Water and Ecosystem Accounting

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[1] *The views and opinions expressed in this report are those of the author and do not necessarily reflect the official policy or position of the United Nations or the Government of Norway.*

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Contents

1 Introduction

1. This note summarises the conceptual and methodological material related to water in the context of the development and application of the System of Environmental-Economic Accounting–Experimental Ecosystem Accounting (SEEA-EEA). The SEEA-EEA was presented to the United Nations Statistical Commission at its 44th Session in 2013. The report of the 44th Session "welcomed" the SEEA-EEA and "encouraged its use by international and regional agencies and countries" [2].

2. This note provides countries and agencies embarking on a program of ecosystem accounting with a starting point for the development of ecosystem accounts relating to water. Water has an important place in ecosystems and environmental processes and in economic activity. The extensive role of water in the environment and the economy requires a comprehensive approach to its measurement and reporting and the SEEA-EEA provides this building on the concepts, methods and data sources related to the SEEA Central Framework and the ecosystem services and natural capital accounting literature.

3. Water is in continuous flux through the processes of precipitation, evaporation, runoff, infiltration and flows to the sea. The natural cycle of water, the hydrological cycle, involves connections between the atmosphere, the oceans, the groundwater and land surface, including vegetation cover, and sub-surface flows. Accounting for water considers the stocks and changes in stocks of water in the inland water resources (surface water, groundwater and soil water) and the exchanges (or flows) between these and the vegetation, atmosphere, oceans and the economy. In this the hydrological system provides the water (via precipitation) and the movement of the water across the landscape is accounted for spatially in the SEEA-EEA. Within the economy the use and discharge of water by industries and sectors is covered by the SEEA Central Framework. A distinguishing feature of the SEEA-EEA is that spatial units are the basis of the accounting. In this the units can be land cover or ecosystem types (e.g. forests, shrub lands, crops, etc.), river basins or administrative areas (e.g. countries, states, provinces, boroughs, shires, prefectures, etc.).

4. Figure 1 presents a stylised view of the hydrological system and the economy and the main stocks and flows covered in water accounting. This representation, while showing the water resources (e.g. surface and groundwater) does not explicitly show the relationship to ecosystems, and in particular the vegetation cover which provides some of ecosystem services related to water (e.g. water filtration and regulation).

5. Accounting for water in the context of ecosystem accounting, and the SEEA-EEA in particular, is very new. As such definitive treatments and classifications of the ecosystem assets and ecosystem services relating to water are not yet established. As such, while the SEEA-EEA provides a starting point, this note includes a section titled "Issues for Resolution" (Section 6) and provides references to a range of other material. Related to this is the issue of terminology, which is discussed in Section 1.3.

1.1 Water and the SEEA-Experimental Ecosystem Accounting

6. The SEEA-EEA includes water in four contexts:
   - Water as an asset (Table 4.2, p. 86)
   - Water as a characteristic of ecosystem asset condition (Section 4.3 and Tables 4.3 and 4.4)
   - Water as an ecosystem service, and specifically water provision (Table 3.2 p. 59, Paragraphs A3.11 to A3.15, pp. 70)

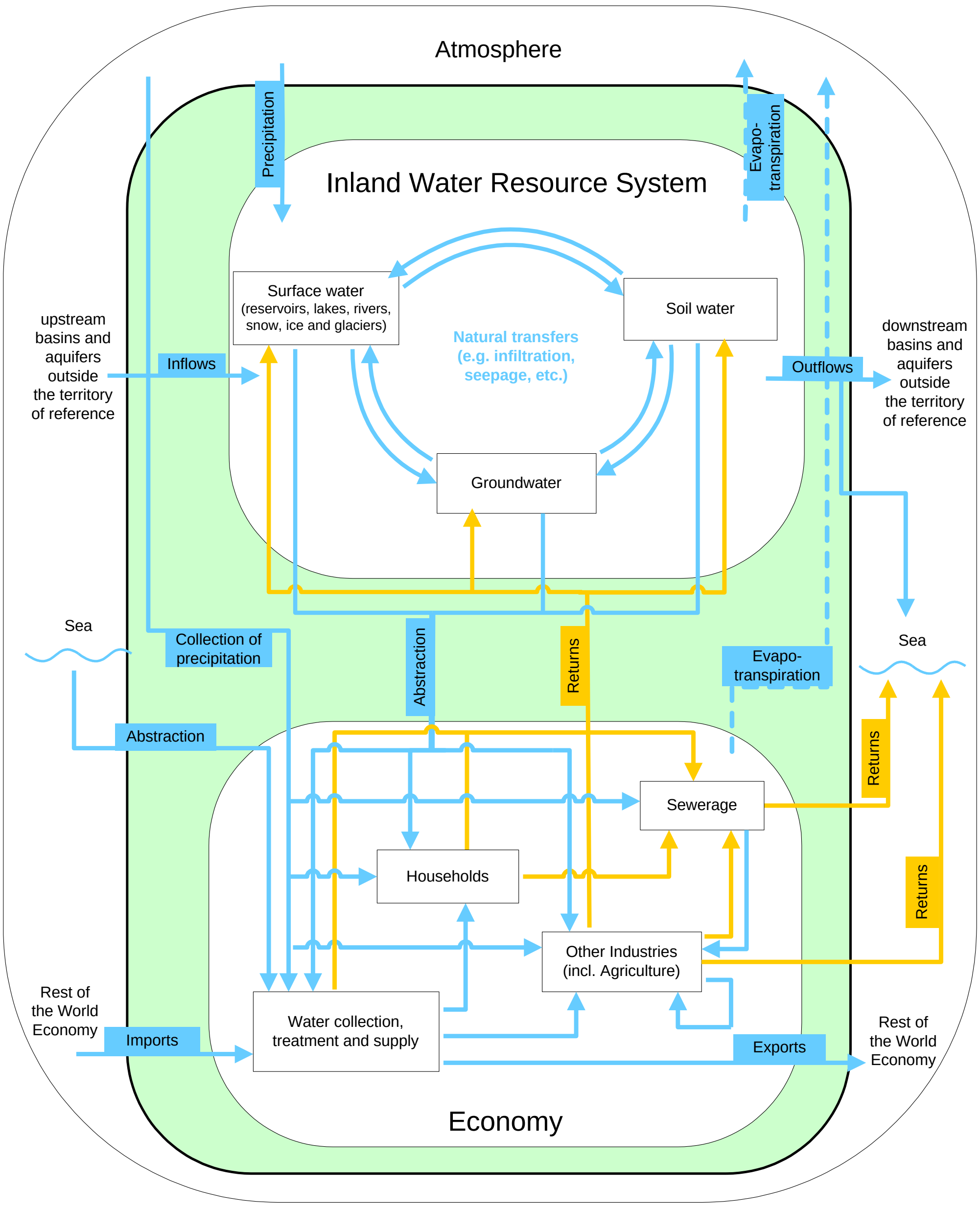
[2] UN Statistical Commission Report of the forty-fourths session (26 February-1 March 2013), Page 10. http://unstats.un.org/unsd/statcom/doc13/2013-Report-E.pdf

- A water related ecosystem services – flood protection (Figure A3.6 Paragraphs A3.23, pp. 73). This and other related ecosystem services, such as water filtration, are not provided by the water *per se* but by other elements of the ecosystem (e.g. riparian ecosystems).

7. This note outlines the basic concepts of water accounting and how these relate to ecosystem accounting in the SEEA-EEA. It also provides information of data sources and methods as well as links to additional material to aid in the construction of accounts for water. For this, water accounting is well supported by reference material and country experience when compared to other components of environmental and ecosystem accounting. In particular the UN documents the SEEA-Water (UN 2012a), International Recommendations for Water Statistics (IRWS)(UN 2012b) and Draft Guidelines for the Compilation of Water Statistics and Accounts (UNSD 2013).

8. Not covered in this note is the use of water as a provisioning service in the generation of hydro-electricity. This aspect of accounting is covered in the SEEA-Energy and the International Recommendations for Energy Statistics and is mentioned here for completeness.

Figure 1. The main elements of the water accounts



Source: After SEEA-Water, Figure II.2 (p. 20)

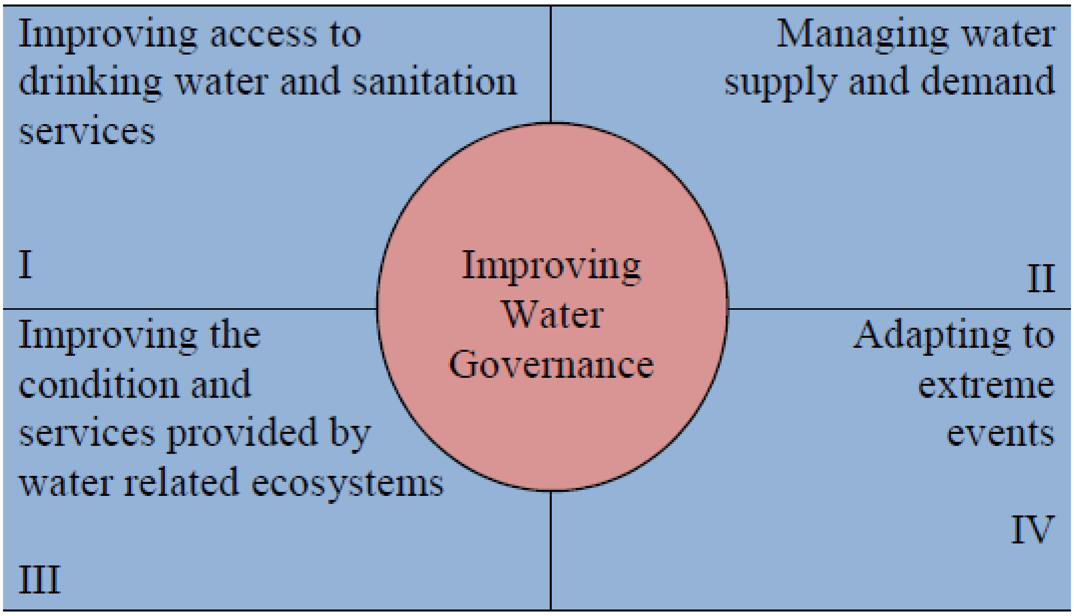
1.2 Uses of water accounts

9. Water accounts can assist in a wide range of analytical and policy situations. These uses have been summarised in a range of documents some specifically on water (e.g. Chapter IX of UN 2012a, Vardon et al. 2007) or environmental accounting more generally (e.g. UN et al 2014, Smith 2014). A useful summary is provided by UNWWAP and UNSD (2011) who group the broad objectives of water policy under four headings (Fig 2):
   I. Improving water supply and sanitation services
   II. Managing water supply and demand
   III. Improving the state of environmental and water resources
   IV. Adapting to extreme hydro-meteorological events

10. Ecosystem accounting is relevant to all 4 areas of water policy. For example:
   I. For the provision of drinking water and sanitation services to households, the water accounts provide information on the amount of water supplied to households as well as the amount of wastewater generated and either collected by sewerage systems or discharged directly to the environment. Combined with economic information from the water supply industry, water accounts can show the cost of production of water. This could also be extended through modelling to estimate the cost of supply water and sewerage services to a greater proportion of the population. Combined with information from relevant ecosystem accounts, information can be provided on the extent and condition of water-related ecosystems as well as the subsequent quality of ecosystem services provided by them that are related drinking water, sanitation (e.g. water filtration/purification), water availability and disaster risk reduction.
   II. For managing water supply and demand the water accounts include information on the total water available and how much is being extracted and used in the economy and by what parts of the economy (e.g. in agriculture, manufacturing and for drinking water). Information on the price of water and the physical use of water can be matched and combined with measures of economic performance to provide indicators of physical water-use intensity and economic productivity and efficiency. Such information can help to inform decisions about investment in water supply infrastructure as well assessing alternative water pricing regimes. In areas with marked temporal fluctuations, this can be combined with information from relevant ecosystem accounts on water regulation (including retention) as an ecosystem service.
   III. For improving the condition and services provided by water-related ecosystems, the accounts and in particular the ecosystem accounts, provide much of the biophysical information necessary for tracking changes in extent and condition of water-related ecosystems, as well as for measuring the ecosystem services provided (e.g. water filtration, regulation or retention – see above). The accounts can be used to identify water-related ecosystems declining in quality, the economic and other uses dependant on them and hence allow for the targeting of investment in remediation to achieve the greatest overall benefit. This can include policy tools such as ecosystem conservation and restoration, the payments for ecosystem services or the application of the polluter pays principle.
   IV. For adapting to extreme events, the water accounts can show the impacts on economic production, mortality and asset losses of droughts and floods, while a broader set of ecosystem accounts can show the benefits from the services of flood protection, drought mitigation and water flow regulation. Further changes in the condition and services provided by water-related ecosystems can be linked to extreme events and climate change over the longer term.

11. Various indicators can be derived directly from water accounts or in combination with other information, such as land area, population, and industry value added. The suite of indicators listed in the SEEA-Water (Annex III) can provide a rich information source for policy makers, researchers and the public. For example, comparing the water stocks in different ecosystems with the demand for water from different human activities (e.g. agriculture, hydro-electric power and drinking water). This can inform water planning where there are significant competing uses of water (e.g. water for water-related ecosystems and water for urban consumption).

Figure 2. Broad grouping of water policy objectives



1.3 Terminology

12. The terminology surrounding ecosystem services, natural capital, water and environmental accounting is varied and is often confusing. Different terms are being used to describe the same or similar concepts or a single term is being used to define very different concepts. This is particularly the case for ecosystem services where a variety of terminology and concepts are in use.

13. The terminology used in this note is based on the SEEA-EEA and the SEEA-Water. In particular the SEEA-EEA[3] contains a glossary that includes the terms ecosystems, ecosystem capacity, ecosystem services, ecosystem characteristics, ecosystem condition, ecosystem degradation, etc. Annex 1 is a list of selected terms from the SEEA-EEA glossary.

14. In addition to the glossary, terms are defined in the text below as appropriate. In some cases terms are used before they are defined, as in this introduction. This is done to make the document as easy as possible to read. Reference should be made to glossary in Annex 1 and to the SEEA-Water (UN 2012a)[4] for specific water terms.

1.4 Structure of this note

15. This note is composed of 7 Sections and an Annex. Section 1 is the introduction. Section 2 is on the water asset accounts and water as an indicator of ecosystem condition. Waters role in assessing ecosystem condition is dealt with only briefly, with the broader issue of ecosystem condition and capacity dealt with in a separate note.

16. Section 3 is on the ecosystem services. It mainly covers the ecosystem service of water provision but also covers the connected water related ecosystem services of water filtration. Water flow regulation and flood protection are mentioned but not covered in any detail. Section 4 is on data sources and methods that can be used to populate accounts for carbon and in particular the carbon stock account. Section 5 provides additional reference material and links to other ecosystem service and environmental accounting initiatives, while Section 6 is a summary of the issues in relation to water

[3] See SEEA-EEA, pages 159-169, http://unstats.un.org/unsd/envaccounting/eea_white_cover.pdf

[4] See SEEA-Water, pages 193-197, http://unstats.un.org/unsd/envaccounting/seeaw/

accounting which require testing and ultimately resolution. The main part of this note concludes with Section 7, the references. Referencing is by author date and, where possible, links to publically accessible websites are provided. Annex 1 is a glossary of terms from the SEEA-EEA.

2 Physical asset accounts for water resources and water as a measure of ecosystem condition

17. The section describes the main concepts and basic structure of the water asset account and how water is treated in the ecosystem condition account. In the latter, different measure of water quality are described along with indices of stream condition.

2.1 Physical asset account for water resources

18. The physical asset account for water resources of the SEEA-EEA is a basic resource account following the general structure of the natural resource accounts for the SEEA Central Framework[5]. Water asset accounts record the stock changes due to human activities (e.g. extraction for irrigation) and natural causes (e.g. evaporation). The accounts include the flows between different territories (which could be river basins or countries).

19. The physical asset account for water resources in the SEEA-EEA is show in Table 1. The table is identical to the Table 5.25 in Chapter V of the SEEA Central Framework (UN et al 2013) and is a minor variation on Table VI.1 from Chapter VI of the SEEA-Water (UN 2012a). The differences are mostly cosmetic and with the separate identification of water abstracted for hydro-power generation and for cooling water shown in the SEEA-Central Framework and SEEA-EEA but not in the SEEA-Water.

20. ***Water resources consist of fresh and brackish water in inland water bodies including groundwater and soil water***[6]. As such, the physical asset account for water resources excludes salt water oceans and saltwater seas. The complete disaggregation of inland water resources is shown in the columns as:

- Surface water, including artificial reservoirs, lakes, rivers and streams and glaciers, snow and ice;
- Groundwater and;
- Soil water.

21. Surface water comprises all water that flows over or is stored on the ground surface regardless of its salinity levels. Surface water includes water in:
    - Artificial reservoirs, which are man-made structures used for storage, regulation and control of water;
    - Lakes which are, in general, large bodies of standing water occupying a depression in the earth's surface; rivers and streams which are bodies of water flowing continuously or periodically in channels;
    - Snow and ice which include permanent and seasonal layers of snow and ice on the ground surface; and
    - Glaciers which are defined as an accumulation of snow of atmospheric origin, generally moving slowly on land over a long period.

22. Overland flows, i.e. the flows of water over the ground before entering a channel, are also part of surface water but the stock of these flows at any one time is small and hence not separately recorded.

[5] See SEEA Central Framework, pages 139-142, including Table 5.2.
http://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf

[6] See SEEA Central Framework, page 212.
http://unstats.un.org/unsd/envaccounting/seeaRev/SEEA_CF_Final_en.pdf

Table 1. Physical asset account for water resources (cubic metres).

	Type of water resource						Total
	Surface water				Groundwater	Soil water	
	Artificial reservoirs	Lakes	Rivers and streams	Glaciers, snow and ice			
Opening stock of water resources	1 500	2 700	5 000		100 000	500	109 700
Additions to stock							
Returns	300		53		315		669
Precipitation	124	246	50			23 015	23 435
Inflows from other territories			17 650				17 650
Inflows from other inland water resources	1 054	339	2 487		437	0	4 317
Discoveries of water in aquifers							
Total additions to stock	1 478	585	20 240		752	23 015	46 071
Reductions in stock							
Abstraction	280	20	141		476	50	967
for hydro power generation							
for cooling water							
Evaporation & actual evapotranspiration	80	215	54			21 125	21 474
Outflows to other territores			9 430				9 430
Outflows to the sea			10 000				10 000
Outflows to other inland water resources	1 000	100	1 343		87	1 787	4 317
Total reductions in stock	1 360	335	20 968		563	22 962	46 188
Closing stock of water resources	1 618	2 950	4 272		100 189	553	109 583

Source: SEEA-EEA Table 4.2 and SEEA Central Framework Table 5.25

23. Although artificial reservoirs are not natural components of the earth's surface, once in place, the stocks and flows of water are treated in the same way as the stocks and flows associated with natural stores of water, in particular natural lakes. They are separately identified in the classification of inland water resources since, in many cases, the flows associated with artificial reservoirs, and in particular evaporation and the change in timing of water flows, are of particular analytical interest.

24. Groundwater comprises water that collects in porous layers of underground formations known as aquifers. An aquifer is a geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to wells and springs. It may be unconfined, by having a water table and an unsaturated zone, or may be confined when it is between two layers of impervious or almost impervious geological formations.

25. Soil water consists of water suspended in the uppermost belt of soil, or in the zone of aeration near the ground surface. Soil water can be discharged into the atmosphere by evapotranspiration (i.e. the quantity of water transferred from the soil to the atmosphere by evaporation and plant transpiration), be absorbed by plants, flow to groundwater, or flow to rivers (run-off). Some part of transpiration and absorption of water by plants is used in production (e.g. the growing of crops). Use of this water equates to what is sometimes described as use of "green water".

26. Wetlands are not separately identified as water resources in Table 1 or in the SEEA Central Framework or SEEA-Water. However, "open wetlands" are identified in the tables for ecosystem services and ecosystem assets of the SEEA-EEA (i.e. tables 2.2 and 2.3). As such wetlands (or "open wetlands") could be added as an additional column in the physical asset account for water resources. If this is done care must be taken not to double count the water included in other categories. This is a particularly challenging task given the broad ranging and cross-cutting definition given in the Ramsar Convention:
    - "The Convention uses a broad definition of wetlands. It includes all lakes and rivers, underground aquifers, swamps and marshes, wet grasslands, peatlands, oases, estuaries, deltas and tidal flats,

mangroves and other coastal areas, coral reefs, and all human-made sites such as fish ponds, rice paddies, reservoirs and salt pans[7]."

27. For the water asset account, the row entries follow the basic form of the asset account with:
    - Opening stock;
    - Additions;
    - Reductions and;
    - Closing stock.

28. The stock of surface water is the quantity of water in a territory of reference measured at a specific point in time (usually the beginning or end of the accounting period, 1st of January and 31 December). The stock level of a river is measured as the volume of the active riverbed determined on the basis of the geographic profile of the riverbed (i.e. length and depth) and the water level. This quantity is usually very small compared to the total stock of water resources and the annual flows of rivers.

29. Stocks of groundwater and soil water are also measured at a point in time. The measurement of soil water may extend to cover all soil but may also be limited to particular uses. For example, to the use of soil water in agricultural and forestry areas. Soil water is important for understanding the stock and use of water in rain fed agriculture (i.e. non-irrigated agriculture) as well as the volume of water used in irrigated systems (e.g. in years with more rainfall, less irrigation is needed because more of the water is sourced from soil water). The measurement scope of soil water should be clearly articulated in any asset account for water resources.

30. In countries where there is a consistent and regular hydrological year with a distinct dry period, the stock of soil water at the end of the hydrological year may be negligible in comparison to groundwater or surface water. While soil water can be distinguished from groundwater and surface water in theory, it may be difficult to measure it directly although it can be estimated indirectly using a variety of data.[8]

31. The additions to the stock of water resources are:
    - Returns represent the total volume of water that is returned to the environment by economic units into surface, soil and groundwater during the accounting period. Returns can be disaggregated by type of water returned, for example, irrigation water, treated and untreated wastewater.
    - Precipitation consists of the volume of atmospheric precipitation (e.g. rain, snow, hail etc.) on the territory of reference during the accounting period before evapotranspiration takes place. The majority of precipitation falls on the soil. A proportion of this precipitation will run off to rivers or lakes and is recorded as an addition to surface water. Amounts retained in the soil should be recorded as additions to soil water. Some precipitation also falls directly onto surface water bodies. It is assumed that water would reach aquifers after having passed through either the soil or surface water (e.g. rivers, lakes, etc.), thus no precipitation is shown in the asset accounts for groundwater. The infiltration of precipitation to groundwater is recorded in the accounts as an inflow from other water resources into groundwater.
    - Inflows represent the amount of water that flows into water resources during the accounting period. The inflows are disaggregated according to their origin: (a) inflows from other territories/countries; and (b) inflows from other water resources within the territory. Inflows from other territories occur with shared water resources. For example, in the case of a river that enters the territory of reference, the inflow is the total volume of water that flows into the territory at its entry point during the accounting period. If a river borders two countries without eventually entering either of them, each country could claim a percentage of the flow to be attributed to their territory. If no formal convention exists, a practical solution is to attribute 50 per cent of the flow to each country. Inflows from other resources include transfers, both natural and man-made, between the resources within the territory. They include, for example, flows from desalination facilities and flows of infiltration and seepage.

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[7] See http://www.ramsar.org/about/the-ramsar-convention-and-its-mission

[8] See *International Recommendations on Water Statistics* (UN, 2010) paragraph 4.29

- Discoveries of water in new aquifers. These flows should be recorded in terms of the quantity of water in the newly discovered aquifer as distinct from the overall capacity of the aquifer. Increases in the volume of water in a known aquifer should be included as an inflow of water resources to groundwater.

32. The reductions to the stock of water resources are:
    - Abstraction, which is the amount of water removed from any source, either permanently or temporarily, in a given period of time. It includes the abstraction of water by households for own-consumption, water used for hydroelectric power generation and water used as cooling water. Given the large volumes of water abstracted for hydroelectric power generation and for cooling purposes, these flows are separately identified as part of the abstraction of water. Abstraction also includes the abstraction of soil water by plants in areas of rain-fed agriculture and cultivated timber resources in line with the definition of abstraction for the water PSUT (see Section 3.5). The water abstracted from soil water is either absorbed by the plants or returned to the environment through transpiration.
    - Evaporation and actual evapotranspiration, which are the amount of evaporation and actual evapotranspiration that occurs in the territory of reference during the accounting period, excluding amounts already recorded as abstracted from soil water. Evaporation refers to the amount of water evaporated from water bodies such as rivers, lakes, artificial reservoirs, etc. Actual evapotranspiration refers to the amount of water that evaporates from the land surface and is transpired by the existing vegetation/plants when the ground is at its natural moisture content as determined by precipitation and soil properties. Actual evapotranspiration will typically be estimated using models.9
    - Outflows which are the amount of water that flows out of water resources during the accounting period. Outflows are disaggregated according to the destination of the flow, namely (a) to other water resources within the territory, (b) to other territories/countries and (c) to the sea/ocean.

2.2 Water and measures of ecosystem condition

33. Ecosystem condition reflects the overall quality of an ecosystem asset. Measures of ecosystem condition are generally combined with measures of ecosystem extent (e.g. in ha or km^2) to provide an overall measure of the state of ecosystem assets. Ecosystem condition also underpins the capacity of an ecosystem asset to generate ecosystem services and hence changes in ecosystem condition will impact on expected ecosystem service flows. Ecosystem condition changes are due, for example, to diversions of water for human use as well as changes due to land use and land management. Both types of changes will impact of the quality and quantity of water available for use by people or in the environment and hence the condition of ecosystems. This in turn will lead to changes in the delivery of ecosystem services (Described in Section 4).

34. Ecosystem capacity is not defined from a measurement perspective in the SEEA Experimental Ecosystem Accounting but it is linked to the general model of ecosystem assets and ecosystem services that are described. In general terms, ecosystem capacity refers to the ability of a given ecosystem asset to generate a set of ecosystem services available for potential use by people in a sustainable way into the future. While ecosystem capacity is relevant to assessments of ecosystems, measurement of ecosystem capacity requires the selection of a particular basket of ecosystem services. Measures of ecosystem capacity are more likely to relate to consideration of a range of alternative ecosystem use scenarios than to a single standard basket of ecosystem services.

35. Table 2 shows the table for ecosystem condition presented in the SEEA-EEA. Water is used as one of the indicators or characteristics of ecosystem condition show in the table.

[9] Actual evapotranspiration differs from potential evapotranspiration which is the maximum quantity of water capable of being evaporated in a given climate from a continuous stretch of vegetation that covers the whole ground and is well supplied with water.

Table 2. Measures of ecosystem condition for particular areas.

	Ecosystem extent	Characteristics of ecosystem condition				
		Vegetation	Biodiversity	Soil	Water	Carbon
	Area (proportion of EAU)	Indicators (e.g. Leaf area index, biomass index)	Indicators (e.g. species richness, relative abundance)	Indicators (e.g. soil fertility, soil carbon, soil moisture)	Indicators (e.g. river flow, water quality, fish species)	Indicators (e.g. net carbon balance, primary productivity)
Type of LCEU						
Forests						
Agricultural land						
Urban areas						
Inland water bodies						

Source: SEEA-EEA, Table 2.3, p. 35

36. There are various measurements relating to water which may contribute to an assessment of ecosystem condition. In this indicators can be a determinant of both ecosystem condition and the quality (or condition) of water. In this condition is usually determined in reference to a particular reference state, often that considered to be natural or with minimal human disturbance. Table 3 presents a range of possible indicators and their relationship to water quality and ecosystem condition. In this some indicators of water quality and ecosystem condition are high correlated.

37. An explanation of the accounting for the condition of ecosystems is not the focus of this note. However, accounting for ecosystem condition is the focus of a separate note and is discussed elsewhere[10]. Ecosystem capacity in relation to water requires additional research and is something that countries may consider investigating.

38. Water quality accounts and water quality indicators are discussed in the SEEA-Water in Chapter VII. A number of examples of the measurement as well as tabular and graphic presentations are provided but a standard account for water quality is not presented.

3 Ecosystem services and water accounting

39. Ecosystem services are defined in the SEEA-EEA to be the contributions of ecosystems to benefits used in economic and other human activity and aligns with what is called “final ecosystem services” in some contexts. As such, the definition of ecosystem services in the SEEA-EEA excludes the set of flows commonly referred to as supporting or intermediate services. These flows are called intra- and inter ecosystem flows in the SEEA-EEA and together with the ecosystem condition are reflected in ecosystem processes.

40. For the water provision service this means that supporting or intermediate services are embedded in the final service and would be considered inter or intra ecosystem flows in the SEEA-EEA. Of particular relevance to the water provisioning service are the water filtration and water flow regulation services which help determine water quality, and hence the types of uses that the water provision service may support, as well as the timing of the availability of water. Section 4 deals with some of the related ecosystem services, focusing on water filtration and water flow regulation but also includes flood control. These services, while related to water are provided by vegetation.

[10] E.g. Rapport, D.J. and Singh, A. 2006. An Ecohealth-based framework for state environment reporting, Ecological Indicators 6. pp. 408–429, Elsevier, the Netherlands, and David J. Rapport and Walter G. Whitford, 1999, How Ecosystems Respond to Stress, BioScience, Vol. 49, No. 3, pp. 193–203

Table 3. Indicators of ecosystem and water condition

Indicator	Notes	Water quality	Ecosystem condition
Nutrient levels (e.g. N, P, K) and pollutant loads (e.g. heavy metals, pesticides)	Nutrients and other pollutants are transported by overland flow in water courses. A large determinate of nutrient levels is agricultural practices relating to fertilizer use. Nutrient and pollution levels can be measured directly through water sampling or modelled using a range of climatic, geographic, land cover and agricultural practices variables.	High nutrient and pollution loads are a general indication of poor water quality. This means that the water less able to be used for water supply and that it can also affect the composition in terms of species of downstream ecosystem (e.g. in freshwater wetlands or marine ecosystems).	High nutrient and pollution loads are correlated with a range of factors including agricultural production and industrial pollution. Areas with large amounts of agricultural production and industry are likely to be in poor condition and hence there will be a correlation between water quality and ecosystem condition.
Sediment load	Sediment (e.g. small particles of silt and clay) is transported by the water flow. Suspended sediment loads tend to be higher in ecosystems that have higher degrees of human influence (e.g. from mining and agriculture) and in step and erodible terrain. Crop type and tillage practices in agriculture are particularly key variables in assessing sediment loads. Loads can be measured directly through water sampling or modelled using a range of climatic, geographic and land cover variables.	High sediment loads are a general indication of poor water quality (e.g. less able to be used for water supply and led to increase rates of deterioration in water supply infrastructure). They can also lead to changes in the species composition of downstream ecosystems (e.g. damage coral reefs)	Sediment load is influenced by the type of vegetation surrounding water courses. In general higher levels of natural vegetation indicate better ecosystem condition and are likely to have lower sediment loads and hence better water quality. Hence, water condition and ecosystem condition are correlated
River or stream flow	The timing and volume of flow is rivers or streams is influenced by the climate (i.e. precipitation), geography and vegetation of ecosystems. In general natural ecosystems tend to moderate the flows (i.e. less the peaks and the troughs) of seasonal variation in precipitation.	River and stream flows that align closely with seasonal precipitation patterns	As river or stream flow is determined in part by the surround vegetation, the extent of natural vegetation will be correlated not only with ecosystem condition but also water quality.
Species richness and abundance (or indicator species)	This is a measure of the number, type (e.g. vascular plants, invertebrates, fish) of species occurring in the water. Species richness and abundance is measured on ground.	The number, distribution and abundance of aquatic species can be used as an indicator of water quality. For example, particular species or groups of species are sensitive to changes in the levels of nutrients or sediments loads.	Biodiversity is an indication of ecosystem condition, with higher levels of natural (i.e. native) species an indication of ecosystem condition.
Riparian vegetation	The type of vegetation immediately adjacent to the rivers and streams can have an impact on nutrient levels, sediment load and water flows. The vegetation can filter out nutrients, sediments and slow water flows. Riparian vegetation can me measured using remote sensing or on-ground techniques.	In general the presence of riparian vegetation is correlated with higher water quality.	

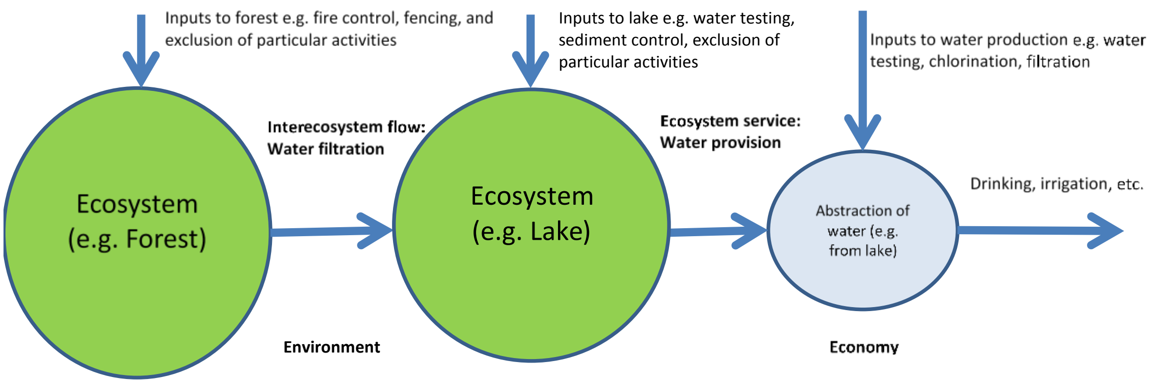
3.1 Water provisioning

41. Water provision is a commonly measured ecosystem service and was identified in 21 of 61 studies examined by Egoh et al. (2012) and 7 of 71 studies reviewed by Martinez-Harms and Balvanera (2012). The SEEA-EEA includes the ecosystem services of water provision and it is also included in the Common International Classification of Ecosystem Services (CICES) as water provision at the 3-digit level of CICES, the most disaggregated level. Specifically the SEEA-EEA notes:

> ". . . Data on water resources is often available, in particular regarding the abstraction of water for drinking and other purposes. However, the link between ecosystem management and water provisioning is less clear, with regards to such aspects as water purification in aquatic ecosystems or in the soil, water storage in ecosystems in upper watersheds, etc. Given the economic importance of water supply and the pressure on water resources in many parts of the world, including this service in ecosystem accounts may be a priority in many countries. A challenge is to better understand, in particular at high aggregation levels, the infiltration, purification and storage processes involved. The incorporation of measures relating to water within ecosystem accounting is significantly aided by the development of international standards on accounting for water presented in SEEA-Water and a companion standard, the International Recommendations for Water Statistics."[11]

42. Water provision includes the abstraction of water from ecosystems for use as drinking water and irrigation. Where the water is directly abstract by the beneficiary (e.g. in the case of a person drinking water directly from the river) then they have used the ecosystem service of water provisioning. Similarly, where water from a lake is used by the water supply industry for distribution to a household for drinking water, then the water supplier has used the ecosystem service of water provisioning as one of its inputs to the production of water. In both cases a water filtration service, provided by a separate by connected ecosystem has been used (Fig 3). In this both the person drinking the water and the water supplier have used a water filtration ecosystem service. In the SEEA-EEA, which only accounts for final ecosystem services, the inter-ecosystem flow (or intermediate ecosystem service) of water filtration service is embedded in the final ecosystem service of water provisioning. Two options for explicitly accounting for the water filtration service are outlined in Section 6 ("issues for Resolution").

Figure 3. Provisioning of water



43. Ecosystem management affects the water provision service and in particular the quality of water and quantity of water. For example, a natural forest (i.e. one that has been many years without disturbance) will in have a different pattern of water flow to a cleared area or managed forest. The quality of the water may

[11] See SEEA-EEA, paragraph 3.84, p. 63

also be higher due to less soil erosion and hence sedimentation. If the water has been contaminated by pollutants (e.g. from chemical used in mining for ore extraction) then these can be absorbed by the vegetation and pollution levels reduced prior to its movement to downstream. The type and condition of vegetation also affects the flow of water over time, particularly infiltration into the ground.

44. While there may be some differences that emerge through testing, accounting for the water provision service appears closely aligned with the concepts and structure of the physical and monetary supply and use tables for water of the SEEA Central Framework and the SEEA-Water. The physical supply and use table for water is shown in Table 4. Note that this table extends over two pages, with the first page the supply half of the account and the second page the use.

45. The full physical supply and use table accounts for all flows of water in the economy and the exchanges between the economy and the environment. The parts of the table relevant for ecosystem accounting are: abstracted water (in both the supply and use parts of the table) and the source of abstracted water (in the use part of the table). These are equivalent to the natural inputs in the SEEA Central Framework and the water provisioning service in the SEEA- Experimental Ecosystem Accounting. A simplified table focusing only on the use of the water provision service (Table 5) is shown in Section 4.

46. Physical supply and use tables can be compiled for different areas and at various levels of detail, depending on the required policy and analytical focus and data availability. For the purposes of water resource management the compilation of data for river basins is likely to be the most appropriate accounting unit. It is noted however, that while physical data may be available for river basins, corresponding economic data will generally only be available for administrative regions and these two geographic boundaries may not align, so compromises will needed to align the different geographic boundaries.

47. The supply and use of water is organised in columns by economic activity, as classified according by the International Standard Industry Classification (ISIC). Table 3 shows the following grouping:
    - ISIC 01-03 which includes Agriculture, Forestry and Fishing;[12]
    - ISIC 05-33, 41-43 which includes: Mining and quarrying, Manufacturing and Construction;
    - ISIC 35 - Electricity, gas, steam and air conditioning supply;
    - ISIC 36 - Water collection, treatment and supply;
    - ISIC 37 - Sewerage;
    - ISIC 38, 39, 45-99, Other industries.

48. Industry classes of electricity supply (ISIC 35), water supply (ISCI 36) and sewerage (ISIC 37) are specifically identified because of their importance in the supply and use of water and provision of water-related services. The electricity supply industry (ISIC 35) is a major user of water for hydroelectric power generation and cooling purposes. While the water supply (ISIC 36) and sewerage industries (ISIC 37) are the main industries for the distribution and treatment of water and wastewater.

49. The rows of the physical supply and use table (Table 4) are divided into five sections that organize information on:
    - Abstraction of water from the environment;
    - Distribution and use of abstracted water across enterprises and households;
    - Flows of wastewater and reused water (between households and enterprises);
    - Return flows of water to the environment; and
    - Evaporation, transpiration and water incorporated into products.

50. The abstraction of water by source is recorded in the supply part of the table as being supplied by the environment. The same volume of water is also recorded in the use table, “Sources of abstracted water”. Water may be abstracted from artificial reservoirs, rivers, lakes, groundwater and soil water.

[12] For certain analytical purposes it may be relevant to distinguish between the uses of water by these different industries.

The capture of precipitation from the roofs of houses in water tanks, is recorded as abstraction via precipitation. Precipitation direct to the inland water system is not recorded in this table but is recorded in the asset account for water resources (i.e. Table 2, above).

51. Abstraction is the amount of water removed from any source, either permanently or temporarily, in a given period of time. Water used for hydroelectric power generation, is considered as abstraction and is recorded as a use of water by the abstractor. Water abstraction is disaggregated by source and by industry.

52. Abstraction of soil water refers to the uptake of water by plants and is equal to the amount of water transpired by plants plus the amount of water that is embodied in the harvested product. Most abstraction of soil water is used in agricultural production (e.g. rain fed agriculture) and in cultivated timber resources. In theory all the soil water abstracted for use in production, for example, including soil water abstracted in the operation of golf courses should be included.[13]

53. Water that has been abstracted must either be used by the same economic unit which abstracts it (referred to as abstracted water for own use), or be distributed, possibly after some treatment, to other economic units (referred to as abstracted water for distribution). Most of the water for distribution is abstracted by the water supply industry (ISIC 36). However, there may be other industries that abstract and distribute water.

54. The "Abstracted water", in the supply part of the table shows the industries undertaking the abstraction with the differentiation as to whether the water is for own use or for distribution. This part of the supply table also records imports of water. This is shown as from the rest of the world in Table 3 as the table is accounting for a country. If the table is accounting for a river basin then this could changes to other river basins. The total of water abstracted for own-use, abstracted for distribution, and imported represents the total water available for use in the economy.

55. The use of this water is shown in the use part of the table where the water available for use is shown as the intermediate consumption of industries, the final consumption of households or exports to economic units in the rest of the world.

56. The abstracted water received from other economic units refers to the amount of water that is delivered to an industry, households or the rest of the world (or river basin) by another economic unit. This water is usually delivered through systems of pipes (mains), but other means of transportation are also possible (such as artificial open channels, trucks, etc.).

57. Within the economy, water is often exchanged between water distributors before being delivered to users. These water exchanges are referred to as intra-industry sales. These are the cases, for example, when the distribution network of one distributor does not reach the water user and hence water must be sold to another distributor in order for the water to be delivered. In principle, all intra-industry sales should be recorded following standard accounting principles. However, these exchanges are not recorded in the Table 4 as their recording would increase the total flows recorded even though there may be no additional physical flows of water.

[13] Soil water abstracted by non-cultivated plants is not in scope of the PSUT but there may be interest in recording these flows, for example, in respect of natural timber resources.

Table 4. Physical supply and use table (cubic metres)

Physical supply table for water										
	Abstraction of water; Production of water; Generation of return flows							Flows from the rest of the world	Flows from the environment	Total supply
	Agriculture, forestry and fishing	Mining & quarrying, Manufacturing and Construction	Electricity, gas, steam and air conditioning supply	Water collection, treatment and supply		Sewerage	Other industries	Imports		
				Total (excluding household activity)	Household activity					
Sources of abstracted water										
Inland water resources										
Surface water										
Groundwater										
Soil water										
Total										
Other water sources										
Precipitation										
Sea water										
Total										
Total supply abstracted water										
Abstracted water										
For distribution										
For own-use										
Wastewater and reused water										
Wastewater										
Wastewater to treatment										
Own treatment										
Reused water produced										
For distribution										
For own use										
Return flows of water										
To inland water resources										
Surface water										
Ground water										
Soil water										
Total										
To other sources										
Total Return flows										
Evaporation of abstracted water, transpiration and water incorporated into products										
Evaporation of abstracted water										
Transpiration										
Water incorporated into products										
Total supply										

Table 4. Physical supply and use table (cubic metres), continued

Physical use table for water	Abstraction of water; Intermediate consumption; Return flows							Final consumption	Accumulation	Flows to the rest of the world	Flows to the environment	Total use
	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		Exports		
				Total (excluding household activity)	Household activity							
Sources of abstracted water												
Inland water resources												
Surface water												
Groundwater												
Soil water												
Total												
Other water sources												
Precipitation												
Sea water												
Total												
Total use abstracted water												
Abstracted water												
Distributed water												
Own use												
Wastewater and reused water												
Wastewater												
Wastewater received from other units												
Own treatment												
Reused water												
Distributed reuse												
Own use												
Total												
Return flows of water												
Returns of water to the environment												
To inland water resources												
To other sources												
Total return flows												
Evaporation of abstracted water, transpiration and water incorporated into products												
Evaporation of abstracted water												
Transpiration												
Water incorporated into products												
Total use												

3.2 Water flow regulation, water filtration and flood protection

58. The water related regulating service of flood protection is described in the in the SEEA-EEA. (Annex A3.1, Figure 3.6, paragraph A3.23, p, 73). Water flow regulation and water filtration are not described in the SEEA-EEA but are included in the Common International Classification of Ecosystem Services (CICES). In this water flow regulation is shown at the 3-digit level of CICES, the most disaggregated levels, while the service termed water filtration is termed "Dilution, filtration and sequestration of pollutants in CICES, again at the 3-digit level. As noted earlier these regulating services are not provided by the water but are provided by other components of the ecosystem (e.g. the vegetation and climate).

59. The SEEA Experimental Ecosystem Accounting needs further development in this area. As noted earlier the water filtration service is embedded in the water provisioning service but it could be accounted for as an intermediate ecosystem service. At least some of the water flow regulation service is embedded in the water provisioning service. Here this service potentially smooth's the availability of water. That is, when water is abundant the water flow regulation service provided by the vegetation moderates the discharge of water and water is therefore available in times of relative scarcity.

4 Data sources and methods

60. This section provides information on the data sources and methods for producing water asset accounts as well as for measuring the ecosystem service of water provision. It is provided as a general introduction. Key references for this material are the International Recommendations for Water Statistics (UN 2010) and the Draft Guidelines for the Compilation of Water Statistics and Accounts (UN 2013). Other documents and data sources are referenced in the text and additional reference material is outlined in Section 5.

61. Data for the regulating services of flood protection and water filtration is generally from information on land cover and so sources of information on land cover are provided along with a basic outline of the methods that may be used to measure these services. Additional material is briefly described and linked in Section 7 Additional Reference Material.

62. In order to be able to produce accounts for water in the context of ecosystem services, access to suitable technology is needed. In addition to the standard software used for databases and statistical procedures, access to a Geographic Information System (GIS) and the expertise needed to use are it are often useful. It is beyond the scope of this paper to provide information on the technical characteristics of the hardware and software or technical expertise needed. It is mentioned here so that agencies investigating the production of water accounts can check with specialist areas either within their own agencies (e.g. a geography unit) or external agencies (e.g. Department of Forestry or land planning agencies) on the availability of suitable information technology to support ecosystem accounting.

4.1 Data sources

63. Water accounts are compiled from a combination of data sources. For example, a national statistical office may use the aggregated data on precipitation from an agency responsible for meteorological information in a physical asset account for water resources along with an estimate of water abstraction of irrigation water by agriculture from a farm survey.
.

64. The main data sources used for producing water accounts and water related ecosystem services are:
    - Survey data
    - Administrative data
    - Hydrological/meteorological data
    - Research data
    - Land cover data

65. Surveys and administrative data sources are used mostly to produce the data from or about economic agents (households, businesses, and government). For example, surveys of agriculture industry to obtain information about the area of irrigated crops, which would feed information into the physical

supply and use table. Hydrological/meteorological data and research data are used mostly to produce the data items related to the water resources, and in particular the stocks and flows of the asset account. National statistical offices traditionally collect data via surveys and by accessing administrative records, and this can also include the collection of hydrological/meteorological data from other agencies.

66. Survey data are collected directly from the economic units concerned. This is done either by collecting data from all the units in the population (i.e., a census) or by collecting data from only a few representative units scientifically selected from the survey frame (i.e., a sample survey). It should be noted that surveys under this definition are restricted to those which collect information directly from economic units (households or establishments). Surveys of physical resources, such as groundwater, conducted by technical teams are included in hydrological/meteorological data.

67. Government administrative processes are often set up to monitor and enforce legislation and regulations and this sometimes includes compiling a register of the economic units. These registers may be of households or establishments and also contain a variety of data about these units. For statistical purposes, most administrative data are received from government agencies. However, administrative data may also come from NGOs, such as industry associations.

68. Hydrological and meteorological data concern the water cycle. Such data are typically collected by the national agencies responsible for weather forecasting and water resources management but may also be collected by agencies responsible for other areas such as mining or geological surveys. Collection methods include the use of field monitoring stations (i.e. constituting a sample) and remote-sensing, and modelling techniques are frequently used for estimation. Agencies collecting hydrological data may also collect data regarding flows between the environment and the economy.

69. While national data are the logical and preferred starting point a range of international data sources are available. For example, global hydrological datasets and a range of other resources are available from the World Meteorological Organisation (WMO)[14] and the Food and Agriculture Organisation (FAO)[15]. Of particular relevance is the World Climate Data and Monitoring Programme (WCDMP)[16], World Hydrological Cycle Observing System (WHYCOS)[17] of WMO and Aquastat[18] of FAO. These sources and others are highlighted in the Convention on Biological Diversity Quick Start Package for Ecosystem Natural Capital Accounts.[19]

70. Aquastat is a global water information system. It collects and makes available information on water resources, water uses, and agricultural water management in particular. It has a searchable country database that includes the main agencies in countries with water information. Aquastat also has a range of supporting material to help understand and use the information in the database and provides a starting point for information discovery and experimentation in countries. Similarly the WMO keeps a list of national meteorological and hydrological agencies and contacts[20]. The lists of agencies and contacts may be useful to those without detailed knowledge of the national agencies and their data holdings of hydrology or meteorology.

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[14] Hydrology and Water Resource Programme WMO https://www.wmo.int/pages/themes/water/index_en.html

[15] FAO http://www.fao.org/home/en/

[16] WCDMP http://www.wmo.int/pages/prog/wcp/wcdmp/index_en.php

[17] WHYCOS http://www.whycos.org/whycos/

[18] FAO Aquastat. http://www.fao.org/nr/water/aquastat/main/index.stm

[19] CBD http://www.cbd.int/doc/publications/cbd-ts-77-en.pdf

[20] WMO National Meteorological and Hydrological Contacts http://www.wmo.int/pages/members/members_en.html

71. The WCDMP also provides and range of information on monitoring networks and data management. It links to World Data Centres[21]. WHYCOS aims to support developing countries in particular with the collection, access and management of data. In facilitates data exchanges and is aimed at improving data collection.

72. Research data are typically collected and compiled by universities, research agencies or NGOs, which may have a number of research projects and programmes related to water and associated with agriculture, Earth sciences, economics, engineering and environmental studies. NGOs sometimes undertake water-related research to influence decision-making and priority setting in Governments, while industry associations may also undertake research or collect data to influence government decisions, benchmark their performance or better understand the demand for water or sewerage services by industries and households. Research data are often used in water statistics to fill in data gaps or to derive coefficients for estimation purposes.

73. Land cover data or vegetation maps are used in combination with rainfall and other meteorological data as well as information on geology and soil to estimate the level of water absorption in soil, infiltration to groundwater and the amount of water run-off. A range of modelling tools are available for this (e.g. the Soil and Water Assessment Tool or SWAT)[22].

74. Land cover data and are available from a variety of national sources and well as from international sources of global information (e.g. GLOBCOVER GLC2000,) and more detailed or higher resolution data are usually available at the continental or national levels. These data sources are covered in another technical note and are mentioned here for completeness.

75. A particular issue with the land cover data or vegetation maps is the resolution of data contained within them. In this resolution refers to the spatial resolution (i.e. size of the grid), the technical equipment making the measurements in terms of spectral or radiometric resolution and the frequency with which data is collection (i.e. every 5 days, every 24 days). The spatial resolution of the information is particularly important to understand. This can range from of $1km^2$ to $2.5m^2$. If comparing data from two different sources, with different spatial resolutions, then at least some of the differences will be apparent rather than real. There are methods to account for these differences (e.g. upscaling) but these are beyond the scope of this paper.

4.2 Methods for the physical asset account for water resources

76. Details on data sources and methods references are provided in the International Recommendations for Water Statistics (UN 2010) and the Draft Guidelines for the Compilation of Water Statistics and Accounts (UN 2013). What is included is a brief summary of these documents and related materials.

77. The main elements of the asset account for water are:
    - Opening stocks
    - Additions to stock
    - Reductions in stock
    - Imports and exports
    - Closing stock

78. The source of the information on water stocks depends on which particular component of water resources is being estimated. For example:
    - Water in large artificial reservoirs used to supply water to urban areas or for irrigation can usually be obtained from the water suppliers (e.g. the water utilities). This information can

[21] WMO World Data Centres http://www.wmo.int/pages/prog/wcp/wcdmp/GCDS_5.php

[22] SWAT http://swat.tamu.edu/

often be found in their annual reports, websites or other publically accessible information. If necessary it can be collected via direct contact (e.g. a survey of water suppliers). Information on smaller artificial reservoirs, such as those on farms used for stock drinking water, is more difficult to obtain. The number of small artificial reservoirs on farms can be collected via agricultural surveys or they can be counted from remotely sensed images. The number of these small reservoirs can be converted to a total volume via the use of additional information on the capacity of these reservoirs and the application of statistical techniques.

- For lakes, the volume that they contained may be known hydrological, meteorological or other scientific agencies. Water in lakes can also be estimated by the area of lakes and the depth or average depth of the lake if known. In this complete data will be lacking and assumptions will have to be made.
- The volume of water in most rivers is small at any one time, although the flow through the river channel over the year may be great. The approximate volume of rivers can be found by multiplying the length of the river by the average depth and average width of the river. Like lakes, complete data will be lacking and assumptions will have to be made.
- Estimates of snow, ice and glaciers may be obtained from hydrological, meteorological or other scientific agencies. Like lakes, an estimate can again be based on area covered and information on depth.
- Groundwater is difficult to measure at large scales. Estimates may be available from hydrological agencies. Often a proxy is used, such as depth to water table, which is not easily correlated with a volume of water. Ground water can be measured by remote gravity sensors[23].
- Soil water, like groundwater, is difficult to measure at large scales. Soil water is often not included in the estimates of water stocks. Soil water, like groundwater can be measured by remote gravity sensors. It can also be measured using other remote sensing technology, for example via satellites with microwave senses or ground penetrating radar.

79. The information for the rows on additions and subtractions to particular reasons for change (e.g. precipitation, evapotranspiration, inflows, etc.) can come from a variety of sources, but by in large are collected or estimated by hydrological or meteorological agencies based on networks of physical sensors, including remote-sensing technologies. The exception to this is information for abstractions.

80. The information on abstraction is directly related to the physical and supply and use table the data sources and method for which are described below in Seciton 4.3. The total amount abstracted in both tables is same but in the asset account it is shown by the resource from which the extraction occurs (i.e. the source of water), whereas in the physical and supply and use table the amount extracted is shown by the industry extracting (e.g. agriculture, water supply industry, etc.) in the columns and the source of water in the rows.

4.3 Methods for the physical supply and use table for water resource

81. A simplified version of the full supply and use table for water accounts is shown in Table 4. While ideally the full table shown as Table 3 would be complied, for the purposes of accounting for the ecosystem service of water provisioning, a simplified version provides a tractable starting point. In this the accounting is limited to input of natural water as defined in the SEEA Central Framework

82. The sources of information for this table are again varied. The emphasis in the physical supply and use tables is on the extractor and this usually means that the information on water use can be collected from the extractor either directly or in-directly calculated from information supplied. For example, the amount of water extracted by the water supply industry may be collected directed from these businesses, while information on the area of irrigated crops collected via an agricultural survey can be used to calculate the amount the water used from surface water or groundwater.

[23] Gravity Recovery and Climate Experiment http://www.csr.utexas.edu/grace/

83. The key industries for which data are required are agriculture, water supply and electricity supply while information is also needed on household water use. These areas will generally account for the majority of water use and hence the use of the water as a provisioning service. In brief the data sources, methods and other for compilation advice for these are:

- Agriculture, which typically accounts for the majority of water use in countries, can come from agricultural surveys or censuses as well as derived from land cover data (e.g. the area of rain fed and irrigated crops and pasture) and meteorological information. Agriculture surveys usually contain information on the area devoted to different crops or pastures and if the areas are irrigated or not. Sometimes information on the source (e.g. ground water, river, etc.) and volume of water used by crop type is also collected. Abstraction of soil water by agriculture is calculated based on the area under cultivation using coefficients of water use. Different coefficients should be used for different plants and should take into consideration location effects (e.g. soil types, typography and climate). Licenses for water use may also be used although caution needs to exercise since the amount actually extracted may be greater or less than the amount licensed. For the full water account, information from the irrigation authorities (i.e. the water suppliers) can be used to determine the amount of distributed water supplied to agriculture but note that the use of distributed water by agriculture would not be the use of a water provisioning service.
- Water suppliers generally have good records of the amount of water distributed to others and this is often publically available or can be collected via survey or more informal means particularly if there are very few water suppliers. While the number of water suppliers varies by country, the number is not usually large, especially when compared to other industries, which means they are amenable to survey. The amount of water lost in distribution is important to collect or estimate as this is recorded as a use of self-abstracted water (=water provisioning service) by the water supply industry. The amount of water supplied by the water supply industry as distributed water plus the amount of water lost in distribution equals the use of the water provisioning service.
- The electricity industry is usually relatively small in terms of number of businesses generating power. As such it can usually be easily surveyed if there is no public information available on water use (e.g. in annual reports). The industry uses water in two keys ways: (1) to generate electricity directly (i.e. hydro-electric power) and (2) for cooling in thermal (e.g. coal) power plants. In the first the water that runs through the turbines is a use of water. The water is counted each time it passes through a turbine and hence if the water runs through a chain of turbines it is counted each time. In the full water account the water is also recorded as a return flow and so while the use is high, water consumption is usually zero. For cooling, the source of the water is essential to establish. In some cases the water is pumped directly from a water source (e.g. a river) into a cooling tower and then returned to the water source. In this case the water is counted each time abstracted from the water source. In other cases, water is pumped from a water source in a pond or series of ponds and taken from there into the cooling tower, and is then released into a cooling pond, from where the water is usually re-used in the process. In this case the water is only counted when it is pumped from the water source into the pond. Water supplied by the water supply industry to the electricity industry is not the direct use of the ecosystem service by the electricity industry but a use of distributed water (with the water supply industry using the water provisioning service to produce the distributed water)
- Households use of water directly from the environment via extraction of water from surface water (rivers, lakes, etc.), groundwater (e.g. from wells) and the water collected from rooftops. The first is clearly a use of the water provisioning service of ecosystems. Water available through abstraction of water from groundwater and collection of water from rooftops is still an ecosystem service but their treatment in ecosystem accounting needs to be clarified. For the purpose of experimentation they should be included but separately identified (as it is the physical supply and use table). Data sources for households include surveys and censuses. As part of the Millennium Development Goals information on household source of water is collected[24], usually via these means. For household connected to a distributed water supply (i.e.

[24] See Joint Monitoring Programme for Water Supply and Sanitation www.wssinfo.org/

from the water supply industry), the amount of used may be obtained from the water supplier. This information may then be used to estimate the total amount of water used by the fraction of households not connected to a distributed water system.

Table 5. Simplified physical water use table for ecosystem accounting

			Use of water							Total use
			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	
Sources of abstracted water										
	Inland water resources									
		Surface water								
		Groundwater								
		Soil water								
		Total								
	Other water sources									
		Precipitation								
		Sea water								
		Total								
	Total use abstracted water									
Abstracted water										
	Distributed water									
	Own use									

5 Additional reference material

84. A variety of material relating to water accounting is available for generating estimates of stocks of water and/or the ecosystem service of water provision. This includes:
- AQUASTAT[25] (FAO)
- Joint Monitoring Programme for Water Supply and Sanitation[26] (WHO/UNICEF)
- Natural Capital Accounts Quick Start Package (Webber 2014)
- Water Accounting Plus (WA+)(Karimi et al 2013)
- Country examples and academic papers
- Other international ecosystem accounting initiatives

85. The main features of these and how they relate to the SEEA EEA are outlined in general below. Most of the material has not been developed specifically for the purpose of ecosystem accounting but the methods in these documents are generally applicable for producing SEEA based water accounts.

5.1 AQUASTAT

86. AQUASTAT[27] is a global water information system housed by FAO. It provides information on water resources and water uses, with an emphasis on agricultural. AQUASTAT maintains a database of containing over 70 data items[28] and maintains a separate page of water uses.

5.2 World Water Development Report

87. The World Water Development Report is an annual report that focuses on different strategic water issues each year. It aims to provide decision-makers with the tools to implement sustainable use of our water resources. It also includes regional aspects, hotspots, examples and stories, making the report relevant to a broad range of readers, at different levels and in different geographical areas. The latest report from 2014 focuses on the links between water and energy and contains an annex on data and indicators and references to a range of material that could be useful for water accounting.

5.3 Joint Monitoring Programme for Water Supply and Sanitation

88. The Joint Monitoring Programme for Water Supply and Sanitation summarises data on source of water for all countries[29]. In this the unimproved sources are the ones providing the ecosystem service of water provision directly to households, while the improved data source of "piped water" represents the use of the provisioning service by the water suppy industry. Access to country data is provided through a linked website[30].

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[25] See http://www.fao.org/nr/water/aquastat/main/index.stm

[26] See www.wssinfo.org/

[27] See http://www.fao.org/nr/water/aquastat/main/index.stm

[28] See http://www.fao.org/nr/water/aquastat/dbases/index.stm

[29] See 2014 Report
http://www.wssinfo.org/fileadmin/user_upload/resources/JMP_report_2014_webEng.pdf

[30] See Data and estimates http://www.wssinfo.org/data-estimates/

5.4 Quick Start Package

89. The general methods and data sources outlined in Chapter 6 of the Quick Start Package[31] are applicable to accounting for water in the context of SEEA. Indeed, the package specifically references the SEEA-EEA, the SEEA-Water (UN 2012a), the International Recommendations for Water Statistics (UN 2010) and uses example from countries compiling water accounts according to the SEEA.

90. While the methods and data source described are very useful, the tables presented in the Quick Start Package are not the same as in the SEEA. For water, Table 6.01 (on pp. 157-158) is the 'Aggregated ecosystem water accounts by water assets'. Part I of the table is the "Ecosystem Water Basic Balance" (i.e. rows W1 to W3) and is very similar to the asset account for water resources (Table 1 of this document). Part III of Table 6.01 is title "Total water uses". In Part III of the table is the equivalent of the physical supply and use table although it arranged differently. Row 81 is the equivalent of the use of surface and groundwater in the physical supply and use table by all sectors of the economy, while row 82 is the use of soil water by agriculture and forestry only. Water collected from rooftops is row W83. The other parts of the Table 6.01 go beyond the SEEA. The Quick Start Package was trialed in Mauritius (Weber 2014).

5.5 Water Accounting Plus

91. Water Accounting Plus (WA+) (Karimi et al. 2013) is a framework that provides spatial information on water use. It uses a combination of information, including remotely sensed information, on land cover, land use, evapotranspiration and other aspects of the water cycle. The WA+ covers the waters resources, calculation of evapotranspiration sheet, uses of water (including as input to ecosystem services such as food provision and carbon sequestration) and can be linked to the SEEA. The methods described, and in particular those using remotely sensed data are useful. In the WA+, while the SEEA is acknowledged, there appears to be some misunderstanding in the treatment of soil water by Karimi et al (2013), perhaps arising from the fact that the example of water accounts examined from Australia does not include soil water use (and hence a limitation of the Australian account, not the SEEA *per se*)

5.6 Country examples and academic papers

92. The Searchable Library of Publications on Environmental Accounting hosted on the UNSD website reveals 94 publications containing the key word "water"[32]. In addition there are a range of academic publications on water accounting including: Godfrey and Chalmers (2012), Karimi et al (2013), Lange et al (2007), Onda et al. 2012), Peranginangina et al (2003) and Vardon et al. (2007).

93. In addition to these there are examples of special frameworks for particular industries (e.g. the water accounting developed by the minerals[33] and water supply and management[34] industries in Australia).

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[31] Ecosystem Natural Capital Accounts: A Quick Start Package
http://www.cbd.int/doc/publications/cbd-ts-77-en.pdf

[32]As at 4 November 2014, see http://unstats.un.org/unsd/envaccounting/ceea/archive/

[33] See Water Accounting Framework for the Minerals Industry
http://www.minerals.org.au/file_upload/files/resources/water_accounting/WAF_UserGuide_v1.2.pdf

[34]Australian Water Accounting Standard http://www.bom.gov.au/water/standards/wasb/wasbawas.shtml

94. In addition to the academic papers on water accounting a large number of academic papers have been produced on ecosystem services and many of these include information on water provisioning. Three papers that reviewed multiple papers that can be searched for specific country references are: Martinez-Harms and Balvanera (2012); Egoh et al. (2012) and; Crossman et al. (2013). Another review by Bagstad et al (2013) examined the use of modeling tools that produce estimate of multiple ecosystem services, including water provision.

5.7 International ecosystem accounting initiatives

95. There are a number of initiatives advancing ecosystem servicers or natural capital accounting underway around the world. In addition to the ones mentioned above specifically in regards to water accounting there is:
    - ProEcoServe (Project for Ecosystem Services) http://www.proecoserv.org/
    - WAVES (Wealth Accounting and Valuation of Ecosystem Service) https://www.wavespartnership.org/en
    - MAES (Mapping and Assessment of Ecosystems and their Services) http://biodiversity.europa.eu/maes
    - The Ecosystem Services Partnership http://www.es-partnership.org/esp/82222/9/0/50

96. In addition to this is the work of the London Group on Environmental Accounting, which holds annual meetings, and the 20th Meeting held recently (October 2014) in New Dehli had a session specifically on ecosystem accounting (see http://unstats.un.org/unsd/envaccounting/londongroup/). More broadly the UNSD maintains a Searchable Archive of environmental accounting publications which is added to regularly (see http://unstats.un.org/unsd/envaccounting/ceea/archive/).

6 Issues for resolution

97. The development of ecosystem accounting requires a number of theoretical and practical issues to be resolved in order to bring the ecosystem accounts to the level of an international statistical standard (i.e. and sit alongside the System of National Accounts and SEEA- Central Framework). These are outlined in general in the Research Agenda of the SEEA-EEA.

98. This section outlines a number of issues that could be addressed by countries and agencies compiling or seeking to compile accounts for water in the context of ecosystem accounting. It is provided as guide, is not exhaustive and can be updated as needed.

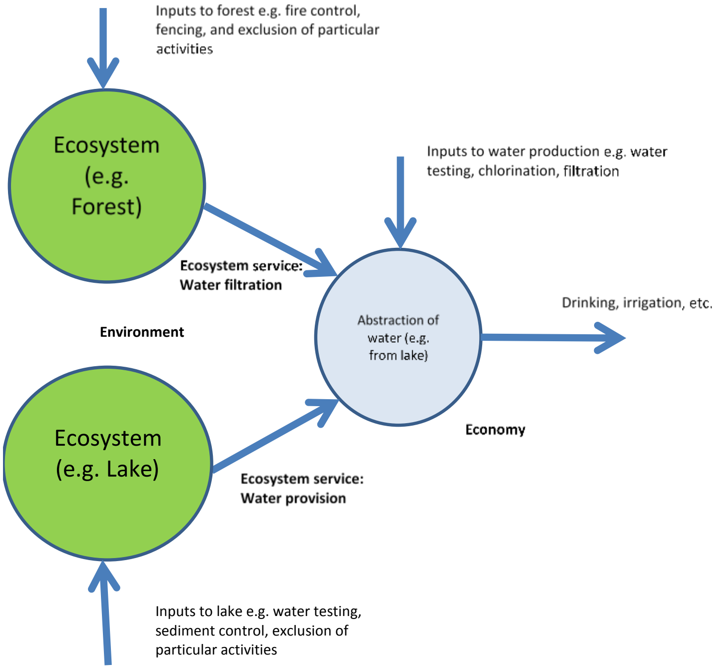
6.1 Accounting for inter and intra ecosystem flows

99. Because of the accounting approach taken in the SEEA-EEA the services of water flow regulation and water filtration are embedded in the water provision service. However, it is important to recognise that these are different, albeit linked, services and both are important for ecosystem management and ecosystem accounting. It may be that in it is useful to account for these services and intra and inter-ecosystem flows. The basic structure of supply-use tables and the notions of intermediate and final consumption provide a starting point for representing them in accounts.

100. It is also possible to show differently the relationship between water filtration and water provisioning in ecosystem accounting. Figure 3 (presented earlier in this note) shows the current interpretation of the relationship, in which the final ecosystem service is all that is shown. Figure 4 shows an alternative relationship of these services in relation

to the production of water used in the economy. If this depiction were used then there would be no need to account for inter or intra ecosystem flows but two distinct services which should be relatively straight forward to account for. However practical this simplification it is not a true reflection of the system.

Figure 4. Alternative depiction of provisioning of water and water filtration services



6.2 A simplified water provisioning service supply and use table

101. The physical supply and use table of the SEEA-Central Framework and the SEEA-W provides a comprehensive coverage of flows of water in the economy and between the economy and the environment. The part of the table relevant to ecosystem accounting and in particular the service of water provision is limited mainly to the abstraction and distribution of water. A simplified representation of limited to these flows could help and one is presented in this document as Table 4. In further developing such a table the relationship to the full physical supply and use table would need to be established.

6.3 Clarifying the account of the water provision service

102. A specific accounting issue related to the development of a simplified water provisioning table is how to treat the abstraction of groundwater and water collected from rooftops and used in households or other parts of the economy. These could both be the use of an ecosystem provision service, but they are different from the abstraction of water from surface water. Groundwater is sub-soil and sub-soil mineral assets are not part of the SEEA-EEA, but at least some groundwater is connected to terrestrial ecosystems (e.g. natural springs), recharged regular and so should probably be included. Use of "fossil" groundwater is probably not an ecosystem service. Rooftop collection of water is is probably an ecosystem service. However, these treatments will need to be confirmed.

6.4 An account for water quality

103. Neither the SEEA-Central Framework nor the SEEA-W provides guidance on the concepts and standard structure of an account of water quality. Countries using water quality as an indicator of ecosystem condition may like to explore the development of

such and account, testing the amenability of different measures of water quality in an accounting framework.

6.5 Terminology and classifications

104. The range of material reviewed in the development of this note show that there are a range of terms being used to describe water related ecosystem services. For example, the CICES[35] classifies water as a provisioning service, while Martiinez-Harms and Balvanera (2012) class it as a regulating service.

105. A related issue is the classification of the intra and inter- ecosystem flows. These could be classified as per existing classifications of "final" ecosystems, such as the CICES. Such a classification and establishment of accounting treatments is particularly relevant for the service of water provisioning and water filtration, which are intimately connected.

106. The water resource types identified in the SEEA Central Framework and SEEA-Water do not explicitly include wetlands. For ecosystem accounting having an additional class of wetlands would probably be beneficial. In this clearly defining the wetlands and ensuring that the boundaries between the other water resources is a key challenge. Internationally wetlands are defined very broadly in the Ramsar Convention[36], with the definition cutting across all water resource types. In this it also needs to be understood that the water resources classes are distinct from the land cover classes identified in the SEEA as well as the ecosystem accounting units. One solution would be to spatially define wetlands as a particular type of ecosystem accounting, mutually exclusive from other areas, which may not strictly match either water resource types or land cover classes.

6.6 Spatial units

107. The identification, delineation and classification of the spatial units are general issues for ecosystem accounting. There are a number of specific issues highlighted in the development of water accounts.

108. The SEEA-EEA defines ecosystem accounting units (EAU). These are areas that aggregate the data from the LCEU in areas suitable for analysis or management. The country level is the highest level EAU but it may be that within countries smaller nested EAU may be appropriate for subnational analysis or management. For example, the management of particular river basins or provinces or states within countries. For water accounting in isolation river basins are clearly the most appropriate sub-national unit. However for water accounting in the context of ecosystem accounting it may be that other sub-nation units are equally appropriate.

109. In particular if would useful to test if building water asset and water provisioning accounts from land cover/ecosystem functional units (LCEU) aggregated to a country level leds to a different understanding from that derived from aggregation by river basin. The LCEU are classified according the FAO Land Cover Classification System (LCCS

[35] SEEA-EEA, pages 54-55, Table 3.1.

http://unstats.un.org/unsd/envaccounting/eea_white_cover.pdf

[36] "The Convention uses a broad definition of wetlands. It includes all lakes and rivers, underground aquifers, swamps and marshes, wet grasslands, peatlands, oases, estuaries, deltas and tidal flats, mangroves and other coastal areas, coral reefs, and all human-made sites such as fish ponds, rice paddies, reservoirs and salt pans." See http://www.ramsar.org/about/the-ramsar-convention-and-its-mission

Ver. 3). For water accounting the stage of maturity of forests (e.g. a young vs old forest) is an important factor, since the level and timing of run-off varies according to this. For example, in general younger forests produce more run-off, while older forests produce a more even flow of run-off.

110. The issue of the most appropriate units for linear features, such as rivers and streams needs further elaboration. Here the notion of reaches, particular lengths of rivers or streams, is well developed in some countries (e.g. Australia) and can be tested elsewhere.

6.7 Scale, measurement methods and data quality

111. Combining information from different information sources invariably means that data from different spatial scales (or resolution) and different measurement methods (e.g. satellite images and field surveys) are being combined. The effects of spatial resolution are relatively well known and there are techniques to address these. The combination of different measurement methods is a more difficult problem and is not unique to ecosystem accounting.

112. A recurring theme in reviews of ecosystem services is that the broad scale data available from global remotely sensed sources is not as accurate as information from local sources, often obtained from field surveys (see for example, Egoh et al. 2012). Such data are used to estimate water provisioning services as well as water filtration, water flow regulation and flood control. Karimi et al (2013) in the WA+ use remotely sensed data to fill information gaps and testing of this and improving the links to the SEEA may be an effective way forward.

113. Robust statistical techniques are needed to merge data from different sources and scales and these methods should attempt to quantify of errors. Descriptions of data quality are needed and existing frameworks, like the Statistics Canada (2002) Quality Assurance Framework.

6.8 Policy uses and indicators

114. A range of potential uses of water accounts were identified earlier in this note. Exploring how water accounts can be applied to particular decisions or decision-making processes will be an important driver of adoption in countries and international agencies. A particular issue which will be essential to the widespread adoption and use of environmental and ecosystem accounts is consideration of what headline indicators could be drawn for the water accounts and related information from the ecosystem accounts.

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Annex 1. Definitions from the SEEA-EEA

Cultural services:

Cultural services relate to the intellectual and symbolic benefits that people obtain from ecosystems through recreation, knowledge development, relaxation, and spiritual reflection. (3.4(iii))

See also Ecosystem services, Provisioning services, Regulating services.

Ecosystems:

"Ecosystems are a dynamic complex of plant, animal and micro-organism communities and their non-living environment interacting as a functional unit." (Convention on Biological Diversity (2003), Article 2, Use of Terms)

Ecosystems may be identified at different spatial scales and are commonly nested and overlapping. Consequently, for accounting purposes, ecosystem assets are defined through the delineation of specific and mutually exclusive spatial areas.

See also Ecosystem assets, Ecosystem Accounting Units, Land Cover/Ecosystem functional units.

Ecosystem Accounting Unit (EAU):

Ecosystem Accounting Units (EAU) are large, mutually exclusive, spatial areas delineated on the basis of the purpose of accounting. Generally, they will reflect a landscape perspective. Factors considered in their delineation include administrative boundaries, environmental management areas, socio-ecological systems and large scale natural features (e.g. river basins). (2.64)

A hierarchy of EAU may be established building from a landscape scale to larger sub-national and national boundaries. EAU at the landscape level may be considered to reflect ecosystem assets. EAU are the highest level of the spatial model used to define areas for the purposes of ecosystem accounting.

See also Basic Spatial Units, Land Cover/Ecosystem functional Units, Ecosystem assets

Ecosystem assets:

Ecosystem assets are spatial areas containing a combination of biotic and abiotic components and other characteristics that function together. (2.31, 4.1)

Depending on the analysis being conducted, an ecosystem asset may be defined to contain a specific combination of ecosystem characteristics (e.g., a tropical rain forest represented by an LCEU) or it may contain areas that contain a variety of combinations of ecosystem characteristics (e.g., a river basin containing wetlands, agriculture and settlements represented by an EAU).

Ecosystem assets should be distinguished (a) from the various individual components (e.g. plants, animals, soil, water bodies) that are contained within a spatial area; and (b) from other ecosystem characteristics (e.g., biodiversity, resilience). In different contexts and discussions, each of these components and other characteristics may be considered assets in their own right (for example in the SEEA Central Framework many individual components are considered individual environmental assets). However, for ecosystem accounting purposes, the focus is on the functioning system as the asset.

The term “ecosystem assets” has been adopted rather than “ecosystem capital” as the word “assets” is more aligned with the terminology employed by the SNA and also conveys better the intention for ecosystem accounting to encompass measurement in both monetary and physical terms. In general however, the terms “ecosystem assets” and “ecosystem capital” may be considered synonymous.

See also Ecosystems, Ecosystem Accounting Unit, Land Cover/Ecosystem functional Unit, Ecosystem capital, Environmental assets, Natural Capital, Natural Resources

Ecosystem capacity:

The concept of ecosystem capacity is not defined from a measurement perspective in SEEA Experimental Ecosystem Accounting but it is linked to the general model of ecosystem assets and ecosystem services that is described. In general terms, the concept of ecosystem capacity refers to the ability of a given ecosystem asset to generate a set of ecosystem services in a sustainable way into the future. While this general concept is very relevant to ecosystem assessment, definitive measurement of ecosystem capacity requires the selection of a particular basket of ecosystem services and in this regard measures of ecosystem capacity are more likely to relate to consideration of a range of alternative ecosystem use scenarios than to a single basket of ecosystem services.

See also Ecosystem assets, Ecosystem services, Ecosystem condition

Ecosystem characteristics:

Ecosystem characteristics relate to the ongoing operation of the ecosystem and its location. Key characteristics of the operation of an ecosystem are its structure, composition, processes and functions. Key characteristics of the location of an ecosystem are its extent, configuration, landscape forms, and climate and associated seasonal patterns. Ecosystem characteristics also relate strongly to biodiversity at a number of levels. (See Section 2.1 for more details)

There is no classification of ecosystem characteristics since, while each characteristic may be distinct, they are commonly overlapping. In some situations the use of the generic term “characteristics” may seem to be more usefully replaced with terms such as “components” or “aspects”. However, in describing the broader concept of an ecosystem, the use of the term characteristics is intended to be able to encompass all of the various perspectives taken to describe an ecosystem.

See also Ecosystems, Ecosystem assets, Ecosystem condition

Ecosystem condition:

Ecosystem condition reflects the overall quality of an ecosystem asset, in terms of its characteristics. (2.34)

Measures of ecosystem condition are generally combined with measures of ecosystem extent to provide an overall measure of the state of an ecosystem asset. Ecosystem condition also underpins the capacity of an ecosystem asset to generate ecosystem services and hence changes in ecosystem condition will impact on expected ecosystem service flows.

See also Ecosystem assets, Ecosystem characteristics, Ecosystem extent, Expected ecosystem service flows.

Ecosystem degradation:

Ecosystem degradation is the decline in an ecosystem asset over an accounting period due to economic and other human activity. It is generally reflected in declines in ecosystem condition and/or declines in expected ecosystem service flows. Measures of ecosystem degradation will be influenced by the scale of analysis, the characteristics of the ecosystem asset, and the expectations regarding the use of the ecosystem asset in the future. Ecosystem degradation may be measured in physical and monetary terms. (For details see 4.27-4.32)

Ecosystem goods and services (see Ecosystem services)

Ecosystem services:

Ecosystem services are the contributions of ecosystems to benefits used in economic and other human activity. (2.23)

The definition of ecosystem services in SEEA Experimental Ecosystem Accounting involves distinctions between (i) the ecosystem services, (ii) the benefits to which they contribute, and (iii) the well-being which is ultimately affected. Ecosystem services should also be distinguished from the ecosystem characteristics, functions and processes of ecosystem assets.

Ecosystem services are defined only when a contribution to a benefit is established. Consequently, the definition of ecosystem services excludes the set of flows commonly referred to as supporting or intermediate services. These flows include intra- and inter-ecosystem flows and the role of ecosystem characteristics that are together reflected in ecosystem processes.

A range of terms is used to refer to the concept of ecosystem services defined here. Most common are the terms "ecosystem goods and services" and "final ecosystem services". These two terms highlight particular aspects of the definition above. The first recognises that ecosystem services includes flows of tangible items (e.g. timber, fish, etc) in addition to intangible services. The second recognises that only those ecosystem services that contribute to a benefit – i.e. they are final outputs of the ecosystem – are within scope.

Ecosystem services as defined in SEEA Experimental Ecosystem Accounting exclude abiotic services and hence do not encompass the complete set of flows from the environment. A complete set of flows from the environment may be reflected in the term “environmental goods and services”.

Three main types of ecosystem services are described: provisioning services, regulating services and cultural services. The Common International Classification for Ecosystem Services (CICES) is an interim classification for ecosystem services.

See also Abiotic services, Provisioning services, Regulating services, Cultural services, Intra- & Inter-ecosystem flows.

Environmental assets:

Environmental assets are the naturally occurring living and non-living components of the Earth, together constituting the bio-physical environment, which may provide benefits to humanity. (SEEA Central Framework 2.17)

This definition of environmental assets is intended to be broad and encompassing. As explained in the SEEA Central Framework the measurement of environmental assets can be considered from two perspectives. First, from the perspective of individual components, i.e., individual environmental assets, that provide materials and space to all economic activities. Examples include land, soil, water, timber, aquatic, and mineral and energy resources.

Second, environmental assets can be considered from the perspective of ecosystems. However, the scope of environmental assets is not the same as ecosystem assets as it includes mineral and energy resources which are excluded from the scope of ecosystem assets.

Also, the scope of environmental assets is broader than natural resources as it includes produced assets such as cultivated crops and plants (including timber, orchards), livestock and fish in aquaculture facilities.

In the SEEA Central Framework, the measurement scope of environmental assets is broader in physical terms than in monetary terms as the boundary in monetary terms is limited to those assets that have an economic value in monetary terms following the market valuation principles of the SNA.

See also Ecosystem assets, Natural resources, SEEA Central Framework Chapter 5

Expected ecosystem service flow:

Expected ecosystem service flow is an aggregate measure of future ecosystem service flows from an ecosystem asset for a given basket of ecosystem services. (2.39)

In general terms the measure of expected ecosystem service flows is an assessment of the capacity of an ecosystem asset to generate ecosystem services in the future. However, the focus is on the generation of a specific, expected combination of ecosystem services (the given basket) which may or may not be able to be produced on a sustainable basis. Thus the measure is not necessarily reflective of sustainable or optimal scenarios of future ecosystem asset use. At the same time the expectations of future ecosystem service flows must be informed by likely changes in ecosystem condition noting that the relationship between condition and ecosystem service flow is likely to be complex and non-linear.

See also Ecosystem services, Ecosystem asset, Ecosystem condition

Inter-ecosystem flows:

Inter-ecosystem flows are flows between ecosystem assets that reflect ongoing ecosystem processes. (2.12). An example is the flows of water between ecosystem assets via rivers.

These flows may relate directly or indirectly to flows of ecosystem services. Most commonly, inter-ecosystem flows relate to the flows considered supporting or intermediate services.

See also Ecosystem services, Intra-ecosystem flows.

Intra-ecosystem flows:

Intra-ecosystem flows are flows within ecosystem assets that reflect ongoing ecosystem processes. (2.12) An example is nutrient cycling.

These flows may relate directly or indirectly to flows of ecosystem services. Most commonly, intra-ecosystem flows relate to the flows considered supporting or intermediate services.

See also Ecosystem services, Inter-ecosystem flows.

Land cover:

Land cover refers to the observed physical and biological cover of the Earth's surface and includes natural vegetation, abiotic (non-living) surfaces and inland water bodies such as rivers, lakes and reservoirs. (SEEA Central Framework, 5.257)

Provisioning services:

Provisioning services reflect contributions to the benefits produced by or in the ecosystem, for example a fish, or a plant with pharmaceutical properties. The associated benefits may be provided in agricultural systems, as well as within semi-natural and natural ecosystems. (3.4(i))

See also Ecosystem services, Regulating services, Cultural services

Recreational services (see Cultural services)

Regulating services:

Regulating services result from the capacity of ecosystems to regulate climate, hydrological and bio-chemical cycles, earth surface processes, and a variety of biological processes. (3.4(ii))

Regulating services are also commonly referred to as “regulation and maintenance services”. In the context of the definition of ecosystem services used in SEEA Experimental Ecosystem Accounting these two terms are synonymous.

See also Ecosystem services, Provisioning services, Cultural services

Supporting services (see Ecosystem services, Intra- & Inter-ecosystem flows)