounting tables are presented: (1) reservoir water is treated as a produced asset, and; (2) reservoir water as a non-produced asset. In these tables water as a natural resource in the Central Framework is equated to the ecosystem service of water supply in the SEEA-EA. (See Section 2, terminology).

5.1 Current tables in SEEA-CF, SEEA-Water and SEEA-EA

The SEEA-Water tables for the physical water supply and use of water and the asset account are found in Supplementary Tables. A feature of the SEEA-Water PSUT is that the use table precedes the supply table. This presentation was used to enable water consumption (i.e., water abstracted from water resources but not returned to water resources, SEEA Water A3.9) to be calculated from the supply and use tables. The table also presents two views of water abstraction. Rows 1.a and 1.b split abstraction by water for own use and water for distribution, while rows 1.i to 1.ii show abstraction by water source. This presentation was chosen so that direct abstraction by industries, the own-account production of “natural water” (CPC 1800) which in SNA should theoretically be reallocated to water supply industry, can be seen in the tables.

The SEEA-CF PSUT greatly expands the SEEA-Water table, spanning 4 pages, and presents the supply side of the table before the use side. The split presentation of abstraction by source and abstraction for own use or distribution shown in the SEEA-Water PSUT is maintained in the use side and added to the supply side. The recording of wastewater is also expanded. A water consumption identity is not shown, but the amount of water abstracted that is transpired, evaporated or incorporated into products is separately shown, allowing the calculation of indicators from the accounts (e.g., water footprint). The differences between the PSUT in the SEEA-CF and SEEA-Water are not explained in the SEEA-CF and the SEEA-CF makes only a few cross-references to SEEA-Water (pp. viii, 4, 70, and footnote 78, p. 217). The differences in table format have casued confusion.

The water accounts in the SEEA-CF and SEEA-Water are often modified. Many countries simplify the accounts, reducing the number of industries and flows recorded in the accounts (Vardon et al. 2023). This is mostly due to lack of data, but also because not all flows are relevant in all circumstances. Countries also make different presentations of the data. For example, Australia, presents the industries and households in the rows and water flows in the columns and subdivides agriculture water use by commodity type, rather than by industry subdivision.

SEEA-EA shows the supply and use of the water-related ecosystem services. The SEEA-EA essentially expands the column "environment" in the SEEA-CF and SEEA-Water to ecosystems, with the ecosystem classification shown in Table 2. In the SEEA-CF and SEEA-Water, the final ecosystem service of water supply is provided by a water body of some type (e.g. surface water or groundwater), shown in the rows rather than the column, as abstraction by industry or households. The difference between the SEEA-CF and SEEA-Water PSUT and the SEEA-EA PSUT, is that in the SEEA CF and SEEA-Water water abstraction by industries is shown in the rows by water sources, while in the SEEA-EA abstraction from ecosystems (e.g. surface or groundwater) is shown in the columns and aggregated to the one line in the row as the ecosystem service of water supply.

5.2 Proposed tables

To aid the integration of the SEEA-CF and SEEA-EA we propose integrated SUT. These are provided for: (1) reservoir water as a produced asset, and (2) reservoir water as a non-produced asset. The integrated tables record final and intermediate ecosystem services, as well as products. The supply and use of wastewater (including return flows and reuse water) are not shown but could be added.

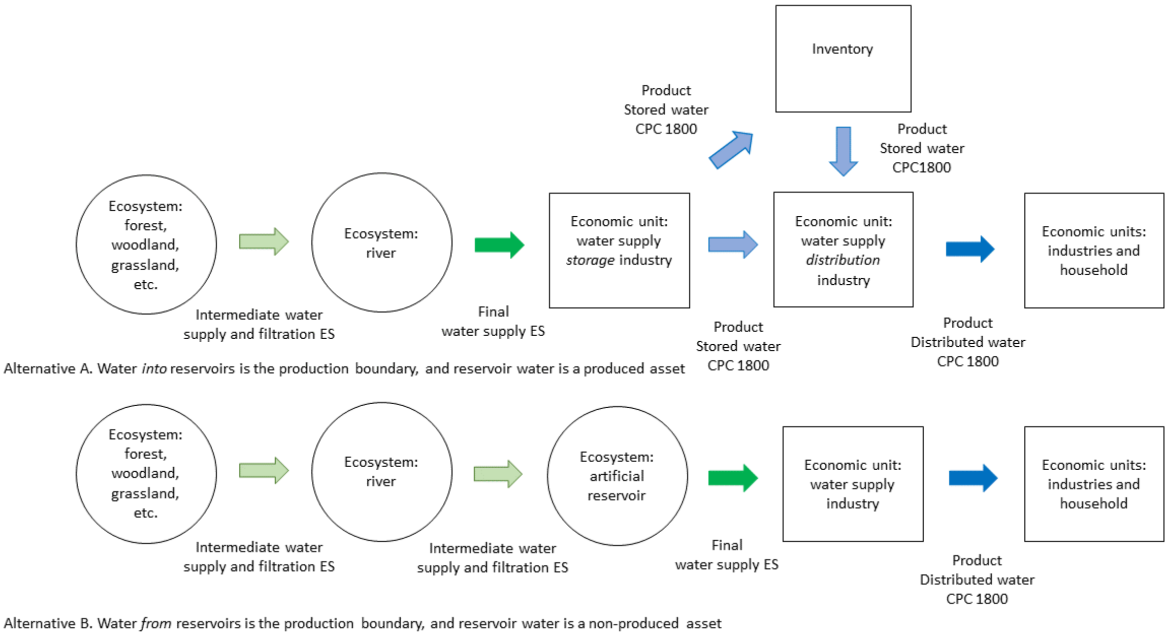

Figure 1. Alternative accounting treatments for (A) water as a produced and (B) water as a non-produced asset. The change in asset classification also changes the recording of the final water supply ecosystem service (ES) and the flow of water products stored and distributed water (CPC 1800) (After: Chen et al., submitted).

Figure 1 compares the alternative accounting treatments for water as a produced asset (Alternative A) and water as a non-produced asset (Alternative B). The alternative treatments shown in Figures 1A and 1B have significant impacts on the valuation of the water supply ES, with the volume of the ES changing depending on treatment, which has implications for how observed prices or replacement cost methods are used for water valuation (Chen et al., submitted). The key difference between the alternative treatments is when the final ES is recorded, which is when water converts from a natural resource (ecosystem service) to a product, which is the production boundary, and the question of when (or if) water becomes a produced asset.

Alternative A (Fig. 1a) is when reservoir water is treated as a produced asset; hence the final water supply ES is recorded when the water flows into an artificial reservoir, while in Alternative B (Fig. 1b) the final water supply ES is recorded when water flows out of an artificial reservoir, and reservoir water remains a non-produced asset. Alternative B results in a simpler supply and use table, but this treatment masks the impact on water availability caused by reservoirs (e.g., evaporation) and does not show the connection between reservoirs and the ecosystems (e.g., the flows from terrestrial ecosystems to rivers to reservoirs). Alternative B also results in the final water supply ES used by the water supply industry equalling the volume of distributed water. We use an example to illustrate the difference in the recording of flows using the two treatments.

Examples of Treatments A and B are provided. Water as a produced asset, is shown in Figure 2 and Table 3, while Treatment B, water as a non-produced asset, is shown in Fig 3 and Table 4. Recording reservoir water as a produced asset results in an expanded supply and use table. An example is shown in Figure 2 and Table 3. In this, the water supply industry is split into the water storage and water distribution in the columns, and with the two associated water products, stored water, and distributed water (both CPC 1800) are split into rows. In this recording, the volume entering the reservoir equals the final water supply ES. In this example, 359 million m^3. The chain of flows extends back: the river runs into the reservoir, other rivers run into rivers (1 million m^3 from within the accounting area and 1 million m^3 from upstream of the accounting area), and water runs off terrestrial ecosystem systems into rivers (but total run-off is not equal to the ecosystem service). In this example, 292 million m^3 from Natural Woodland. The data in the systems described in Figures 2 and 3 and in Tables 3 and 4 are the same.

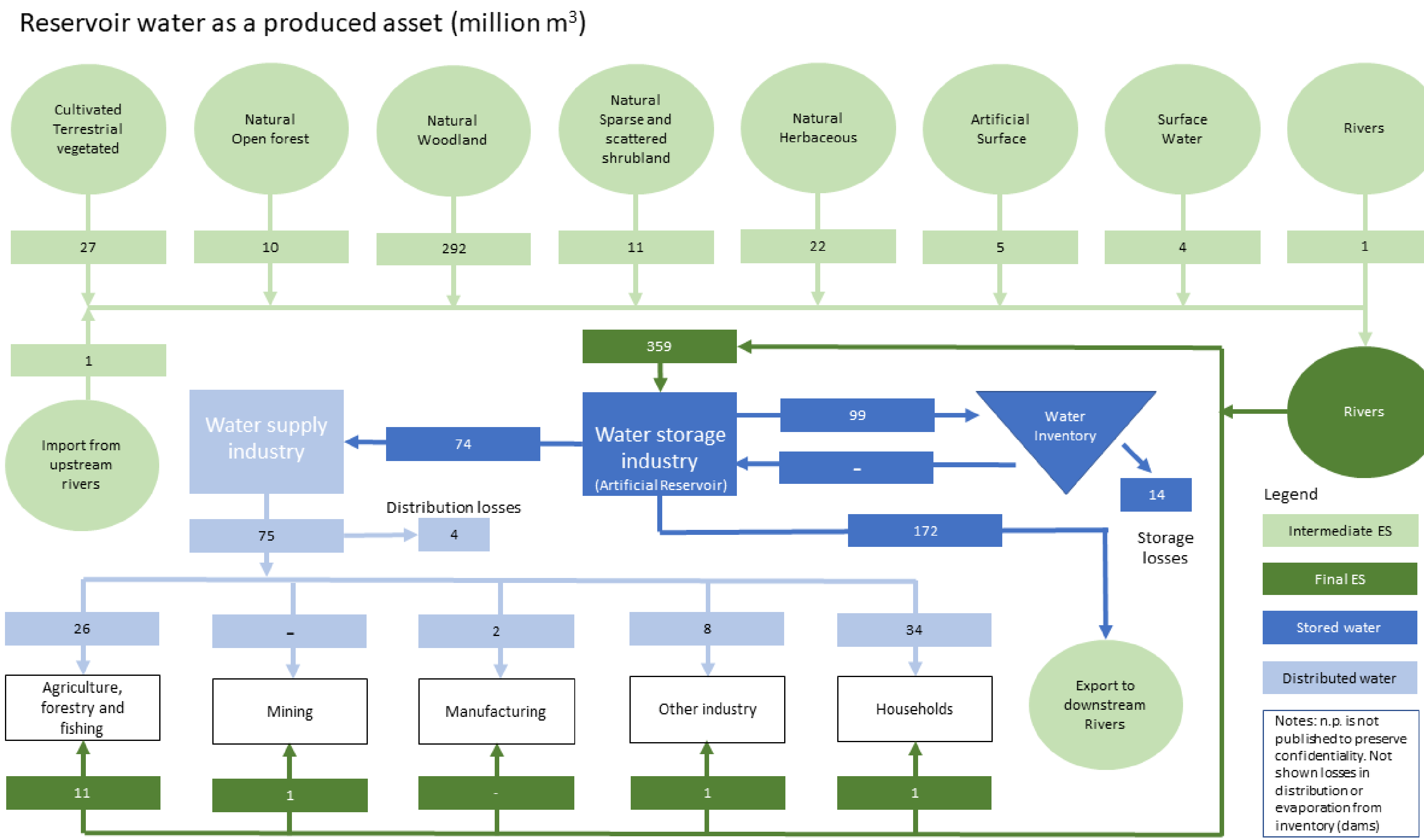

Figure 2. ***Water as a produced asset example***

Table 3. Water as a produced asset example

			Economy									Environment									
ES or product		Units	Agriculture, forestry and fishing	Mining	Manufacturing	Water storage industry	Water distribution industry	Other industry	Households	Inventory	Import (supply) / Export (use)	Cultivated terrestrial Vegetated	Natural Open forest	Natural Woodland	Natural Sparse and scattered shrubland	Natural Herbaceous	Bare Surface	Surface Water	Rivers	Import (supply) / Export (use)	**Total**
Supply																					
Intermediate ES																					
	Water supply	million m3										27	10	292	11	22	5	4	1	1	**373**
Final ES																					
	Water supply	million m3																	373		**373**
Products																					
	Stored water	million m3				359															**359**
	Distributed water	million m3					74														**74**
Use																					
Intermediate ES																					
	Water supply	million m3																	373		**373**
Final ES																					
	Water supply	million m3	11	1		359		1	1												**373**
Products																					
	Stored water	million m3				14	74			99	172										**359**
	Distributed water	million m3	26		2		4	8	34												**74**

(Data matches that in Fig. 2)

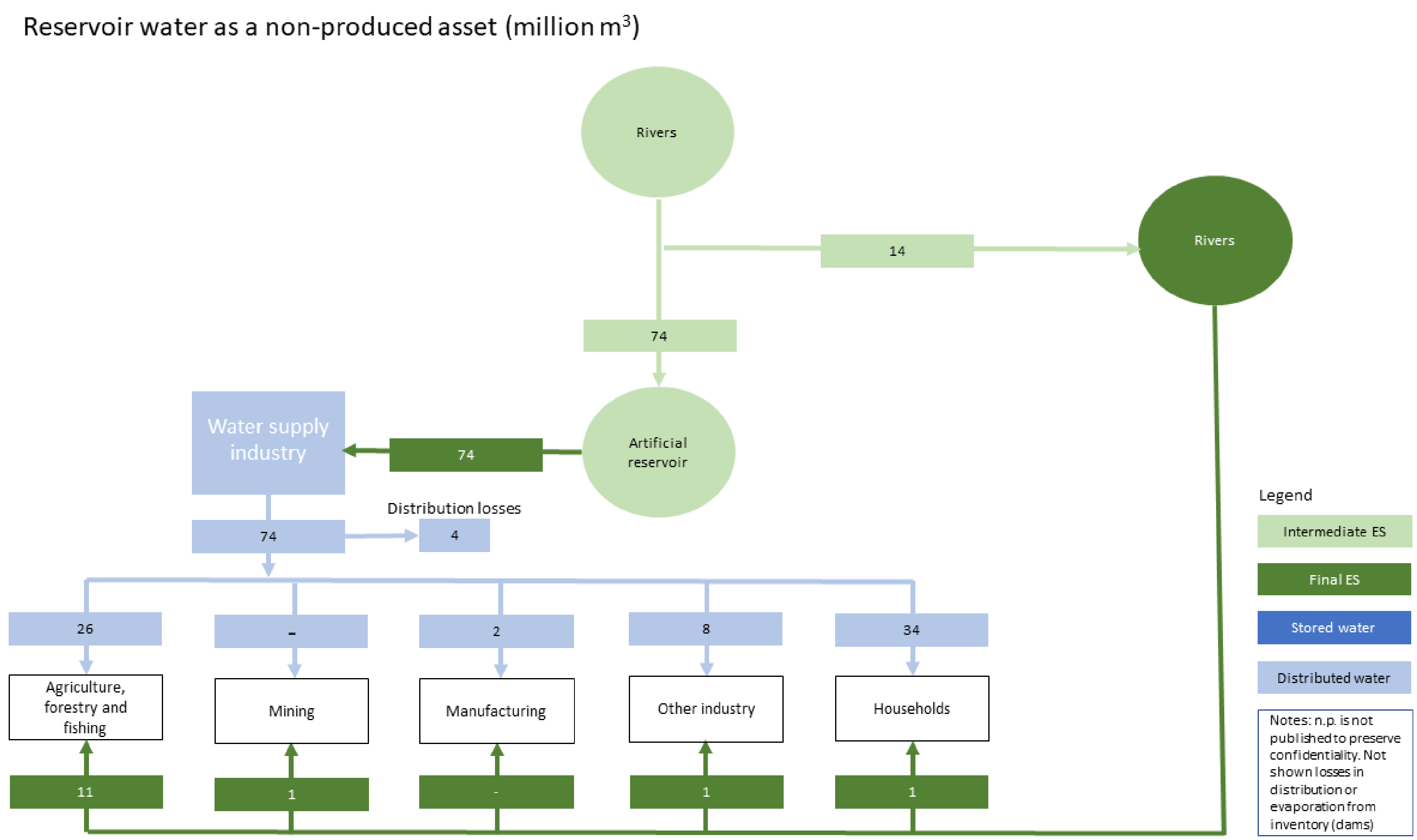

Figure 3. Water as non-produced asset example

Table 4. Water as a non-produced asset

			Economy									Environment										
ES or product		Units	Agriculture, forestry and fishing	Mining	Manufacturing	Water storage industry	Water distribution industry	Other industry	Households	Inventory	Import (supply) / Export (use)	Cultivated terrestrial Vegetated	Natural Open forest	Natural Woodland	Natural Sparse and scattered shrubland	Natural Herbaceous	Bare Surface	Surface Water	Artificial reservoirs	Rivers	Import (supply) / Export (use)	**Total**
Supply																						
Intermediate ES																						
	Water supply	million m3																		88		**88**
Final ES																						
	Water supply	million m3																	74	14		**88**
Products																						
	Stored water	million m3																				
	Distributed water	million m3					74															**74**
Use																						
Intermediate ES																						
	Water supply	million m3																	74	14		**88**
Final ES																						
	Water supply	million m3	11	1			74	1	1													**88**
Products																						
	Stored water	million m3																				
	Distributed water	million m3	26		2		4	8	34													**74**
	Nil by defintion																					
	Removed industry and product																					
	Added environmental asset																					

(Data matches that in Fig. 2)

Figure 3 and Table 4 show a subset of the flows in Figure 2 and Table 3. With water treated as a non-produced asset, the recording of flows is more straightforward. This is the recording in the SEEA-CF and SEEA-Water. The Intermediate water supply ecosystem service from the vegetation is not shown, just the flow from rivers into reservoirs, reservoirs are explicitly recorded to the ecosystem types (they are already in the surface water classification of SEEA-EA, see Table 2), and the water storage industry and stored water are deleted from the tables. The losses from evaporation in reservoirs are not shown, nor the flows out of the reservoir exported downstream. The later could be shown as return flows from the water supply industry.

Monetary tables consistent with the PSUT would be included. Valuation is discussed further in Section 7

Recommendation 5. That physical and monetary supply use tables integrating the Central Framework and Ecosystem Accounting are developed along the line presented in this paper.

6. Water quality

Accounting for water quality is of great interest as water quality significantly impacts water availability and ecosystem condition. For example by:

- Reducing the usable water. When water is polluted or contaminated, it may not be suitable for drinking, agriculture, or other purposes without expensive treatment processes. This effectively reduces the amount of usable water available, even if there is plenty of water physically present.

- Increasing water treatment costs. Poor water quality necessitates increased treatment efforts to make it safe for use. This raises the cost of water supply and can limit availability, particularly in areas with limited resources.
- Human health Impacts. Contaminated water can cause various health problems, further straining water resources as people seek alternative sources or require medical treatment
- Ecological Damage. Poor water quality can harm aquatic ecosystems, impacting the natural processes. For example, algal blooms caused by nutrient pollution can deplete oxygen levels, killing fish and disrupting the water cycle.

6.1 Current situation

Water quality accounts are included in Part Two of SEEA-Water. The water quality accounts have a straightforward structure (Table 5). Water quality accounts describe the quality of the stocks of water resources and the structure of these accounts is similar to that of the asset accounts. The only difference is the addition of the quality dimension, which describes the volumes of water in different water asset classes by water quality classes. Variations in water quality arise from non-linear relationships and attributing changes due to human activities versus those stemming from natural factors is challenging.

Table 5. SEEA-Water quality accounts

SEEAW Standard Table: Quality accounts

physical units

	Quality classes				
	Quality 1	Quality 2	...	Quality n	Toital
Opening Stocks					
Changes in stocks					
Closing Stocks					

Note: This table was also included in the 2003 SEEA

Water quality is also part of the ecosystem condition accounts for freshwater ecosystems condition account of SEEA-EA (SEEA-EA, Table 5.2, p. 94, Table 5.3, p. 99). The water quality accounts for either the SEEA-Water or SEEA-EA account could be included as a separate asset account in the updated SEEA-CF. Further discussion is necessary to determine whether this additional account is warranted, considering overlap with the SEEA-EA. The issue could be addressed through an update to the SEEA-Water (Sections 8 and 9).

While constructing quality accounts may seem straightforward conceptually, there are problems defining and measuring water quality classes. Typically, water quality is defined based on specific concerns (e.g., can it be used for drinking water), but there is limited standardization of concepts, definitions, and aggregation methods for different water concerns. Aggregation can occur across (a) different pollutants to create an index that assesses the collective impact on water resources, (b) time to account for seasonal variations, and (c) space, to derive a unified quality measure across various measurement locations. The guidance in SEEA-EA can be used to describe water quality accounts in the SEEA-CF update.

6.2 Relationship to emissions accounts

Changes in water quality may have multiple different causes – a key cause is the emission of pollutants, leading to a direct link between water quality and water emissions accounts. Other causes include self-purification (e.g., via ecosystem services), changes in dilution factors owing to the increased abstraction of water and increased run-off due to uncontrolled events or new regulations restricting emissions.

Some of the pollutants emitted into water resources are highly toxic and thus negatively affect the quality of the receiving body of water and ultimately human health. Similarly, other substances, such as nitrogen and phosphorus, can lead to eutrophication, or organic substances that can have negative effects on the oxygen balance, thus adversely affecting the ecological status of the receiving body of water.

The value of water for a particular use is affected by the quality of the water and the reliability of supply. Issues such as salinity, emissions of pollutants and whether water is categorised as potable, where the quality is fit for human consumption, or non-potable, all impact the value of the water.

Recommendation 6. That the water quality accounts from the SEEA-Water become part of the Central Framework.

7. Water values and water valuation

The valuation of water resources is contentious. This is because the allocation of benefits, whether in physical or monetary terms, is challenging, particularly considering the multiple sources of water (e.g., surface water, groundwater, desalinated water), the ways water is sourced (e.g., directly from groundwater, surface water, via distributed water networks, "tap water", or collection rainwater), and the many ways water is used in economic production and by households (e.g., drinking, bathing, watering gardens), and own-account agricultural production by households which is common in low- and middle-income countries.

SEEA-Water, SEEA-CF and SEEA-EA align with the SNA which primarily focuses on the economic uses of water and the benefits that accrue to the owners of water assets. The SNA relies on the ability to clearly define ownership rights, and the associated benefits derived from the use of assets. However, water resources have complex ownership and usage rights, with many potential beneficiaries. The SEEA-CF removes the need for ownership or benefits for non-produced assets to be recorded in physical terms.

The SNA, SEEA-CF and SEEA-EA explicitly use exchange values. 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). While the concept of exchange values is clear, how this gets applied to water flows and assets in the SEEA is not. A key to greater clarity is the distinction and classification of water flows and water assets (see Section 3) and the recording of these flows in accounts (Section 5).

Treating water as an economic good is important for directing water to its best economic use, and guiding investments in the sector (Wheeler et al., 2023). Valuing water can help better understand trade-offs and analyse the (distribution of) costs and benefits of decisions that impact water. Confounding water valuation is that water resources are part of complex and interconnected systems, with flows and impacts often extending beyond administrative or ecosystem boundaries. Water valuation needs to consider these interconnections and potential externalities, such as downstream impacts of pollution or upstream effects of water abstraction. The SEEA-EA acknowledges the need for further research and methodological development to address these complexities and ensure a comprehensive and consistent valuation of water flows and assets.

7.1 The challenge of accounting for water values

While distributed water (natural water, CPC 1800) from the water supply industry may be sold, the price paid by consumers does not usually reflect the exchange value, due to, for example, government subsidies. An exchange value can be calculated based on the cost of production, as is done for public education and public health. More importantly, the political and economic characteristics of water mean that exchange values do not fully reflect the value of water (Grafton et al., 2020).

The values of water are difficult to define, given water's multifaceted nature, and is a topic of great academic and policy interest. For example, it was the focus of the 2024 UN Water

Day and the World Water Development report (UN, 2021). What values water has depend on its framing: as a human right, a commodity, or an entity with intrinsic value (e.g., Pascual, et al. 2023; Manero et al., 2024). The decision context also affects the assigned value of water (why is it being valued?).

A wide range of decisions related to water planning, allocation, conservation, and infrastructure development can be informed by water accounting, which seeks to highlight the direct connections between water and the economy (SEEA–CF, SEEA-Water) and the role of ecosystems in water supply (SEEA-EA) by using exchange value to reconcile natural resources with other economic measures in the SNA.

The exchange value is agnostic to prevailing market conditions and is not equivalent to the free market price. Exchange values also differ from welfare values used in cost benefit analysis for public policy decisions primarily because they do not include consumer surplus nor externalities. As such, they do not–nor are they meant to–reflect the value of ecosystems to the economy or broader society. With exchange values, the monetary value is not a welfare measure, but rather money is a medium of exchange and store of wealth (Manero et al., 2024; UN, 2014).

Observed prices of water are an unreliable measure of exchange value because water price is heavily regulated, supply is a natural monopoly, there may be rationing, property rights are often absent, and few robust water markets exist due to water's bulky nature, among others (Vardon and Onder 2023; SEEA-Water p 117). In addition to the institutional issues, valuation is confounded by the multi-faceted biophysical nature of water – it is dynamic, cyclical, place-based, and of varying water quality. Water is valuable when it is in the right place at the right time, and of adequate quality for its intended use. Too much or too little water can be catastrophic, while pollution can render water worthless. For instance, the same unit of water may concurrently be of high value to an industry that receives a consistent, minimum amount of water that it requires to produce its product, while of low value for use by another industry that requires more flow and higher quality to run its operations. Other challenges that complicate water valuation include scaling and aggregation issues, the risk of double counting, and the lack of information on marginal value.

7.2 Valuation in the SNA, SEEA-CF, and SEEA-Water

Estimating the exchange value of water is theoretically possible but practically difficult. In practice, the monetary supply and use table (MSUT) developed using the SEEA-CF records the product natural water (CPC 1800) using either the prices paid for the product by consumers, or the production cost of natural water (CPC 1800) where the price is below production cost. Both ways are methodologically straightforward and depend largely on data availability. It is interesting to note that the SEEA-CF does not include a water MSUT, and that the MSUT are the least compiled type of water account (Vardon et al., 2023).

The value of water as a natural resource (non-produced asset) abstracted from environmental assets that are not artificial reservoirs is not included in the MSUTs of SEEA-CF, but the same flow is often valued in ecosystem accounting as a final water supply ecosystem service abstracted from water ecosystem assets (Table 2). As the abstraction of water resources from environmental assets for use by economic units is equivalent to the use of the final ecosystem service of water supply by economic units (Section 5), the methods for valuation outlined in the SEEA-EA , and elaborated in NCAVES and MAIA (2022) can be used for the valuation of the natural resource water in the SEEA-CF and SEEA-Water.

A variety of academic studies have undertaken water valuation for accounting: in the Netherlands (Edens and Graveland, 2014; Remme et al., 2015; Schenau et al., 2022), Australia (Keith et al., 2017), the USA (Fenichel et al., 2016; Bagstad et al. 2020) and for water-related ecosystems at the large scales (e.g. La Notte et al., 2012) and around the world (Siikamaki et al., 2021).

There are several options for valuing water (Tables 6 and 7). The SEEA-Water (Table 6) focuses on water as an intermediate input to production, water as a final consumer good, and the waste assimilation services of water. Other water-related values for recreation, navigation, biodiversity, and water reliability and timing, are acknowledged but not addressed. The SEEA-Water provides a review of the valuation techniques with an eye towards consistency with the SNA, but it does not make recommendations on methods.

In rare cases, water rights are purchased by water users (e.g., in Australia), and in others, water rights are embedded within the land market, enabling inference of water's market value. The latter is recognised in the SNA (para 10.184). The value of water in production by different industries and households can be estimated using different approaches (Table 6). Finally, the waste assimilation service can be approximated through damage or benefits estimates.

The SEEA-EA goes a step further than the SEEA-Water, connecting water to its natural sources. The SEEA-EA introduced ecosystems as a producer of goods and services, thereby placing the environment within the production boundary and similarly identifying the flow of income from services. Including ecosystem services (ES) in the production frontier was a major step towards highlighting the linkages between the environment and the economy. Some ES already fall within the SNA production boundary (e.g., timber and fisheries); in these cases, the SEEA-EA simply serves to clarify the productive role of the environment and does not affect the aggregate estimates (e.g., GDP). Such services are called SNA-benefits. In many other cases, particularly for non-market ES that are outside the SNA production boundary, such as cultural and recreation ES, are known as non-SNA benefits. The application of the SEEA-EA will affect estimates of production and consumption, and thus

GDP will change. Their inclusion in the production boundary enables ecosystems to be considered as a form of capital that appreciates or depreciates over time.

Table 6. Valuation techniques for water (SEEA-Water, p 124)

Water as a final consumer good	Sale and rental of water rights; demand functions from water utility sales; mathematical programming models; alternative cost; contingent valuation
Water as an intermediate input to production	Residual value; change in net income; production function approach; mathematical programming models; sales and rentals of water rights; hedonic pricing; demand functions from water utility sales
Environmental services (waste assimilation)	Cost of actions to prevent damages; benefits from damages averted

The SEEA-EA technical guidance on monetary valuation (2022) reflects the underlying purpose of the accounts, that is, to supplement and integrate into the System of National Accounts (SNA). Valuing ecosystem services adds another layer of complexity to the water valuation challenge. Many ecosystem services are non-marketed. Much progress has been made in the past few decades in non-market methods, though only a handful do not include consumer surplus and thus are compatible with exchange values used in the SEEA. Another issue is delineating ecosystem services (Sections 3-5). The subject of valuation must be a final ecosystem service, and services must be differentiated from benefits to avoid double counting. Moreover, many ecosystems are poorly understood, and thus functional and structural changes cannot be causally linked to changes in ecosystem services production (Weiskopf et al., 2022).

To estimate the value of ES, the SEEA-EA (Chapters 8, 9, and 12) and monetary valuation technical guidance (NCAVES and MAIA 2022) offer an array of valuation methods that are consistent with the exchange value concept. Where markets are sufficiently robust, the exchange value is directly observable or, where markets are absent, can be derived from, for example, prices of similar goods and services.

In many cases, however, the benefits of nature are externalities and thus no market exists from which to observe prices. For some non-market ecosystem goods and services, the exchange value is embodied in market transactions and can thus be estimated. One can also estimate what it would cost to replace the ES (revealed expenditures on related goods and services) or simulate expenditures or markets. Value transfer functions can be carefully applied to extrapolate values spatially (e.g. Siikamaki et al., 2021). Not all non-market methods can feasibly estimate exchange values for all ecosystem services, thus the technical guidance ranks preferred methods in tiers for each service type based on their accuracy and resolution, market vs. non-market nature of the service, and the proximity to the concept of exchange value.

Table 7. Tiered valuation methods for water-related (NCAVES MAIA, 2022, p 49-50)

Ecosystem Service		Tier 3 (better)	Tier 2 <-------------->	Tier 1 (less good)
Water supply		Directly observed prices Productivity change method	Replacement costs	Residual value
Water purification services (water quality regulation)	Retention and breakdown of nutrients	Directly observed prices	Replacement cost Avoided damages	
Soil and sediment retention services	Soil erosion control services	Productivity change	Replacement cost Avoided damages	
Water flow regulation services	Baseline flow maintenance services Peak flow mitigation services	Productivity change Averting behaviour	Replacement cost Avoided damages	
Recreation-related services	Travel related Local	Simulated exchange value + random utility model Hedonic pricing	Consumer expenditure	

Specifically for water supply services, which are the “combined ecosystem contributions of water flow regulation, water purification, and other ecosystem services to the supply of water of appropriate quality to users for various uses” (NCAVES and MAIA 2022, p. 62), four methods are identified (Table 7). Notably, the guidance suggests that water supply be separated into water flow regulation and purification services, if possible. These services can be values with an additional method calculating avoided damages. Other hydrological services, which include soil and sediment retention services, water flow regulation, recreation, and perhaps also visual amenity and spiritual/artistic/cultural heritage services (see Table 1), require their own treatment.

7.3 Extending beyond exchange values

For various reasons, there has been some pushback to the exchange value concept, which relies on resource rent and cost-based approaches in order to be compatible with the SNA (Normyle et al., 2021; Femia and Capriolo, 2022; Grimsrud et al., 2018; De Valck et al., 2023) In these times of environmental crises, many have called for following the tradition of purpose-driven pragmatism that historically characterized the underlying SNA method development, however urgent environmental management action is arguably delayed by the technical constraints of the SNA-mandated exchange value concept (Turner, et al., 2019).

The SEEA-EA guidance cautions against the use of numerous valuation methods that are commonly applied in environmental economics (i.e., stated choice methods) due to their incompatibility with the concept of exchange value. As a result, the array of services that can be valued in the SEEA-EA is limited to those for which behaviour can be observed. The injunction from using stated preference methods in EA results in many non-market monetary values of ES being omitted from the accounts. While the physical metrics in the accounts can inform decisions, by excluding welfare values, the applicability of the accounts for public policy analysis is diminished (e.g., cost-benefit and sustainability analysis).

The goal of the SEEA, and ecosystem accounting in particular, is greater than ensuring data fit into the SNA. The SNA is not designed to measure changes in human wellbeing nor assess how economic activity affects the environment (externalities). The SEEA-CF adds the impacts of pollution (e.g., solid waste, air and water emissions) and the extraction of natural resources (timber, minerals, and water), and the SEEA-EA, ecosystem condition, addresses at least part of the economy's impacts on the environment.

Many aspects of nature’s contributions to human wellbeing, including benefits derived from water and related ecosystem services, cannot be expressed in exchange values, or even in monetary terms, e.g., spiritual or cultural heritage. The constraints of exchange value have led to a line of research to develop alternative accounting approaches that are more flexible (in terms of data needs and valuation methods) and pragmatic (in terms of required technical capacity and policy relevance). Bridge tables, for example, can integrate accounting and welfare values, including non-use values, and illustrate externalities and ecosystem disservices (SEEA-EA, Ch 12, p 256). In another innovation, the complementary accounting network approach allows for including non-monetary methods to reflect the importance of ecosystems. In this hybrid approach, valuation methods could extend beyond anthropocentric, instrumental values to also represent social, relational, and intrinsic values people hold for nature. Value indicators could expand to biophysical or socio-cultural realms and would likely do a better job of encompassing the diversity of values people hold for the environment. Such broadening would directly respond to recent methodological advice by the International Panel on Biodiversity and Ecosystem Services, which calls for diversifying valuation to reflect alternative worldviews and values. Another approach is wealth accounting, which aims to measure changes in total (natural, human, productive) wealth. Wealth accounting is, however, data-intensive and requires knowledge on how much each form of capital contributes to human wellbeing (Grimsrud et al., 2018).

Recommendation 8. That alternative representations of water values are recognised in the Central Framework update.

Note recommendation 5 also applies to valuation.

8. Policy applications

Effective water policy and management is needed with increasing uncertainty in water supply and a growing water demand resulting from climate change and population growth. This is reflected in Sustainable Development Goal 6 (SDG 6), to “*Ensure availability and sustainable management of water and sanitation for al*l” with targets covering the management issues of water security, sustainable and efficient water supply and use and water quality.

There is general agreement that reliable and timely data and transparent and evidenced-based assessments are needed for policies for sustainable development and this is specifically recognised for water in Principle 5 of the Principles on Water Governance (OECD, 2015) is to “*produce, update, and share timely, consistent, comparable and policy-relevant water and water-related data and information, and use it to guide, assess and improve water policy”* and Principle 12 is to “*promote regular monitoring and evaluation of water policy and governance where appropriate, share the results with the public and make adjustments when needed*”. Water accounting can provide policy-relevant information by organising existing data in a coherent manner and highlighting data gaps and deficiencies for correction (Vardon et al., 2023, Bagstad et al., 2020).

One way to address the demand for policy-relevant accounting information is to update the SEEA-Water, clarifying it status and relationships to the SNA, SEEA-CF and SEEA-EA, providing more guidance on valuation and values, and linking these directly to water policy and management. An update of the SEEA-Water could be done without policy linking, which could be in a separate document, as has been done for climate change[5], and biodiversity[6], and the SDGs[7] by the UN.

Recommendation 9. That the SEEA-Water is updated, integrating the relevant parts of the Central Framework and Ecosystem Accounting, more guidance of values and valuation, and with material on how water accounting can be used for water policy and management.

9. Conclusions

The development of this paper has highlighted the needed to update the SEEA-CF to clarify the intersections of it with the SNA and SEEA-EA, the status of the SEEA-Water, for more guidance of values and valuation, and to raise the awareness and understanding of water accounting among potential users.

Key conclusions are:

- The theoretical and practical intersections between the Central Framework and Ecosystem Accounting are many.
- Different terminologies are a source of confusion, especially where the same flow is given a different name.
- A supply use table integrating ecosystem services and water products can be produced and this should aid understanding.
- The Central Framework SUT is large and complex and differs in structure to the PSUT in the SEEA-Water.

[5] https://seea.un.org/content/climate-change
[6] https://seea.un.org/content/biodiversity
[7] https://seea.un.org/content/sustainable-development-goals

- Water valuation and recording water values in accounting remains an ongoing area of research.
- Few understand how water accounting can be applied to water policy and management

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Supplementary tables

Table S1. SEEA-Water physical use table

SEEAW Standard Table I: Physical use table

Physical units

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

Note: grey cells indicate zero entries by definition.

Table S2. SEEA-Water physical supply table

SEEAW Standard Table II: Physical supply table

Physical units

		Industries (by ISIC categories)							Households	Rest of the world	Total
		1	2-33, 41-43	35	36	37	38,39, 45-99	Total			
Within the economy	**4. Supply of water to other economic units**										
	of which :										
	4.a Reused water										
	4.b Wastewater to sewerage										
To the environment	**5. Total returns** (= 5.a+5.b)										
	5.a To water resources										
	5.a.1 Surface water										
	5.a.2 Groundwater										
	5.a.3 Soil water										
	5.b To other sources (e.g. sea water)										
6. Total supply of water (= 4+5)											
7. Consumption (3-6)											

Note: grey cells indicate zero entries by definition.