EPI WATER

Evaluating Economic Policy Instruments for Sustainable Water Management in Europe

Special Report on the Environmental Accounts

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Executive Summary

In EU and at international level the interest for developing national accounts to include the supply and demand of water related ecosystem services is considerable. The interest originates from recognizing that national economic accounts do not in sufficient way describe the interaction between the economic sphere and the environment. Both nature's contribution to economic welfare and the consequences for nature of economic activities should be included.

National water accounts describe the annual supply and use of water flows, emissions to water and the annual supply and demand of water related ecosystem services, as well as the stock of water and water quality that form part of nature capital. Water accounts do not evaluate if the water bodies and resources are in good ecological status, e.g. according to the requirements in the Water Framework Directive, and if water resources are used in a sustainable way. However, the information can be used in line with other environmental indicators to make such evaluations.

This report *National Water Accounts and their use for policy analysis* is prepared for WP 5.3 of the EU financed EPI Water project. This project analyses Environmental Policy Instruments used in relation to water management problems and in line with the requirements of the call specific attention should be made to draw lessons on the use of national accounts to support i) the design, ii) the monitoring and iii) the evaluation of EPI. These lessons should be based on the application of national accounts for case studies made under WP 3 and WP 4 in the EPI water project. Possible adaptations in these accounts that would facilitate their use for supporting policy making should also be identified.

The report on the one hand shows how a national water resource accounting system can be drawn up, and on the other hand discusses how the accounting system can be used in supporting policy making. Hence, the report is a methodological report and does neither intend to present the numbers and empirical data that form the water resource accounts nor to make policy analysis based on the accounts. Methodically the accounts are in line with other parts of the national account system and they can be integrated into this system. This makes the account very applicable for economic policy analysis at national level. The accounts are drawn up in accordance with the principle of nature as supplier of a number of ecosystem services that society demands.

The basis for the analyses in this report is a separate part of the SEEA system which is related to water resources and is called *System of Environmental*

Economic Accounting for Water (SEEAW) - cf. United Nations (2012a). The extensions are worked out in a way which means that the whole national account system preserves its consistency - i.e. the extensions are built up around supply and use accounts, division of supply into industries is preserved as well as the use categories, while the basic valuation method based on marginal values is maintained as far as possible.

SEEAW concerns freshwater - not marine waters. Its accounting system includes five main parts.

1. Annual supply and use of water and emissions to water all measured in physical units and divided into economic sectors.
2. Annual supply and use of water measured in physical units combined with economic accounts that cover costs of extraction, purification, distribution, sewers and waste water treatment as well as payments for these services including public subsidies.
3. Stocks of water measured in physical units at a certain date or as an average over a certain period.
4. Quality of water stocks measured in relevant physical units at a certain date or as an average over a certain period.
5. Valuation of the water resources - both the value of the annual flow of services related to water and the value of the water resource stock.

The three first mentioned accounts concern water as a material input to production and consumption and as a recipient of waste water. All other services of water are meant to be covered by water quality accounting and valuation of water resources - i.e. the two last mentioned accounts. However, while the three first accounts are very thoroughly prepared and described in detail the last two accounts are only in the experimental stage. So, there is a great need for more work in relation to these two accounts.

One thing that it is important to remember in relation to national water accounts is that these are only accounts which describe annual supply and demand flows of water and water related services. Furthermore stock of water and water quality that form part of nature capital are described. So, in total water accounts only describe the actual state of the water resources and do not represent an evaluation if the water resources live up to requirements for good biological conditions and if water resources are used in a sustainable way. However, the information can be used in line with other environmental indicators to make such evaluations.

It also needs to be remarked that water accounts do not state causes of changes in flows, stocks and quality of water. I.e. even if a change in water quality from one period to another is registered this does not tell anything about the causes for the change - if it is because of water policy measures, other economic changes or natural reasons. The amounts of different matters that industries and household annually discharge to the aquatic environment are also registered and of course this is a part of the reason for the registered change, but a real integrated economic water model is needed to give a full explanation.

Consequently it can be asked if the water accounts can support the i) monitoring, ii) evaluation, and iii) design of EPIs at all? Relating the water accounts to the Drivers-Pressure-State-Impact-Response (DPSIR) framework, the water accounts capture the driving forces and pressures related to the water system such as specific economic activities and sectors. Therefore, national water accounts can be used as basis for ex post analyses of the consequences of implemented policy measures to improve the aquatic environment. The impact of water policy and management responses on the water system and their effectiveness can be derived from the water accounts in principle through time series analysis of water use per economic sector, emission loads per economic sector, etc. Similarly, through time-series analysis, one could get information on the cost-effectiveness of different EPIs once implemented.

Yet, this kind of analysis usually requires also a more in-depth assessment of the various influencing factors that may have played a role in the observed trend (e.g. institutional set-up, external factors that are difficult to decouple, etc.). Attributing an observed effect on the sole impact of an EPI (or a bundle of EPIs) can be very difficult since in many cases a mix of measures may have led to that effect. This can only be analysed within an integrated economic water resources model. However, the statements in the accounts can be used as part of basis for estimating the models - cf. national economic accounts are the main data base for estimating macro-econometric models.

Such models are also very important in ex ante analysing the economic and aquatic environmental consequences of using a specific EPI - cf. Kossida et. al. (2013). Finally the accounts are very important frameworks for presentation of the results of such consequence analyses.

However, conclusions on whether water accounts could be a help in designing EPIs are really difficult to draw. First of all, it is important to clarify to water policy and decision-makers how to use the water accounts and how to interpret the information supplied by these information systems. Even though the source and destination of the water flow (opening, closing stocks, change in stocks) can be traced with the help of the water accounts and even if emissions to different water catchment area, water quality changes and changes in supply of ecosystem services could be stated the information still has to be interpreted with the necessary care in view of the fact that possible important indirect relationships are not included.

Especially if we want to take into account the scale effect - i.e. designing a certain EPI that might only be of local relevance in a specific context determined by regional particularities - it will be difficult to base a detailed design of an efficient EPI on national water accounts. Such design requires coupling of robust regional models (hydrological, economic, water quality, ecosystems services) cutting across the society and the aquatic environment. Model simulations coupled with information gained in the stakeholders participatory processes is necessary to pre-assess the potential impacts following the implementation of EPIs both on the economy and the aquatic environment and on this basis guide the design of EPIs. In this direction the water accounts as such can only support the provision of organised and harmonised datasets.

This judgment is reflected in the lacking use of national water resources accounts in the case studies of the EPI water project. The main reason for this may be that national water accounting systems like SEEAW have not been drawn up in the respective countries. Relevant data may available, but they have not been incorporated in a national accounting context. Another reason is that water accounts are not relevant for the regulating problems analyzed.

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D 5.3 - Environmental Accounts

1 Introduction

In EU and at international level the interest for developing national accounts to include the supply and demand of water related ecosystem services is considerable. The interest originates from recognizing that national economic accounts do not in sufficient way describe the interaction between the economic sphere and the environment. Both nature's contribution to economic welfare and the consequences for nature of economic activities should be included.

National water accounts describe the annual supply and use of water flows, emissions to water and the annual supply and demand of water related ecosystem services, as well as the stock of water and water quality that form part of nature capital. Water accounts do not evaluate if the water bodies and resources are in good ecological status, e.g. according to the requirements in the Water Framework Directive, and if water resources are used in a sustainable way. However, the information can be used in line with other environmental indicators to make such evaluations.

Nature's contribution to the economy can be described by the supply of a number of ecosystem services which directly or indirectly is demanded by industries and households. Normally ecosystem services are divided into four types of services - supporting, provisioning, regulating and cultural services, cf. Millenium Ecosystem Assessment (2005).

Supporting services include all services that are necessary for nature to be able to "produce" the other services - i.e. photosynthesis, pollination and contributions from the micro-fauna of soil. In principle it is possible to calculate how much each supporting service contributes to the other services, but in practise it will by and large be impossible. Therefore, in an accounting context it is most realistic to concentrate on the other three services:

- **Provisioning services** particularly include industries use of nature as a production factor - i.e. the use of land for agricultural production and the sea for commercial fishery.
- **Regulating services** include on the one hand nature's protection of economic activities - i.e. the protection against soil erosion by windbreaks and the protection against floods by coastal forelands - and on the other hand nature's ability to absorb polluting substances that are emitted as a consequence of economic activities - i.e.

the ability of surface water and ground water to detain and transform nutrients and the absorption of CO_2 by plants, soil and water.

- **Cultural services** mostly include the supply of recreational possibilities by nature, but also the possibility of learning about nature and the historical development of landscapes are cultural services. Millenium Ecosystem Assessment (2005) also regards nature's content of cultural diversity, aesthetical values and religious values as cultural services. However, it can be discussed if such values make up real services that contribute to peoples' utility or perhaps rather should be regarded as characteristics that have values in themselves independent of peoples' utility.

Under EU' biodiversity strategy Target 2, Action 5 the member states are requested to investigate, map and calculated ecosystem services on a national level and to investigate and calculate their economic value. It is also recommended that these values should be worked into national account and reporting systems before 2020 - cf. European Commission (2013).

To meet such a political desire of systematically within the national account framework to describe the interaction between the economic sphere and nature it is appropriate to start from the guidelines in *System of Environmental - Economic accounting: Central Framework* (SEEA) which is prepared by UN's statistical office - cf. United Nations et. al. (2012). Compared with the national accounting framework *System of National Accounts* (SNA) - cf. United Nations et. al. (2009) - SEEA includes a number of material and energy flows between the economy and the environment measured in physical units of measurement. SEEA is internationally adopted as environmental economic accounting system.

In continuation of SEEA UN's statistical office has prepared *SEEA Experimental Ecosystem Accounting* that directly focus on nature as supplier of ecosystem services - including the services which are connected with the material flows that are included in SEEA - cf. United Nations (2012b). Finally United Nations has prepared a special *SEEA Water: System of Environmental Economic Accounting for Water* which is a more detailed description of SEEA directed against the water resource, but also with elements of the ecosystem service approach that is used in SEEA Experimental Ecosystem Accounting - cf. United Nations (2012a).

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The report on the one hand shows how a national water resource accounting system can be drawn up, and on the other hand discusses how the accounting system can be used in supporting policy making. Hence, the report is a methodological report and does neither intend to present the numbers and empirical data that form the water resource accounts nor to make policy analysis based on the accounts. Methodically the accounts are in line with other parts of the national account system and they can be integrated into this system. This makes the account very applicable for economic policy analysis at national level. The accounts are drawn up in accordance with the principle of nature as supplier of a number of ecosystem services that society demands. Finally the accounts reflect the practical possibilities of gathering data about nature's water resource related ecosystem services.

Since we follow the SEEA Water approach - cf. United Nations (2012a) chapter 2 - which concerns freshwater - not marine waters - the water account system in this report also only deals with freshwater. The reason for omitting marine waters is that these waters should be handled in separate accounts.

The report contributes to the acquisition of knowledge by environmental authorities, statistical agencies and the scientific world about how non-traded ecosystem services can be integrated into the national accounting system and how this system can be used in an economic policy context.

One thing that it is important to remember in relation to national water accounts is that these are only accounts which describe annual supply and demand flows of water and water related services. Furthermore stock of water and water quality that form part of nature capital are described. So, in total water accounts only describe the actual state of the water resources and do not represent an evaluation if the water resources live up to requirements for good biological conditions and if water resources are used in a sustainable way. However, the information can be used in line with other environmental indicators to make such evaluations.

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Correspondingly, national water accounts can be used as basis for ex post analyses of the consequences of implemented policy measures to improve the aquatic environment. However, they cannot be used to carry out ex ante consequence analyses of considered policy measures. For this environmental economic models are needed. Still the accounts are very important frameworks for presentation of the results of such consequence analyses.

The report is structured as follows: In Chapter 2 a short description of the international work with national water resource accounts is presented. In Chapter 3 the structure of a national water accounting system with its various accounts describing water amounts, emissions to water, water quality and water related ecosystem services respectively which constitute the total water accounting system is described. The valuation of water related ecosystem services is also discussed shortly.. The different possible uses of the water accounting system and its limitations are discussed in Chapter 4. It is especially discussed how national water accounts can be used in supporting analyses of the use of economic policy instrument in relation to water management problems including how water accounts have been used in EPI water case studies.

2. Water in UN national accounting systems

This section presents the state of the art with respect to national water accounts at international level. It is explained how water is dealt with by United Nations in different national accounting systems. The European Union co-operate very closely with The United Nations about national accounts and follow by and large their guidelines. Therefore, the methodological work with national water accounts by UN is also representative for EU's work.

The presentation below concentrates on how water is dealt with within the UN national accounting system. The basic national accounting system is the economic *System of National Accounts* (SNA) which is the national accounting framework used in most countries in the world - cf. United Nations et. al. (2009). As mentioned in the introduction, United Nations has developed a version of the general national account system SNA which as a part of the flow accounts includes influences of economic activities on the environment and as a part of the stock accounts assess the stock of environmental resources. This extended account system is called *System of Environmental - Economic accounting: Central Framework* (SEEA) - cf. United Nations et. al. (2012).

Two sub-systems are connected with the SEEA system - one for water *SEEA water* (SEEAW), United Nations (2012a) and one for energy *SEEA energy* (SEEAE) which is under preparation. In addition to these two sub-systems UN has published a report directed against ecosystem service accounting *SEEA Experimental Ecosystem Accounting* (SEEA-EEA), United Nations (2012b). Both SEEAW and SEEA-EEA must be regarded as the main basis for further work on national water accounting which is also reflected in this report. Below is a short description of SEEAW and SEEA-EEA respectively. The presentation here only includes the main framework and ideas of the two guidelines. The details are discussed in Section 3 and 4 where a proposal to a general water accounting system is presented.

2.1 SEEA Water

A separate part of the SEEA system is related to water resources and is called *System of Environmental Economic Accounting for Water* (SEEAW) - cf. United Nations (2012a). The extensions are worked out in a way which means that the whole national account system preserves its consistency - i.e. the extensions are built up around supply and use accounts, division of supply into industries is preserved as well as the use categories, while the basic valuation method based on marginal values is maintained as far as possible.

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As mentioned above all accounts of SEEAW are worked out in way which means that the whole national account system preserves its consistency. However, with regard to geographical delimitation of the accounting statements there may be differences between the traditional administratively based delimitation - i.e. national accounts or municipal accounts - and the geographical delimitation that is environmentally relevant - i.e. water resource accounts should be made on water catchment level. In certain cases where a catchment area includes more than one country this may give rise to problems in relation to drawing up a water resource account that is nationally delimitated.

Also the time frame of SEEAW may differ from the normally used annual or quarterly statements of economic flows and end of the year statements of economic stocks. Especially end of the year statements of environmental quality and value of the environmental resources may be misleading. The state of the environment often changes much over the year and in such cases a statement of the average quality and value for one or several years seems to be more informative.

2.2 SEEA Experimental Ecosystem Accounting

United Nations has published an introduction to how ecosystem services may be worked into national accounts *SEEA Experimental Ecosystem Accounting* (SEEA-EEA) - cf. United Nations (2012b). The report includes ecosystem services related to all the different parts of the environment and therefore also ecosystem services related to water. Where SEEAW mainly focus on physical flows and stocks of water, emissions to water, water quality and valuation of water SEEA-EEA mainly focus on the services generated by water as an ecosystem. But, even if the main focuses are different there are big overlaps between the two accounting systems. The physical statements in SEEAW are also part of the description of ecosystem services in SEEA-EEA and valuation of water flows and stocks in SEEAW is highly dependent on the value of ecosystem services related to water. However, there are also important differences and they be summarized in this way.

1. In addition to the flows of water used for drinking water and as input in production SEEA-EEA also includes other water related services such as decomposition and sequestration of nutrients and toxic substances and use of inland waters for recreational purposes.
2. SEEA-EEA considers water stocks from another perspective than SEEAW. Where SEEAW considers water and its related resources or characteristics individually (number of fish, concentration of different matters etc.), SEEA-EEA considers water from an ecosystem perspective where the different individual resources work together as a functional unit given the stated water characteristics. So, SEEA-EEA adopts a more holistic view on water than SEEAW.
3. The ocean is excluded from the SEEAW framework because volumes of sea water cannot be meaningfully stated. However, the oceans as one or several ecosystems are included in SEEA-EEA. Still, in this report sea water is left out of account.

4. The concept of environmental degradation is broader within the SEEA-EEA framework than within SEEAW. In SEEAW degradation means a decrease in water stock and/or a decrease in water quality while degradation in SEEA-EEA is related to a decrease in the aquatic environments' capacity to supply ecosystem services. Of course this capacity is normally related to water quantity and water quality, but the relationship is not necessarily directly proportional.
5. In SEEAW market prices are used as basis for valuation, but for changes in water quality non-market valuation methods are also used. This is also the case for changes in the supply of water related ecosystem services in SEEA-EEA, but as the number of non-marketed goods and services to be valued is much higher in SEEA-EEA than in SEEAW the need for a consistent and general valuation procedure is more urgent in relation to SEEA-EEA.

In spite of these differences the two accounting frameworks should not be regarded as mutual exclusive but as complementary. This is the position taken in the present report where we take departure in both the SEEAW and the SEEA-EEA methodologies to outline a total water accounting system including all the physical flow, stock, emissions and water quality elements from SEEAW and supplementing this with accounts of the ecosystem services related to water. The ecosystem service accounts both include description of the amount and value of ecosystem services. Of course, the estimated values of some of ecosystem services can also be used within the SEEAW framework alone.

3. The national water resource accounting system and its different accounts

In this section the different parts of a potential total water resource accounting system is outlined. The system presented highly reflects the recommendation by United Nations - cf. United Nations (2012a) and (2012b). As also stressed by the United Nations a very important consideration in building up the system is that it should be possible very easily to integrate it with the rest of the national accounting system. Of course the focus of a water resource accounting system is flows of water, polluting matters, quality of water, amount and value of ecosystem services and stocks of water, but it is also important for the further analyses of the courses of observed changes and the consequences of water related policy measures that the accounting system in consistent with the way the economic activities are described in the economic system of national accounts.

The system is meant as a frame of reference for the further methodological and empirical work with water resource accounts. The results of this work will have consequences for how the final accounting system can be build up.

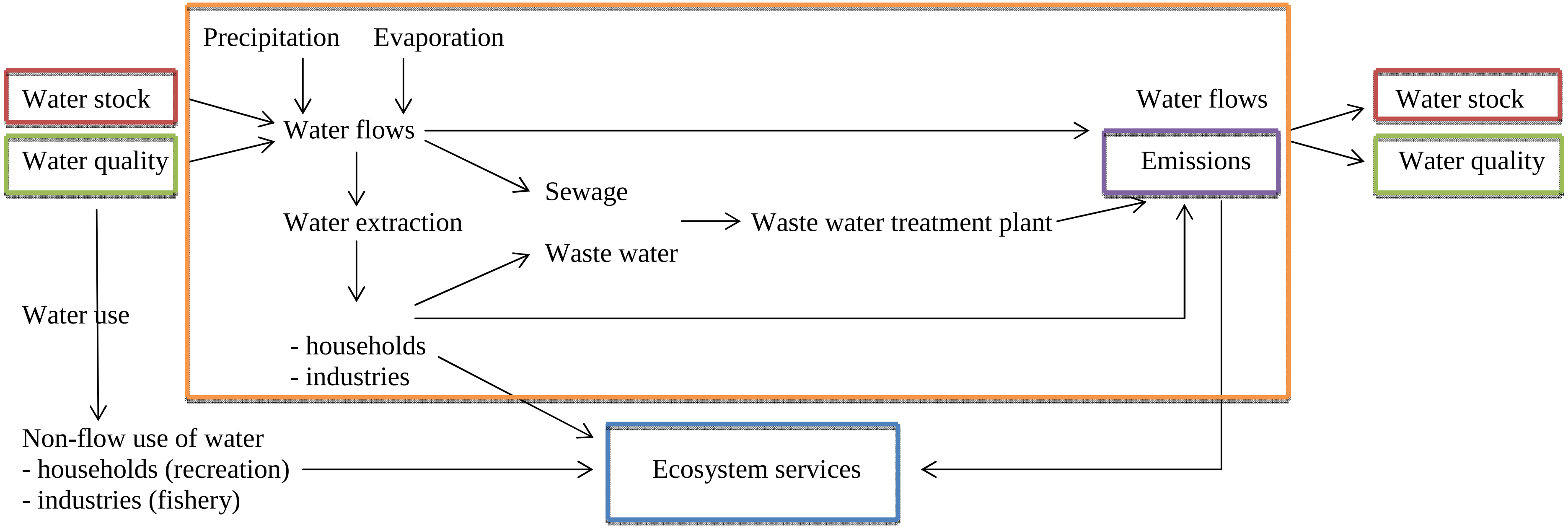
The potential water resource accounting system includes four different types of accounts:

- Water amount accounts where flows and stocks of fresh water are measures in m^3
- Emission to water accounts where different matters emitted to fresh water by industries and households are measured in kg or litre
- Water quality accounts where quality of different fresh water areas is stated in an appropriate unit of measurement
- Ecosystem services account where the amount and value of different ecosystem services supplied by different fresh water areas are stated

The SEEAW system also includes so-called hybrid accounts where supply and use of water measured in physical units are combined with economic accounts. These accounts are not included in the presented accounting system, but they can in principle be drawn up by combining information from the system with economic information from the national accounting system. Of course, this assumes that the two systems are compatible in geographical scale as well as economic sector division.

The four types of accounts which are described in more detail below reflect how the water resource develops and is used by society. This is illustrated in Figure 3.1.1.

The water resource includes both groundwater and surface water. In the beginning of a year there are certain stocks of water of different quality. In the course of the year the stocks are increased by precipitation while they are decreased because of evaporation and net use by the society. The society extracts water for different purposes and leads a part of the extracted water back to the water resource after use. As a result of these water flows the water stocks at the end of the year have changed relatively to the stocks in the beginning of the year. These connections are stated in the water asset accounts described in Section 3.1.



Anm: The five main account types of the total water accounting system are brought out by frames in five different colors.

Figure 3.1.1 The water resource accounts for water flows, water stock, water quality, emissions to water and water related ecosystem services

Society's use of the water resource leads to emissions of different substances including nutrients, hazardous substances, heavy metals etc., back into the water resource. The emissions originate from different sources. Nutrient and other substances are transported from the surface of the soil either to groundwater or directly to streams and waterways and the same is true with regard to constituents and run-off from roads, buildings and plants. Some of these emissions are led directly to surface or groundwater, while others go through waste water treatment plants that receive rain water from sewers. The second main source of emissions is industries which discharge polluted water after its use in production. Also in this case a part of the polluted water is led directly into the aquatic environment while the other part is led to waste water treatment plants that cause the final emissions. The third main emission source is households that also discharge polluted water to the environment and waste water treatment plants respectively. The emissions to the water resource are stated in the emission accounts described in Section 3.2.

As a result of the emissions of different matters in the course of the year the water quality of the different waters stocks will change. Of course the change in water quality is also affected by the ability of the water resource to degrade the emitted matters. The final result is stated in the water quality accounts described in Section 3.3.

The society uses the water resources in different ways which can be expressed as the water resources supply a number of water related ecosystem services. These services include the provisioning services where ground- and surface water resources are used for the provision of drinking water and water for production of crops; the regulating services where water related ecosystems such as wetlands are used as sinks for pollutants - e.g. to retain nutrients from agriculture and households and prevent them from further transport to inland lakes and waterways as well as the marine waters. Add to this that fresh water systems are used for a number of recreational purposes. The amount and value of these different services both depend on the amount of water used and the quality of water. So, there is a connection between the information stated in the three accounts described above and the amount and value of water related ecosystem services stated in the ecosystem service accounts described in Section 3.4.

The way that the water account system is built up makes it very suitable as a basis for several kinds of analyses of the interaction between the economic activities in society and the development of the water resources. Economic activities use water and also discharge polluting matters into the aquatic environment. This has consequences for the stock of water and water quality which further affect the supply of water related ecosystem services. The different kind of analyses based on the national water accounting system is described in Chapter 4 and it especially discussed how the system can support analyses of EPI in relation to water resource management

3.1 Water Quantity accounts

Water amount accounts contain information about flows and stock of water measured in physical units - most often m^3. The accounts concern ground water and surface water and should include traded as well as non-traded fresh water. Fresh water includes desalinated water. Surface water primarily includes lakes, rivers and streams, but in special geographical contexts of course also artificial reservoirs, glaciers and snow and ice are included. Also soil contains water and in fact SEEAW suggests that water in soil should be included in water asset accounts, but here it is left out of account.

Water flows between different parts of the fresh aquatic environment is very difficult to cover statistically, but they are important because the different parts are mutually interdependent. E.g. over-exploitation of ground water resources will have consequences on the amounts of surface water available. Indirectly such interdependencies are registered in the development of the stock of ground water and surface water respectively. Therefore, it is proposed to draw up accounts for both ground water and surface water resources. To make the information in the two accounts comparable their formal setup and aggregation level should be similar.

Below is described in more detail how the flow accounts covering supply and use of water and the asset accounts showing the development in the stocks of water could be organized. The suggestions cover both the accounts for ground water and surface water.

3.1.1 Flow accounts - supply and use of water

The annual supply and use of water measured in physical units are stated in tables that include

- water flows from the environment into the economy - divided in different economic sectors (industries and households)
- water flows between different economic sectors
- water flows from the different economic sectors back into the environment

An account of supply and use of ground water is outlined in Table 3.1.1. A similar account can be drawn up for surface water.

	Waterworks	Industries	Households	Waste water treatment	Environment
Ground water aquifer	+	+	+		
Waterworks	-	+	+		
Industries		-	+		
Total supply and use	+	+	+		
Industries				+	+
Households				+	+
Rainwater sewers				+	+
Waste water treatment				-	+
Total waste water to environment				+	+

Note: The size of water flows is calculated as net-flows, i.e. re-circulation of water is not shown in the account

Table 3.1.1 Flow account - supply and use of ground water

As stated in the note, the table includes net-flows of water and therefore, re-circulation of water is not stated in the table. An increased rate of re-circulation will appear either as a decrease in use of water per produced unit in the economy or decreased consumption of water per inhabitant.

The table should be read like this:

- *1. row.* Amounts of ground water extracted by waterworks, industries and households respectively
- *2.row.* Amounts of ground water supplied by waterworks to industries and households
- *3.row.* Amounts of ground water supplied by industries to other industries and households
- *4.row.* Total amount of water supplied to and used by industries and households. (Any amount of water in this row first column is equal to the amount of water wasted between waterworks and users - i.e. in first row first column is stated a positive number equal to the amount of water that flows to waterworks and in the

second row first column is stated a negative number equal to the amount of water that flows from these works.

- *5. row*. Amounts of waste water supplied and discharged by industries to waste water treatment plants and the environment respectively.
- *6. row*. Amounts of waste water supplied and discharged by households to waste water treatment plants and the environment respectively.
- *7. row*. Amounts of rainwater that are led to waste water treatment plants through sewers
- *8. row*. Amounts of treated waste water discharged by waste water treatment plants to the environment
- *9.row*. Total amount of treated and untreated waste water discharged to the environment - i.e. the last column row five and six state the amounts of untreated waste water and the last column row seven and eight the amounts of treated wastewater.

The supply and use table only include water flows that are related to the use of water as an input into production and as a consumption good by households. Flows of waste water and sewage are also shown in the tables, but all other uses of water are not. Thus, use of water for recreational purposes, fishing waters, water for ship traffic etc. is not included. Of course, this will not be meaningful either. Supply and use tables concern water flows measured in physical units and when water is used for recreational purposes, fishing water or water for ship traffic it is not a water flow or a certain amount of water that is used. The use of water for these purposes which are ecosystem services - see Section 3.4 - cannot be measured in physical units related to amounts of water.

However, recreational use and use of water for fishing and water transport are important services that are supplied by surface water in general. Therefore, as they are not easily registered in a water flow account where flows are measured in physical unit it is important that the services are included in the water quality accounts and especially in the value accounts.

3.1.2 Water asset accounts - water stock beginning of year, change during year, stock end of year

Water asset accounts state the amount of water that is disposable for the society at the start and at the end of the year respectively. The accounts only state the size of stocks measured in physical units. It is not taken into account that the quality of water might have changed in course of the year and that the value of water might have changed. The problems of bringing water quality measures into national accounts have not been solved satisfactorily yet and neither have the problems in relation to valuation of water - cf. Chapter 4.

As mentioned earlier the accounts only include groundwater and surface water - i.e. like for water flow accounts one set of accounts for each. Therefore, water in soil, sea water and water in the atmosphere is not explicitly included in the accounts, but of course water flows between these media and the media included in the accounts will affect the stated stocks of water. The size of these flows forms part of the water asset accounts which include the main entries stated in Table 3.1.2 which is drawn up for surface water

Opening stock		
Increase in stock because of natural processes		
Precipitation		
Other inflow		
Increase in stock because of human activities		
Waste water		
Draining		
Decrease in stock because of natural processes		
Evaporation		
Outflow to sea		
Other outflow		
Decrease in stock because of human activities		
Water abstraction		
Stop draining		
Closing stock		

Table 3.1.2 Water asset account surface water

Table 3.1.2 shows how the relationships between the amount of surface water at the start of the year, the increases and decreases during the year and the amount of water at the end of the year. The account can be drawn up both at catchment level and national level, but of course in most cases the catchment level is most relevant. The water amount is increased by natural processes - primarily precipitation - and human activities among which discharge of waste water is the most important, but also building of new draining facilities may mean that more water will be lead from soil to surface water. The surface water stock is decreased by evaporation and outflow to the sea which are natural processes and by water abstraction and dismantling of draining systems which are human activities.

So, the information in Table 3.1.2 can be used to explain changes in the observed surface water stock during the year. If a similar table is drawn up for ground water it also becomes possible to analyse possible connections between observed changes in stocks of surface water and ground water.

3.2 Emissions to water

The water flows described in Table 3.1.1 and especially the flows back to the environment cause the emissions of different matters to water. Emissions are divided into these matters and are measured in physical units.

There are very large numbers of substances that are emitted to the aquatic environment and for a national water account system the substances that are monitored on a regular basis must be the basis for the accounting. The monitoring of emissions to the aquatic environment is generally performed via National Monitoring and Assessment Programs for the Aquatic and Terrestrial Environment which consist of monitoring sub-programmes for groundwater, streams/rivers, lakes and marine water bodies, including the emissions to these aquatic ecosystems and the water quality of the water bodies. The emissions are regulated according to the objectives of the Water Framework Directive.

For streams and rivers the emissions of environmental hazardous substances and organics matters to the streams /rivers are monitored as well as the ecological conditions, the direct effects on plant and animal life from effluents, physical activities etc. and the changes in hydromorphological conditions affected by changes in the use of agricultural land (draining etc.) which can in turn affect the water flow. For lakes these emissions and physical factors are also monitored, while the loads of nutrients to the lakes are monitored additionally. For groundwater a large number of compounds can be monitored; nitrate, pesticides, chloride, different metals, organic matter, phosphorus, chlorinated compounds.

An account for the emissions of one type of matter can include the entries stated in Table 3.2.1

Matters in rain water which flow directly into freshwater and sea or flow to the waste water treatment industry, freshwater or sea through sewers are included in the emission accounts. Also matters which are transported into national water by streams from foreign countries should be included. However, the accounts only include matters contained in water that is emitted to water and therefore, atmospheric depositions directly to water are not included in the accounts. This means that the emissions stated in the national emission accounts cannot explain all changes registered in the national water quality accounts - cf. Section 3.3.

	Industries	Households	Rain[1]	Foreign countries
1. Direct from industries, households, rain and foreign countries into freshwater				
1a. Without treatment				
1b. After treatment				
2. Direct from industries, household, rain and foreign countries into sea				
1a. Without treatment				
1b. After treatment				
3. From industries, households and rain to waste water treatment industry				
Gross emissions (total emissions from industries, households, rain and foreign countries - except waste water treatment industry) 1+2+3				
4. From waste water treatment industry into freshwater				
4a. Without treatment				
4b. After treatment				
5. From waste water treatment industry into sea				
5a. Without treatment				
5b. After treatment				
Net emissions (direct emissions from all industries - including waste water treatment industry - households and foreign countries) 1+2+4+5				
6. Net emissions into freshwater				
6a. Without treatment				
6b. After treatment				
7. Net emissions into sea				
7a. Without treatment				
7b. After treatment				

Note 1. Including matters that flow with rainwater directly into freshwater and sea or to waste water treatment plants through sewers

Table 3.2.1 Emission account

The emission accounts only include the extra pollution generated in industries and households. So, if an industry uses polluted water for cooling it is not the total amount of matters that are emitted from the industry that is stated in the account, but only the extra amount of matter supplied by the cooling process.

It is seen that the emission accounts distinguish between emissions that flow to freshwater and sea respectively. It is also stated whether the waste water has been treated or not by industries and households themselves before it is drained off directly into the environment. Finally, the part of gross emissions that are drained off to the waste water treatment industry is stated. Thus, gross emissions include emissions drained off directly to freshwater, directly to sea and to the waste water industry.

Waste water drained off to the waste water industry will be treated there and the resulting net emissions to freshwater and sea respectively now include (1) direct treated and untreated emissions from industries and households, (2) direct emissions contained in untreated rainwater, (3) emissions from foreign countries and (4) treated and untreated emissions from the waste water industry.

3.3 Water quality

The water quality of European water bodies are regulated according to the Water Framework Directive and objectives are set to obtain good ecological status of the water bodies for those water bodies that are not classified as heavily modified water bodies, either because of the natural conditions or high pressure. These water bodies are regulated so as to obtain good ecological potential. Both types of water bodies are monitored and their water quality evaluated according to water quality indicators decided upon through the EUs inter-calibration process. Following EU 2013 the inter-calibration exercise envisages a harmonized approach to define one of the main environmental objectives of Directive 2000/60/EC, namely good ecological status. Through the inter-calibration the methods to monitor and classify water bodies according to the water quality standards and the methods to define their initial natural conditions have been elaborated. For this purpose, Member States are organized in Geographical Inter-calibration Groups consisting of Member States sharing particular surface water body types. The methods of setting the objectives for good ecological status or good ecological potential, and the monitoring of the indicators so as to define the water quality status is therefore built on the same principles in the EU countries, but the specific indicators are nationally specific because of differences in which indicators are meaningful to monitor in the different countries and national context.

The emissions described in tables like Table 3.2.1 for each polluting matter affect water quality. In many European countries monitoring of groundwater and freshwater quality has been carried out regularly for many years. The monitoring has been directed against specific matters in groundwater or surface water - e.g. pesticides in ground water and nutrients and heavy metals in surface water. The results have been documented in reports and have also been part of many state of the environment (SoE) reports.

However, water quality statistics have not until now been set into a water accounting context. Therefore, proper water quality accounts will represent a very important extension of the standard water accounts as those described for water flows and assets in Section 3.1. The extension is especially important in relation to the possibilities of drawing up accounts for ecosystem services - cf. Section 3.4. Thus, the amount and value of many water related ecosystem services both depend on amounts of water and water quality.

The water quality of ground water, rivers/streams and lakes as well as marine areas is monitored according to the water quality indicators set forward in national water plans. This means that the water plans and the subsequent monitoring programme deliver a significant data source for the accounts. The problem is to connect the water quality indicators, such as the content of chlorophyll in lakes to ecosystem services and the value of these.

Also with regard to water quality accounts it may be best to work with separate accounts for ground water and surface water respectively. First, because these two water sources do not have many ecosystem services in common. Ground water is only used for drinking purposes and as input in production processes - mainly irrigation in agriculture -, while surface water is mostly used for recreational purposes and for draining of water. Secondly, the impacts on the quality of ground water and surface water are also in many cases different.

In fact, there should be drawn up flow accounts of annual water flows of different quality as well as asset accounts of water stocks of different quality. Flow accounts could be the basis for calculating the annual size and value of water related ecosystem services. However, drawing up of flow accounts must be expected to be too difficult to carry out in practice - especially for surface water. It seems more realistic to restrict oneself to draw up asset account that show annual amounts of ground water and surface water with different water quality or number of water wells/stream/lakes with different water quality. Such asset accounts may be fine indicators of how the state of the aquatic environment develops. Based on such a statement it is still possible to estimate how the supply of different water related ecosystem services has developed.

Even if water quality accounts are restricted to asset accounts there are still several theoretical and practical problems for which acceptable solutions have not been found yet. These problems include

- measuring quality
- possibility of relating quality changes to different causes
- aggregation level

3.3.1 Measuring quality

Water quality depends on several water characteristics - i.e. chemical, physical, hydromorphological and biological conditions. This means that measurement of water quality is directed linked to different matters and conditions depending on the water body observed. It also means that the relevant measure of quality varies between different types of water stocks. The typology developed for the Water Framework Directive is useful as the water bodies are classified in terms of quality on a 5 point scale from bad to very good (very good- good- moderate – poor – bad) where this classification can be tied back to the status of the specific physical and quality conditions of the specific water body. The main problem to be solved is to link this classification to the status of the different ecosystem services.

In the water planning process related to the Water Framework Directive the problems of aggregating different measurements and the presentation of them into an aggregate measure of quality for all water bodies still remain, but there is information about average water quality conditions for the different water bodies in the Water plans. However, this does not link the water quality assessment to the expected services of water - i.e. if water is used for drinking, swimming, angling, irrigation etc. Water may be evaluated of low quality if it should be used for drinking purposes but of satisfactory quality as bathing water.

It is possible to measure and state waters' content in many different matters, but it will soon result in an enormous amount of data. On the one hand this gives a very detailed description of the state of water, but on the other hand it makes it very difficult to give an overall evaluation of water quality. In the work with environmental indicators many solutions to this aggregation problem have been proposed. The solutions are multiple, spanning from the choice of one single matter, plant or animal as a representative indicator for the quality of a specific water stock to advanced aggregated quality indices based on weighting of different indicators. The weights used may reflect human evaluation of the importance of the different indicators with respect to a given use of water or relative degrees of meeting target values set up for the different indicators. However, there are still plenty of possibilities for development of water quality indices.

In many cases water quality varies over time because of seasonal weather conditions and therefore it is necessary to choose both a suitable period for measurement of quality and a way to find a representative quality number from the numbers measured in the chosen period. A solution of this problem should make it possible to compare quality measures between periods in a meaningful way. As natural variations can last for more than a year annual quality estimation is not always the most suitable estimation frequency. Two or even five years intervals may give more correct information about the development of water quality. A simple mean of the measured quality numbers in the chosen period may not give the right picture of quality either. E.g. if quality is measured by the concentration of a polluting matter the worst or highest concentration may be more important for the evaluation of quality in the period. Even if the average number may look satisfactory, the highest number may have had damaging consequences for the environment. In such cases an indicator for the state of the surrounding environment may be a more suitable indicator of water quality.

Finally, water quality also has a space related dimension. Water quality in one part of a water course may be good while bad in another part and if the quality numbers are aggregated, e.g. by weighting the numbers according to the size of the different part, a lot of information is lost. However, this will always be the case when indicators are aggregated. So, the challenge with regard to aggregation of spatial differentiated quality numbers is to find a suitable geographical delimitation of the information presented. This can be quality measures related to specific freshwater courses, aquifers or geographical areas, but these solutions may still result in too much information which may not be manageable within an account system. SEEAW proposes an account which subdivides a well-defined water stock into different quality classes in the beginning and the end of the chosen period - see table 3.3.1.

	Quality 1	**Quality 2**	**Quality 3**	…
Opening stock				
+/- change in stock				
Closing stock				

Table 3.3.1 Water quality account of a well-defined water stock

The advantage of this account is that it sub-divides the water stock into different parts determined by their water quality. In this way one can get a more nuanced picture of the water quality and at the same time preserve the possibility to estimate the average water quality. It is also possible to relate changes in average water quality to specific changes in the amount of water within each quality class.

3.3.2 Possibility of relating quality changes to different causes

It is important to be aware of that the accounts do only inform about the water quality at two points in time and about the change in quality in the period between. It is not possible to distinguish between changes in quality that are caused by human activities and natural processes respectively. Therefore, the accounts do not explain the reasons for the observed quality changes. Of course, this is a weakness because apart from being informed about the state of water quality one of the main purposes of setting up the quality account is to be able to react on observed quality deteriorations in an efficient way. Models that describe the interaction between human and natural influences on water quality are a prerequisite for efficient water management. This presupposes knowledge of the causes of quality changes.

However, if the information from the water quality accounts is linked with information from the emission accounts and information about weather conditions (among other things) it can be used to estimate models that explain quality changes. Of course, a prerequisite for making this link between emissions and water quality is that the same demarcations of water stocks are used in emission accounts and water quality accounts. Therefore, it is important that the drawing up of emission accounts and water quality accounts is geographically adapted.

3.4 Water resource related ecosystem services

The final water accounts suggested by SEEAW are accounts in which water flows and stocks are valuated in economic terms. Therefore, these accounts are the ones that are most in accordance with the traditional national accounts which state money flows related to economic activities and value of economic assets respectively.

In fact the value of water flows and stocks that are traded on a market is already included in the traditional accounts. Thus, the costs of supplying water for industries and households as well as the expenses by industries and households to buy water are included in national accounts. Also the costs of cleaning and protecting water stocks are included and to a certain degree the recreational values attached to freshwater stocks are reflected in house prices or tourist revenues. It is important to be aware of this if the specific water accounts are to be integrated with the traditional accounts, so that double-counting is avoided.

SEEAW do not propose real value accounts for water because there are still many unsolved problems connected with this. Of course, the final target is to be able to set up such accounts, but as long as the possibilities of solving the problems have not been identified it is best not to endorse one particular solution. However, one very promising solution is to value water flows and stocks on the basis of the ecosystem services they provide.

Below, the different ecosystem services related to water are presented. After this suggestion flow and stock tables for ecosystem services supplied by water are put forward. Finally, the possibilities and problems of estimating amounts and values of the different ecosystem services are discussed shortly.

3.4.1 Ecosystem services related to water

European Commission (2013) uses the CICES classification for ecosystem services version 4.3 as basis for a discussion of the problems related to mapping and assessment of ecosystems and their services. From this classification the ecosystem services related to water can be separated for use in water resource accounting. The water related ecosystem services are stated in Table 3.4.1.

It can be seen from the table that ecosystem services related to water include provisioning services, regulation & maintenance services and cultural services.

Provisioning services only include surface water and ground water used for drinking and non-drinking purposes. Non-drinking purposes are domestic use, irrigation, livestock consumption and industrial use. The use of water for power production is not mentioned explicitly, but might be included in industrial use which both includes water used for cooling and water used as raw material in products.

The distinction between drinking and non-drinking purposes or water used as nutrient and material respectively is of course meaningful, but it can be discussed if it is useful in a practical accounting context. The problem is that households and different industries record how much water they use in total, but it may be very difficult for them to state how much of the total use has been consumed for drinking and other domestic use respectively. Therefore, in an accounting context the distinction between surface water and ground water should be maintained on the supply side while on the demand side total water use should be distributed between households and different industries. This suggestion is reflected in the ecosystem service accounts that are drawn up in Section 3.4.2.

Regulation & Maintenance services include many different biological, physical and chemical processes that are very difficult to separate in an accounting context. Common to almost all of them is the fact that they are related to the use of the water resource as recipient of pollution that is degraded or accumulated, but how much of this total service is related to detoxification, decomposition, mineralisation, degradation, biological and bio-physico-chemical filtration, sequestration, storage, accumulation, adsorption, binding, dilution or mineralisation is of course impossible to say in practice.

Therefore, in an accounting context it is suggested only to work with one class of regulation services which includes the CICES division *Mediation of waste, toxics and other nuisances* and the two CICES classes *Decomposition and fixing processes* and *Global climate regulation by reduction of climate gas concentrations*. This regulation class could be subdivided not according to the processes involved but according to the matters involved - e.g. nutrients like nitrogen and phosphorous, heavy metals and other toxic substances. This subdivision of the services on the supply side makes it possible to relate the services to households and different industries on the demand side because it is known from the emission accounts which matters and amounts of matters are emitted by households and industries.

The maintenance services in Table 3.4.1 - i.e. the two classes maintaining nursery populations and habitats and chemical conditions of freshwater - should not be included in the ecosystem service accounts. Of course, these services are important prerequisites for

Section	Division	Class	Examples
Provisioning	Nutrient	**Surface water for drinking**	Collected precipitation or abstracted from rivers, lakes etc.
		Ground water for drinking	Abstracted directly from ground water aquifers or by desalination
	Materials	**Surface water for non-drinking**	Collected precipitation or abstracted from rivers, lakes etc. and demanded for domestic use, irrigation, livestock consumption and industrial use
		Ground water for non-drinking	Abstracted directly from ground water aquifers or by desalination and demanded for domestic use, irrigation, livestock consumption, industrial use
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	**Bio-remediation by micro-organisms, algae, plants and animals**	Detoxification, decomposition, mineralisation and degradation
		Filtration, sequestration, storage and accumulation by micro-organisms, algae, plants and animals or by ecosystems	Biological and bio-physico-chemical filtration, sequestration, storage and accumulation of pollution in freshwater biota and ecosystems, including sediments. Adsorption and binding of heavy metals and organic compounds in freshwater biota and ecosystems
		Dilution by freshwater	Bio-physico-chemical dilution of fluids and waste water in lakes and rivers, including sediments
	Maintenance of physical, chemical and biological conditions	**Maintaining nursery populations and habitats**	Freshwater habitats for plant and animal nursery and reproduction
		Decomposition and fixing processes	Maintenance of bio-geo-chemical conditions of soils by decomposition-/mineralisation of dead organic material, nitrification, denitrification, N-fixing and other bio-geochemical processes
		Chemical conditions of freshwater	Maintenance/buffering of chemical composition of freshwater column and sediment to ensure favourable living conditions for biota etc. by denitrification, re-mobilisation/remineralisation of phosphorous etc.
		Global climate regulation by reduction of climate gas concentrations	Global climate regulation by greenhouse gas/carbon sequestration by freshwater columns and sediments and their biota
Cultural	Physical and intellectual interactions biota, ecosystems and landscapes	**Physical use of landscapes in different environmental settings**	Walking and hiking along rivers and lakes, boating, angling, hunting and swimming
		Experiential use of plants, animals and landscapes in different environmental settings	Bird watching, botanizing, and diving
		Scientific use (intellectual)	Subject matter for research both on location and via other media
		Educational use (intellectual)	Subject matter for education both on location and via other media
		Heritage, cultural use (intellectual)	Historic records and cultural heritage preserved in freshwater bodies
		Entertainment use (intellectual)	Ex-situ experience of natural world through different media
		Aesthetic use (intellectual)	Sense of place, artistic representation of nature
	Spiritual, symbolic and other interactions biota, ecosystems and landscapes	**Symbolic**	Emblematic plants and animals and national symbols
		Sacred and religious	Spiritual and ritual identity such as holy places, sacred plants and animals
		Existence	Enjoyment provided by existence of wild species, wilderness, ecosystems and landscapes
		Bequest	Willingness to preserve plants, animals, ecosystems and landscapes for the experience and use of future generations. Ethical perspective or belief.

Source: After CICES classification version 4.3 in European Commission (2013)

Table 3.4.1 CICES classification of ecosystem services related to water the other services, but as these are already included in the accounts it will be double-counting also to include maintenance or supporting services.

Cultural services include two divisions of services: physical and intellectual interactions with biota, ecosystems and landscapes, and spiritual, symbolic and other interactions with biota, ecosystems and landscapes respectively. Physical use of the water resource encompasses both direct physical use such as walking and hiking along rivers and lakes, boating, angling, hunting and swimming and experiential use such as birdwatching, botanizing, and diving. Of course, these uses represent different activities, but in a practical accounting context it may be very difficult to keep them separate from each other. E.g. you normally walk along lake shore while birdwatching and often you angle or hunt from a boat. Therefore the distinction between physical and experiential use is very difficult to uphold. Instead, one division for recreational use could be formed and perhaps it could be further subdivided in different activities determined by the primary purpose of the activity.

Symbolic use of the water resources includes different so-called intellectual uses such as scientific and educational use. It also includes heritage and cultural use (historic records and cultural heritage preserved in freshwater bodies), entertainment use (ex-situ experience of natural world through different media) and aesthetic use (sense of place and artistic representation of nature). Some of these activities have much in common with recreational use described above and therefore, could be included among these.

By contrast it can be discussed if preservation of cultural heritage in freshwater bodies can be regarded as a utility generating activity. Thus, it can be argued that preservation of cultural heritage has a value in itself and therefore should not be included among all the other utility generating ecosystem services.

The same argument could be put forward with regard to the ecosystem service division designated as spiritual, symbolic and other interactions with biota, ecosystems and landscapes. All the religious, ethical and symbolic values included in this division can be argued to have a value in themselves. It is not their utility for people that make them valuable. Therefore, they should not be included among the utility generating ecosystem services that are valued because of the utility they convey to people.

The discussion above can be summed up in the following way:

- Provisioning services include groundwater and surface water used by different industries and households.
- Regulating services are related to the use of the water resources as recipients of pollution that is degraded or accumulated and the services should be subdivided

not according to the processes involved but according to the matters involved - e.g. nutrients like nitrogen and phosphorous, heavy metals and other toxic substances.

- Cultural services should include different recreational activities and if possible these could be subdivided according to the main activity involved - walking, angling, swimming, boating etc. Also included in this section should be the scientific and educational use of the water resources.

These ecosystem services are supplied by the water resources and should enter into the national water resource accounting system on the supply side of the system. The different services are demanded and used by industries and households. In Section 3.4.2 below is suggested a flow account which is in accordance with this recommendation.

3.4.2 Flow accounts

In Table 3.4.2 is put forward a flow account for the ecosystem services that are related to the water resource. The account includes both services related to ground water and surface water, but in principle it can be split up into two tables one for each of the two water media. In this case an account can be made for both each relevant ground water magazine or water catchment areas and at a national level. On the other hand it may be difficult to relate some of the regulating services to either surface water or ground water because these services are also supplied by water in soil which can be regarded as both surface water and ground water. This indicates that one account including ground water as well as surface water should be preferred.

The flow account can be made for amounts as well as values of ecosystem services. In the first case the account will be directly related to the water flow accounts of Section 3.1 (the provisioning services) and the emission accounts of Section 3.2 (the regulating services) while the amounts of cultural services have no direct relation to any of earlier described accounts. In the other case where the values of ecosystem services are stated in the account it has no direct relation to the other accounts of the water accounting system either.

The supply side of the ecosystem service account (the rows) includes all the different services discussed above and the demand side of the account (the columns) relates the different services to industries and household. Of course, the same classification of industries used in the general national accounting system should be used on the demand side of the ecosystem service account.

Table 3.4.2 includes all ecosystem services related to the water resource. Therefore, it also includes services that are already a part of the SNA and SEEA national accounting system. It especially concerns the value of provisioning services, but also the value of some of the regulating services may indirectly be included in the production value and/or value added of industries. If these were not allowed to emit substances into the water resource perhaps they have been forced to reduce their production or the costs of production have been higher.

Ecosystem services		Industry 1	Industry 2	…	Water catchment industry	…	Households
Provisioning							
Direct supply from water resource	Ground water	+	+	+	+	+	+
	Surface water	+	+	+	+	+	+
Supply from water catchment industry	Ground water	+	+	+	-	+	+
	Surface water	+	+	+	-	+	+
Regulating services							
N-fixing and decomposition		+	+	+	+	+	+
P-fixing and decomposition		+	+	+	+	+	+
Detoxification		+	+	+	+	+	+
Accumulation of heavy metals		+	+	+	+	+	+
…							
…							
Cultural services							
Walking, birdwatching etc.							+
Angling							+
Boating							+
Swimming							+
Hunting							+
Educational and scientific use		+	+	+	+	+	+
…							
…							

Table 3.4.2 Supply and demand of ecosystem services related to the water resource

The point is that the values of ecosystem services cannot be directly added to production values and value added stated in the economic part of the national accounting system to get the total value of human and environmental production of society. To calculate this value it is necessary to make corrections to the ecosystem service values stated in the ecosystem service account so that double-counting is prevented.

Still, presumably there is both a need for an account of the value of ecosystem services related to water and a need for an account of the total value of goods and services provided jointly by industries and the water resource. Therefore, two accounts have to be made, one like Table 3.4.2 showing the total value of all ecosystem services related to water and one showing the value of goods and services provided jointly by the society and the water resource. This account should only include values from the ecosystem service account which are not already included in the traditional SEEA accounts. However, the supply side of these accounts may be changed so that the contributions of services from the water resource become more clearly brought out.

In Section 3.4.4 below the possibilities and problems in relation to measuring and valuing the different ecosystem services is discussed.

3.4.3 Stock accounts

The concept of an ecosystem service is by definition a flow variable and therefore it can be discussed if stock accounts of these services can be meaningfully put forward. However, the annual value of these services now and in the future determines the stock value of the water related part of the nature capital. It is important to estimate this value for two reasons:

- Deterioration of the quality of the aquatic environment that occurs in future years should be stated in the water account as a depreciation of the stock value of the water resource. The value of future ecosystem services has decreased.
- The annual value of depreciations of the value of the water resource is necessary in order to calculate the value of the Green Net Domestic Product and the value of Pure Saving.

Many impacts on the aquatic environment - e.g. different emissions - do not affect the quality of the aquatic environment only in the year where the impact takes place and perhaps the full effects on quality are first experienced in later years. Still, in such cases it is important that the value of the total effects of the impacts is stated in the water accounts in the year where the impacts take place. This is done as a reduction of the value of the water resource - i.e. as a depreciation. Of course an improvement of the water quality now and in the future should be stated in the account as an appreciation of the value of the water resource.

The Green Net Domestic Product and especially Pure Saving are important economic indicators of economic and environmental sustainability - cf. Section 4.6. An important part of the calculation of these measures is the calculation of the depreciation of the value of Nature Capital including the depreciation of the value of the water resource.

The stock value of the water resource is determined by the actual and expected future value of ecosystem services supplied by the aquatic environment. Thus, the stock value is calculated as the present value of these services. Of course, calculation of the stock value of the water resource involves huge practical difficulties related to estimation of expected future amounts and values of ecosystem services. The stock value also depends to a very high degree on the discount rate chosen.

Value of water resource dependent on value of ecosystem services		**Opening value of water resource**	**Increase in value**	**Decrease in value**	**Closing value of water resource**
Provisioning					
Direct supply from water resource	Ground water				
	Surface water				
Supply from water catchment industry	Ground water				
	Surface water				
Regulating services					
N-fixing and decomposition					
P-fixing and decomposition					
Detoxification					
Accumulation of heavy metals					
…					
…					
Cultural services					
Walking, bird watching etc.					
Angling					
Boating					
Swimming					
Hunting					
Educational and scientific use					
…					
…					

Table 3.4.3 Opening and closing stock value of water resource determined by value of expected annual ecosystem services in actual and future years

If these almost insuperable problems could be overcome the results could be stated in a stock value account as the one presented in Table 3.4.3. Like the flow account in Table 3.4.2 for the value of ecosystem services the stock account can be drawn up both for each water catchment area and at a national level dependent on data availability.

The stock values and the changes in these values are determined by;

- the actual use of water amounts stated in the flow accounts of Section 3.1.1 and expected future use
- the actual emissions to water stated in the emission accounts of Section 3.2 and expected future emissions
- the actual quality of the water resource stated in the water quality accounts of Section 3.3 and expected future changes in water quality
- the actual use of cultural services stated in the ecosystem service account of Section 3.4.1 and expected future use of cultural services.

All these conditions are mutually dependent and determine the amount and value of different ecosystem services supplied and demanded. Therefore, the information in stock value account is central for analyzing the relations between use of the aquatic environment for consumption and production purposes as well as emission recipient and the development in the value of natural capital.

3.4.4 Valuation of water resource related ecosystem services

In this section is discussed how the different ecosystem services described in Section 3.4.3 may be valued. The presentation follows the classification of ecosystem services in Table 3.4.2. Valuation of provisioning services is discussed first, then valuation of regulating services and finally valuation of cultural services.

Annually used flows of ecosystem services do only have a direct or indirect use value and therefore, the services should only be valued by methods that estimate use value. However, The water resource do also have an asset value - the water resource is part of the natural capital - which first of all depends on the direct and indirect use value of its expected future supply of ecosystem services, but the asset value may also reflect option value and non-use values. The valuation of these is discussed in the end of this section.

Provisioning services. Provisioning services supplied by the water resource include groundwater and surface water used by industries and household for drinking and input in production. This use has a direct use value for the users which indicate that they obtain a direct benefit from using the water resource for their own purposes.

Water resource provisioning services traded on the market include for producers process water and input as a raw materials in intermediary or final products and for consumers purchase of water in drinking water quality, which they may use for drinking water or non-drinking water purposes. The amounts of traded water are stated in the water flow accounts of Section 3.1.

Valuing traded water resource services is relatively straight forward. The marginal value of water sold to consumers or producers can be set on the basis of actual consumer/producer prices. If the market price included taxes and subsidies it is termed "user price" and if the price does not include taxes and subsidies it is called "factor price". Although water prices may vary across the country it is possible to estimate the total value of water consumption from data about total sale and purchase. This is in accordance to practice in national accounts.

Water resource services may be obtained for direct use through private extraction from the resource, e.g. private boreholes established by industry and agriculture. The annual use of non-traded water is stated in the water flow accounts of Section 3.1. Often, this resource is not sold directly on the market, and no market price exists for this quantity of the water resource. Different ways exist in attributing a marginal value to non-traded water resource services:

- *Average resource rent* – this is calculated by subtracting the value of all other input uses than water (i.e. labour, real capital, land and produced inputs) from the value of the produce in which water is used. For average resource rents to be in accordance with the requirement of marginal values in national account there needs to be information on how production value changes as a consequence of changes in water consumption.
- *Marginal productivity* – this is calculated based on a production function, which necessitates data on input and production. Based on the production function, marginal productivity of different inputs can be estimated, including the marginal productivity of water.
- *Cost based approaches* – this is calculated based on the costs of extracting, distributing and cleansing the water.

In principle, the productivity based approach to valuing marketed ecosystem services should be preferred in those cases where data for calculating resource rent or marginal productivity is available. Only if productivity based approaches prove to be disproportionally difficult to carry out should cost based valuation approaches be considered.
Cost based approaches are in accordance with current methods in national accounts when valuing the supply of public services such as police, national health system, and defence. These services are not traded and therefore do not have a market price nor a known marginal value. As a solution, national accounts define the value of public services as the cost of service provision. Although these cost prices may vary across the country, it is possible to choose a representative cost based price.

If none of these valuation methods can be used because of lack of information non-traded water resource provisioning services may be valued in accordance with the calculated average marginal value of traded water.

Regulating services. Regulating services of the water resource include N-fixing and decomposition, P-fixing and decomposition, detoxification, accumulation of heavy metals etc. - cf. Section 3.4.2. The amounts of these different services are not like the amounts of provisioning services stated in any of the other water accounts described in Section 3.1 - 3.3. They have to be estimated as a part of the total valuation of regulating services.

The basis for valuation of regulating services is the emission accounts of Section 3.2. This is because the value of the water related regulating services is related to the part of total emissions that are fixed or decomposed by the aquatic environment. This part depends on total emissions and can be estimated on the basis of these.

The other part of the emissions which is not fixed or decomposed flows into the aquatic environment where it has negative consequences for the water quality. Some of these consequences may be registered in the same year as the emissions take place, but other consequences may first show up in later years. However, in both cases the negative consequences should be stated in the water asset account as depreciations in the value of the water resource.

Water resource regulation services have what is indirect use value. This means that the value of these services is not directly captured by the market, but only implicitly through the value of marketed products. If water resources have not supplied the different regulating services emissions would have had to be neutralized in other ways to make sure that the aquatic environment is not deteriorated. The alternative neutralization measures include decrease of production activities, use other types or other amounts of input in production and different purification measures. All measures represent costs to society and these saved costs that can be used as indicators of the value of regulating services.

So, valuation of regulating services needs information about first the amount of each substance fixed or decomposed by the water resource and second about the marginal cost of reducing the load of the aquatic environment with each the different substances in alternative ways. This assumes that cost effectiveness analyses of these alternative reduction measures have been made. The calculated marginal costs of reducing the load equal to what the each regulating service do should be can be multiplied with the estimated amount of each service to get the total value of the service.

Regulating services may be valued in an alternative way based on the value of prevented decreases in the value of other ecosystem services. If the water resource has not supplied the different regulating services the aquatic environment would have been deteriorated and this would have meant a decrease in the value of supplied provisioning and cultural services. This prevented decrease reflects the value of regulating services. However, this valuation method is not in accordance with the method used in other parts of the national accounting system where normally non-traded production and consumption are valued on the basis of the production costs. E.g. this is true for public production and consumption.

Cultural Services. Cultural services include recreational activities like walking bird watching, angling, boating swimming and hunting, but also educational and scientific use of the water resource - cf. Section 3.4.2. The supply of these services represents direct use values to the users. However these values fall outside the realm of the market and non-market valuation techniques are needed to attribute values.

Recreation activities refer to services provided by freshwater resources which in most cases cater for several recreational services at the same time. The individual values of the different services may influence each other. E.g. if a lake is used for sailing and swimming the value of these services may be high, but the values of its angling and bird watching services may be low because of the disturbance from the sailing activities and vice versa. Thus, valuation these services individually is no trivial task and is seldom made. Most often, valuation studies focus on estimating the consumer surplus of recreational value of improving the quality of a habitat from the present level to a future hypothetical level, leaving it open for interpretation for which recreational purpose.

Valuation techniques for measuring non-market values are based either on direct or indirect preference elicitation or on price/cost functions. A brief overview is given below:

- *Contingent valuation* – uses direct preference elicitation by asking respondents for the willingness to pay for a quality or quantity improvement or for a willingness to accept a decrease in quality or quantity of the specific ecosystem service.
- *Choice experiment* – uses direct preference elicitation by asking respondents to trade off among a pre-specified set of characteristics of the ecosystem service through a number of choice occasions (typically 6-12 choice occasions). A cost factor (for WTP measures) or a subsidy factor (for WTA measures) is included in the characteristics. Results of choice experiments can reveal i) how much the average individual would be willing to pay for any of the options and ii) how much the average individual would be willing to pay (accept) to obtain (to avoid) specific levels of characteristics.
- *Travel cost* – estimates the value of access to a specific site using the observed relationship between frequency of visit and costs of visiting to derive a demand function for accessing the site.

- *Hedonic pricing* – estimates the value of an ecosystem service using the observed relationship between house price sales and vicinity to e.g. habitat sites, parks, level of air quality, noise levels, isolating other determining factors.
- *Avoided behaviour* – estimates the value of an ecosystem service by observing costs inferred by consumers to purchase market goods as a substitute for environmental quality and deriving the demand function.
- *Alternative costs* **–** estimates the value of an ecosystem service as the costs of obtaining a similar service through the cheapest alternative action.
- *Replacement costs* – estimates the value of protecting an ecosystem service via the costs of re-establishing the quality/quantity of the ecosystem service at the same site or at a different location.

These different valuation techniques can all be used to value the use value of cultural services. However, if the general valuation method in national accounting should be followed valuation of non-traded goods - e.g. public consumption - should be based on the costs of producing the goods. This means that the alternative costs and replacement costs methods should be preferred when valuing cultural services in a water resource accounting context.

Asset value of the water resource. The water resource is part of natural capital and as such it also has an asset value. First of all this value depends on the expected future use value of ecosystem services supplied by the water resource. The expected annual value of these services can be calculated in the same way as the value of the present year's services is calculated - cf. above.

The asset value is calculated as the present value of expected future ecosystem services. This means that a social discount rate has to be used for the calculation. However, there is no general agreement, neither within nor between countries, about which discount rate to use.

In addition to the use values of the water resource which is reflected in the value of water related ecosystem services the water resource may also have so-called option value and different non-use values. Option value is related to possible but not exploited known and unknown uses of the water resource. It has a value to society to preserve these possibilities. Non-use values include existence value and bequest value of water of the highest possible quality. This means that the water resource may have value to actual persons just because it exists or because future persons' welfare has a value to present persons.

Fresh water and especially clean water may have existence value because persons think that clean water as an environmental good has to exist. It is an absolutely necessary part of a natural environment. The possibility that ground water or drinking water has such a value to persons cannot be excluded. However, it is very difficult to distinguish a possible existence value from a possible bequest value. Persons may primarily assign non-use value to fresh water out of regard for future persons' welfare. In practice, though, people's motivation for assigning non-use value to fresh water is not important.

Valuation methods for estimating option value and non-use values include the above mentioned Contingent valuation, Choice Experiment, Alternative costs and Replacement costs methods. However, in practice, it has proven very difficult to value option value and non-use values only. Direct valuation methods are often directed either at use values or total values which include both use and non-use values.

One important purpose of calculating the asset value of the water resource and especially annual changes in this value is to include expected future deteriorations of the aquatic environment in the water resource accounts - e.g. caused by actual emissions which consequences first show up in later years. Such expected deteriorations should be stated in the accounts as depreciation of the value of the water resource - i.e. in the stock accounts of Section 3.4.3. Depreciation may include both decrease in use, option and non-use values of the water resource.

4. The use of water resource accounts as a supporting tool for policy making

For policy making and planning taking an integrated water management (IWRM) approach requires that - cf. Global Water Partnership (2004);

- policies and priorities take water resources implications into account, including the two-way relationship between macro-economic policies and water development, management and use;
- there is cross-sectoral integration in policy development;
- stakeholders are active in water planning and management;
- water-related decisions made at local and river-basin levels are in-line with, or at least do not conflict with, the achievement of broad national objectives; and
- water planning and strategies are integrated into broader social, economic and environmental goals.

The formulation and evaluation of water related policies, such as those aiming at efficient water allocation and cost recovery of water related ecosystem services, are at the heart of water management. Policy makers taking decisions on water need to be aware of the likely consequences for the economy. Those determining the development of e.g. industries making extensive use of water resources, either as inputs in the production process or as sinks for the discharge of wastewater, need to be aware of the long term consequences on water resources and the environment in general. Therefore, they need to have suitable tools for effectively and equitably formulating these decisions. Such tools are not adequately developed or readily available and in many cases need to be based on a uniform integrated system with common concepts, data definitions and classifications, which allows for derivation of consistent indicators across countries and over time.

The national water accounting system presented in Chapter 3 makes up such a system and in the following Sections 4.1 - 4.6 it will be explained in more detail how the water accounting system can support water resource management. Section 4.1 sets out how water accounts can assist policy makers more generally. After this in Section 4.2 - 4.5 is given an account of the different analyses that can be made on the basis of the accounting system. The different types of analyses which can support policy making include:

- Environmental and socio-economic indicator analysis
- Ex-post analysis of the effects of policy reforms
- Input/output based ex-ante scenario projection
- Estimation of macroeconomic water resources models, consequence calculation and forecasts
- Evaluation of sustainability based on Pure Saving

The chapter is concluded with a discussion of the possibilities for using the national water accounting system in designing economic policy instruments for water management and it is summarized how water accounts have been used in the EPI water project.

4.1 How can water accounts assist policy-makers?

Environmental accounting is one of the key tools for assessing environmental issues and their relation to the economy, and was claimed to be the "best option" for integrating social and environmental considerations into EU decision making in the long term" at the "beyond GDP" conference (Brussels, 19 November 2007 - ENDS Europe DAILY 2432, 20/11/07 http://www.endseurope.com/14171?referrer=search). A key advantage of the accounting framework is that it offers a platform for better integrating heterogeneous information, qualifying it and, to some extent, paving the way for accurately quantified scenario analysis. The water resources accounts, aiming at standardizing concepts and methods in water accounting and providing a conceptual framework for organizing economic and hydrological information, is a useful tool in support of IWRM by providing the information system to feed knowledge into the decision making process assisting policy makers in taking informed decisions on - cf. United Nations (2012a):

- **Allocating water resources efficiently**, as it presents the quantity of water used and who is using it, and provides information about the economic values added generated by different industries. It allows thus the derivation of water efficiency and productivity indicators, and helps water managers with developing policies for competing water uses.
- **Improving water efficiency**: the water resources accounting system provides information on the fees paid for water supply and sewerage services, as well as payments for permits to access water resources, either for abstracting water or for using water resources as a sink. It also provides information on the quantity of water which is reused within the economy (water which, after having been used, is supplied to another user for further use) thus offering policymakers a database that can be used to analyze the impact of the introduction of new regulations throughout the economy on water resources.
- **Understanding the impacts of water management on all users** and evaluating tradeoffs of different policy options on all users.
- **Getting the most value for money from investment in infrastructure**. Investment in infrastructure needs to be based on the evaluation of long-term costs and benefits. Policy makers need to have information on the economic implications of infrastructure maintenance, water services and potential cost-recovery. The water accounts provide the information of current costs to maintain existing infrastructure, the service charges paid by the users, as well as the cost structure of the water supply and sewerage industries. Therefore they can be used in economic models to evaluate potential costs and benefits of putting in place new infrastructure.
- **Linking water availability and use**. Improving efficiency in the use of water is particularly important in situations of water stress. For the management of water resources, it is important to link water use with water availability. The water accounts provide information on the stocks of water resources as well as all changes in stocks due to natural causes (e.g. inflows, outflows, precipitation) and human activities (e.g. abstraction and returns). Further, water abstraction and returns are disaggregated by industry, thus facilitating its management.

- **Providing a standardized information system** which harmonizes information from different sources and is used for the derivation of indicators. Information on water is often generated, collected, and analyzed by different agencies. The individual datasets might be collected for different purposes, use different definitions and classifications and show overlaps in data collection. A water resources accounts standard framework allows for disparate information to be integrated.

4.2 Environmental and socio-economic indicator analysis

The water resource accounting system contains several types of information that can be used together with other environmental indicators to evaluate the state of environment in relation to water.

The water flow accounts directly show how the use of water develops over the years and among the sources and users. As the water flows are divided between economic sectors they can depict which sectors are the main users and if their use is increasing or decreasing. If the information from the stock accounts is also included in the analysis it can be evaluated if the actual water use is within the limits set by the total amount of water available for use each year. If water stocks are decreasing water use is too large and vice versa. Over-exploitation of certain resources (e.g. groundwater) can also be observed, as well as increasing water abstraction trends. Such indicators linked with environmental requirements can earmark periods or areas where human water use is tapping into the environmental needs and facilitate linking water quantity with qualitative and ecological status.

The information about water flows can also be combined with economic and demographic statistics to evaluate if industries and households have become more effective in their water use. It is one of the advantages of the integration of water accounts with the general national accounting system that through their common sector division there is a direct link between production and input use in different economic sectors and their use of water. This makes it possible to calculate water use coefficients and productivities for each of the economic sectors (water use per production value and production value per m^3 of water used respectively). These indicators make it possible to evaluate water use efficiency and identify barriers to sustainable economic growth due to its dependence on water-intensive sectors. Nevertheless, if these indicators are to highly aggregated at national scale they miss the regional variability as productivities may highly vary among areas (e.g. NUTS2 scale, River Basin Districts etc.) or among products within a sector (e.g. irrigated crops – maize vs. potatoes). Therefore, it is important that the indicators are estimated at a regional scale and product level that make them usable for answering key policy questions of water resources decoupling, green growth and sustainability.

The same advantage of common sector division applies to *the emission accounts* which either shows the emissions of one matter distributed on different industries and the households or the emissions of different matters of one industry or the households. In this case emission coefficients - i.e. emission per production value or per use of different inputs - for the different matters and industries can be calculated. The coefficients indicate whether production in each industry sector and consumption of households have been less polluting or not. Because the same sector division as in the rest of the national accounting system is used the information can be used for further analyses of the reasons for the observed development in total emissions - cf. Section 4.3.

As set out in Section 3.2 emission accounts should be divided up geographically to be suitable for further environmental analysis of the impacts of the emissions. This is because the water resources consist of several sub-systems that are more or less independent of each other and therefore, in most cases emissions in on area will only have consequences for one sub-system. This complicates integration with the other parts of the national accounting system which normally are not geographically subdivided. Without this subdivision of economic activities it is not possible on the basis of the national accounting system to explain geographically specific changes in water quality and supply of ecosystem services. But still, geographically subdivided emission accounts indicate which water resource systems may be threatened by pollution.

Water quality accounts indicate on one hand if there are water resource systems that have unsatisfactory water quality and on the other hand if water quality is improving or deteriorating. The accounts are not directly linked with the economic part of the national accounting system. The link goes through the emission accounts which of course imply that the same geographical subdivision of water resource systems is chosen in water quality as well as in the emission accounts. If this is the case and the emission accounts as described above are linked with the economic accounts the total from economic cause to environmental effect chain has been established. It can be used as a basis for explanation of observed changes in water quality - cf. Section 4.3 below.

Finally, *the ecosystem services accounts* indicate the economic value of the water resources for the society. As explained in Section 3.4 the water resources supply services which are used by different parts of the society. The value of some of these services - especially the provisioning services - are already included in the economic accounts, but the value of the services that have not until now been included in these accounts increases the total production value and value added generated jointly by humans and nature. Correspondingly, the services are included on the demand side of the national accounting system and increase the value of total demand.

The value of ecosystem services related to the water resources and the stated development in the value may be used in argumentation for protection and preservation of the water resources. Of course, referral to economic value should not be the only argument for protection - also ethical and aesthetical considerations are important - but as economic value can be regarded as an aggregated indicator of the consequences of society's use of the water resources it is highly relevant for the argumentation.

However, it is important to be careful when interpreting the development in the total value of ecosystem services. An increase in the value of ecosystem services related to water is not necessarily an expression of an improvement in the state of the water resource. Thus, the value both depends on the quality of the water resource and the amount of water used (or how many uses the water resource). An increase in the amount of the water resource used increases the value of ecosystem services, but it may also mean a deterioration of the resource. Some examples show this:

1. An increase in the annual amount of groundwater extracted increases the provisioning of ecosystem service related to ground water, but if the amount of water extracted exceeds the natural recharge and renewable stock of the groundwater resource the increase in the ecosystem service value cannot then be interpreted as an indicator of an environmental improvement. This will also be stated in the national accounts as a decrease in the value of the ground water stock - i.e. a depreciation. So, generally the annual value of provisioning services should be stated net of any depreciations of the resource to give a correct picture of the value of the service.
2. An increase in the area of farm land cultivated will be stated as an increase in the provisioning ecosystem service related to farm land, but if the increase in farm land area has been achieved by draining wetlands then the value of regulating and cultural ecosystem services provided by these may have decreased. However, if this decrease is less than the increase in farm lands' provisioning services the result will still be an increase in the total value of ecosystem services. From an economic point of view this can be interpreted as an environmental improvement, but from a broader natural point of view this interpretation may not be correct.
3. If on an annual scale more polluting matters are released to the aquatic environment and the water resource is able to degrade or absorb the matters without any immediate consequences for water quality, the value of the regulating ecosystem service will increase. However, even if water in this case supplies more services it can be debated if this can also be interpreted as an environmental improvement. It is also possible that the ability of the water resource to degrade and absorb pollution will gradually decrease in the future if the emissions of polluting matters continue for several years. It can be difficult to foresee these consequences and even if it is possible they will not appear before several years later as reduced water quality and related to this decreased supply of ecosystem

services. These consequences may be stated in the actual year as a depreciation of the water resource, but because of discounting of the value of future ecosystem services the depreciation may not be as big as the stated increase in the actual value of regulating services.

These examples clearly show that caution should be exhibited when interpreting changes in the value of water related ecosystem services as an expression of similar changes in the state of the aquatic environment, but in most cases there will be such a direct connection.

4.3 Ex-post analysis of the effects of policy reforms

If the different water accounts are fully integrated with the economic part of the national accounting system and not least if the economic part can be subdivided geographically in line with the subdivision suitable for water resource accounting the total accounting system can be used for a number of analytical purposes. One of these is the ex-post analysis. Ex-post analysis focuses on explaining the observed economic or environmental changes that have taken place and on uncovering effects of earlier incidents such as implementation of policy measures. Thus, the analysis gives knowledge of the reasons for observed changes in emissions to water, water quality or value of water related ecosystem services, and it can also give valuable experience about the effects of different policy measures, including economic policy instruments.

Naturally, an accounting system is very useful for ex-post analysis. The total national accounting system including the water accounts forms one big input/output system that is a good basis for analysing the different causes of observed environmental changes. In accordance with the way that the accounting system is structured the analysis is best carried out by going through four different analyses:

- Analysis of the causes of changes in water use and water abstraction
- Analysis of the causes of changes in emissions
- Analysis of the causes of changes in water quality
- Analysis of the causes of changes in the value of ecosystem services supplied

The *water use and supply accounts* are directly linked to water availability stated in the asset accounts as well to the costs of supplying water or the prices of water and finally the revenues generated by using water which are stated in the economic accounts.. On the basis of data about water use, water prices and production revenues it is possible ex-post to analyse how water prices affect the use of water. Water pricing changes induce changes in water use efficiency that results in more water-efficient technology and the reallocation of water among sectors. This in turn influences water abstraction and water availability (i.e. the stocks of the different sources), and consequently the production values of the different industries and the GDP. Thus, water pricing as an EPI has impacts on the GDP.

Water use is affected by water policy instruments, but it is also indirectly affected by policies in other sectors of the economy, which may not anticipate the impact on water resources. For example, agricultural trade policy may have a significant impact on what is produced in a country and indirectly on the use of water for agriculture. Thus, although through an ex-post analysis one can detect impacts of a water policy reform, their attribution to that policy reform is not straight forward as the later may be the observed impact of a bundle of measures and policies that have acted complementary. Isolating the effect of a single instrument is very complex and requires additional in depth analysis - see Section 4.5.

The *emission accounts* are directly linked to the economic accounts and therefore, it is possible on the basis of input/output tables to separate which part of the emission changes are due to:

- General growth in the economy
- Changes in the composition of consumption and other demand
- Changes in industry structure
- Changes in emission coefficients caused by either changes in input use or resource effectiveness

The result of such an input/output based analysis makes up a very good basis for an explanation of observed emission changes, but of course, the result does neither explain the size of general growth nor the changes in demand composition, industry structure and emission coefficients. To explain these changes further analysis is required.

One such analysis could focus on the effects of policy measures, i.e. economic instruments, put in action. E.g. if the price elasticity of demand for a certain polluting input is known it is possible to estimate how much the demand of this input has changed due to a tax on the input. Subsequently this estimate can be used to determine how much of the observed changes in the input related emission coefficients can be explained by changes in the use of input. Finally, the change in emission coefficient can be used to calculate the total change in emissions caused by the tax. Of course, this effect is only the direct effect of the tax on emissions. There may also be several indirect effects caused by substitution of the input in case with another input, and changes in final demand caused by relative price changes triggered by the input tax. These indirect effects are not included in the outlined simple partial analysis. A proper general equilibrium model is needed for this kind of general analysis - see Section 4.5.

The next kind of analysis focuses on the causes of the observed changes in water quality stated in the *water quality accounts*. In most cases the main reason is the changes in emissions related to changes in human economic activity described above. But, also other causes like pollution accidents, trans-boundary pollution and natural incidents may be part of the explanation. Changes in trans-boundary pollution are stated in the emission accounts, but the reasons for the changes cannot be deduced from information in the national accounting system. The same is true for pollution accidents and natural incidents.

The final type of ex-post analysis concerns the reasons for changes in the *value of ecosystem services*. Each change has different reasons depending on the ecosystem service in question.

Changes in the value of provisioning services in most cases have economic reasons related to changes in demand for water for production and consumption purposes. These changes are stated in the economic accounts and the underlying causes can be found by the input/output based analysis described above. In some cases, changes in water quality also affect the value of provisioning services - e.g. catches in the fishery sector - and of course, the reason for these value changes should be found among the explanations for water quality changes stated in water quality accounts.

As explained in Section 4.2, changes in the value of regulating services are related to emission changes and the capacity of the water resources to degrade and absorb the polluting matters. Actual emission changes can be explained on the basis of information in the actual national accounts as described above, but changes in degradation and absorbing capacity have causes related to emissions in earlier years. Therefore, a complete explanation of stated changes in the value of water related regulating services has to incorporate earlier year's economic activities and emissions related to these activities.

Finally, changes in the value of cultural services are caused by changes in people's use of the aquatic environment and their willingness to pay for the services. Of course, these two elements are related. Most cultural services (except hunting and angling) are public goods which are free for the users to use. So, the higher they value the services the more they will use them and their contingent marginal willingness to pay for the services may also be higher. It is difficult on the basis of the information in the national accounting system alone to determine which are the underlying causes of a change in the value of cultural services. Changes in water quality may be part of the explanation, but probably also socio-economic and demographic factors, such as income changes, changes in age distribution and preference changes, are important determinants. Real statistical analysis is needed to settle these questions.

4.4 Input/output based ex-ante scenario projection

Just as the national accounting system can be used as basis for retrospective and explanatory ex-post analysis, it can also be used as basis for forward looking ex-ante scenario analysis. This analysis shows the consequences of an assumed change in economic activity for other economic activities and the aquatic environment. In its most simple form the ex-ante scenario analysis is based on the input/output accounts that are part of the national accounting system. As such an analysis is based on input/output relations stated by fixed coefficients and not real demand and supply functions the analysis is in the nature of a projection and not a forecast. A real forecast must be based on a macroeconomic model - cf. Section 4.5.

An input/output based scenario analysis of an increase in a private consumption category makes use of the following direct and indirect relations between demand and supply of goods. When consumption of a good increases it leads at the same time to an increase in the supply of the good. Some part of the supply comes from an inland production sector while another part may come from import. This is the direct effects of the consumption increase. However, it also leads to indirect effects because to increase production in one economic sector more inputs from other sectors are needed and they should also be produced or imported etc. All these relations are stated by input/output coefficients in the input/output accounts, and on the basis of them the total direct and indirect consequences on production in different sectors and on import due to an increase in a consumption category can be calculated.

At a next step, on the basis of the projected production changes the consequences on water use, water abstraction and emissions to water due to the increased consumption can be calculated. For this is used the production specific water use and emission coefficients that can be calculated from the water supply and use and the emission accounts respectively. However, the calculated emission changes only include emissions generated by the national production sectors. The import of consumption goods and inputs for production generate emissions in foreign countries as well, but these emissions are not included in the national accounting system. Special information about production conditions and the related emissions in foreign countries has to be obtained before emission consequences for foreign countries can be projected.

Thus, the national accounting system with its input/output accounts, water supply and use and emission accounts makes it possible to make simple projections of the national water use and emissions to water of assumed changes in consumption of different consumption categories. Of course the same kind of analysis can be made for assumed changes in the production in different economic sectors.

The use of input/output coefficients and water use and/or emission coefficients to make simple projections of water use and/or emissions can be defended because the coefficients reflect real average relations between demand and supply of goods and between production and emissions. The relations do not have general validity, but they are valid for the specific accounting year that they are calculated for. However, this is not the case for the relations between emissions and water quality and between water quality and value of ecosystem services. These relations are not linear, even not within a single year, and therefore, it is not meaningful to calculate coefficients for the relation between emissions and water quality or for the relation between water quality and value of ecosystem services.

This means that the consequences for water quality and the supply of ecosystem services cannot be directly projected on the basis of the information stated in the water accounts. This information has to be supplemented with real knowledge about how emissions will affect water quality and what changes in water quality will mean for the value of different ecosystem services. Such knowledge will in some cases, be available in form of so called dose-response or dose-effect functions.

The input/output based projections described above are initialised by a change in the final demand or production, but projections of assumed changed in input use or water treatment can also be made. Such changes could be the result of a specific economic policy instrument related to the use of water resources. However, this pre-requires an independent analysis of how emission coefficients are affected by changed input use or water treatment. It may not always be easy to estimate this, but if achieved the consequences for total emissions can easily be projected - moreover assuming unchanged economic activity.

The projections described in this section are calculated on the basis of assumed partial changes in consumption or production activity. This means that basic economic interaction mechanisms have not been taken into account in the analysis - more consumption of one good means less consumption of another and changes in demand affect relative prices which again will affect relative demand etcetera. Such economic interaction can only be handled within real economic models and in fact information from the national accounting system constitutes a good basis for estimating such models.

4.5 Estimation of macroeconomic water resources models, consequence calculation and forecasts

Parallel to estimation of traditional macroeconomic models on the basis of information from the economic part of the national accounting system the information from the integrated national accounting and water accounting systems can be used as input to integrated economic and water resources models, i.e. hydro-economic models. Such models can either take the form of a main macroeconomic model linked to a water resources satellite model (modular models) or they can be fully integrated economic and water resources models (holistic models). The modular models have the advantage of representing the economic and hydrological processes in more detail and are more easily adaptable and expandable since modular. An example of such a model is the WEAP water resources model coupled with the IMDEA- Revealed Preferences Model in Pinios river Basin in Greece - cf. Kossida et. al. (2013). Additional examples is the coupling of the

SWAT hydrological model with the BEMO economic model in the Upper Ems river in Germany - cf. Volk et al. (2008) - the coupling of the WEAP water resources model with a multi-scale non-linear optimisation model using GAMS in the Guadiana river basin in Spain - cf. Blanco (2010) - and the coupling of the CALSIM II hydrological model with the ASPIDE economic model in the San Joaquin river basin in California. Holistic models on the other hand have the advantage to avoid interfaces and better capture the interdependencies, yet they often represent the economic and hydrological processes in a simplified manner - cf. McKinney et. al. (1999). Examples of such models are presented in California - cf. Jenkins et. al. (2004) - in the Adra river in Spain - cf. Pulido-Velazquez et. al. (2009) - in the Nilufer river basin in Turkey - cf. Gurluk and Ward (2009) - and in the Yass river basin in Australia - cf. Letcher et. al. (2007).

The strength of the integrated national economic and water resource accounting system in relation to model estimation is the possibility of estimating a fully integrated economic and water resource model based on coherent and statistically consistent information. Such model also includes feed-back effects from the aquatic environment on the economic activity and value of ecosystem services - e.g. feed-back effects from emissions and water quality on value added in the fishery sector (a provisioning water ecosystem services) or value of water related cultural services.

Development of the fully integrated macroeconomic and water resources model is based on time series for all the relevant data in the economic and water resources accounting system. In addition to the economic demand and supply function. The time series of the accounting system makes it possible to estimate functional connections (not necessarily linear) between environmental investments of industries and water use or emissions to water, between emissions and water quality and between income, water quality and use and economic activity and value of ecosystem services. It is to be noticed that these functions represent statistical regularities and not a in depth insight and analytical description of the economic and natural scientific mechanisms behind the functions. Therefore, it is important they are in accordance with what should be expected based their form and parameter sizes.

It may be possible to construct similar models on the basis of information from many different sources - e.g. by linking independently estimated dose-response relations with economic models as mentioned above. Such models are often based on thorough natural scientific knowledge of the interactions between the society and nature. However, the problem with these models is that they are based on data collected under many different contexts and therefore, data are not necessarily consistent with regard to time scale, economic sector division, geographical scale etc. But, even if the consistency and coherence of the models can be argued, they should be used and their results could be cross-compared with the results from the models estimated on the basis of information from the integrated national economic and water accounting system. These comparisons may lead to a deeper insight into the complex interactions between the economy and the aquatic environment.

The integrated macroeconomic and water resources models can be used for different analytical purposes which comprise two main groups of analyses:

- Consequence analysis of policy measures
- Forecasts of expected economic and environmental development

The advantage of integrated models in relation to consequence analysis is that the models include demand and supply functions that describe how economic agents react on taxes and cost increases caused by environmental regulation. The agents' direct reaction on the regulation may have consequences on demand, supply and prices on other goods than the regulated good which cause further adaption and so on. The economic adaption behaviour has consequences for the aquatic environment and the value of ecosystem services which again may affect economic activities. The total economic and environmental adaption to the policy measures and instruments is described by the integrated model and their final consequences appear as differences between the former and the new economic and water resources equilibrium.

Compared to the input/output based scenario projections the use of integrated models may lead to forecasts of the expected development of the economy and the water resources. This is because the models are build up around functions that describe, to the best possible degree, real economic behaviour and adaption to changed economic and environmental conditions as well as functions that describe how the water resources develop as a consequence of changed economic use of the resource's ecosystem services. The functions are not necessarily linear as in the input/output model, and therefore, they represent a more realistic picture of the economy and the water resources.

4.6 Evaluation of sustainability based on Pure Saving

In Section 4.2 it was described how from the integrated national economic and water resources accounting system can be extracted information about resource efficiency, emissions to water, water quality and value of ecosystem services that can form part of a complete environmental indicator system. In addition to this, the system also includes information that can be used to evaluate if the economic and environmental development is sustainable. In fact, already from the beginning of the development of green national accounting evaluation of sustainability has been an important focus and reason for developing the accounting system - cf. Ahmad et. al. (ed.) (1989).

To begin with, the focus was on the concept of Net Domestic Product (NDP) and on the necessity of improving this indicator so that it would give a more correct picture of the development of pure income and wealth of the society than the traditional NDP. The fundamental theoretical work was done by Mähler (1991) and Dasgupta (1995). They showed that a real Net Welfare Measure (NWM) could be derived from the NDP by decreasing this indicator with the value of defensive measures and increasing it with the value of non-market environmental services. Besides the depreciation of physical capital total depreciations should now include the depreciation of all renewable and non-renewable environmental resources.

This insight could be expressed by using the concept of ecosystem services in the formula for Pure NDP below

$$
\begin{aligned}
Pure\ NDP = NDP \\
&+ value\ of\ regulating\ services\ not\ reflected\ in\ value\ added \\
&+ value\ of\ cultural\ services\ -\ value\ of\ defensive\ measures \\
&-\ depreciation\ of\ natural\ capital
\end{aligned}
$$

The concept of Pure Saving is derived from Pure NDP by subtracting the value of private and public consumption as well as the value of cultural services. Its relevance as an indicator of sustainability is based on the so-called Harwick's Rule according to which the economic and environmental development is sustainable if investments in real capital (including knowledge) correspond at least to the depreciation of natural capital, that is Pure Saving is zero or positive - cf. Hartwick (1977).

Pure Saving is now widely accepted as an indicator of sustainability, but to make it practicable a complete integrated national economic and environmental accounting system has to be drawn up. The water accounts, and especially the accounts of the value of water related ecosystem services and changes in the value of the water resources, constitute an important contribution to this system.

However, it should be noticed that Pure Saving has significant weaknesses as an indicator of sustainability. The two most important are:

- If the value of the total capital already in the present situation is too low for sustainability, then the economic and environmental development may still be unsustainable even if Pure Saving is positive.
- Some parts of nature may have an infinite value, or we are not allowed to destroy them, and therefore it may not be possible to replace all parts of natural capital with real capital as assumed in Hartwick's rule.

In the light of these weaknesses the Pure Saving should not be the main focus when drawing up integrated national economic and water resources accounts.

4.7 Water Accounts and Economic Policy Instruments design

As presented in the previous sections water accounts provide the opportunity to show the supply and use of water in the economy and the interaction with the aquatic environment. It is important to clarify to water policy and decision-makers how to use the water accounts and how to interpret the information supplied by these information systems. Even though the source and destination of the water flow (opening, closing stocks, change in stocks) can be traced with the help of the water accounts and even if emissions to different water catchment area, water quality changes and changes in supply of ecosystem services could be stated the information still has to be interpreted with the necessary care in view of the fact that possible important indirect relationships are not included.

But can the water accounts support the i) monitoring, ii) evaluation, and iii) design of EPIs? Relating the water accounts to the Drivers-Pressure-State-Impact-Response (DPSIR) framework, the water accounts capture the driving forces and pressures related to the water system such as specific economic activities and sectors. The impact of water policy and management responses on the water system and their effectiveness can be derived from the water accounts in principle through time series analysis of water use per economic sector, emission loads per economic sector, etc. Thus monitoring of relevant EPIs which have a direct impact on water use and/or water quality can be achieved. Similarly, through time-series analysis, one could get information on the cost-effectiveness of different EPIs once implemented (this of course requires adequately long time-series and EPIs which are adequately framed by the SEEAW parameters) supporting their evaluation as demonstrated in the previous Sections 4.2 and 4.3.

Yet, this kind of analysis usually requires also a more in-depth assessment of the various influencing factors that may have played a role in the observed trend (e.g. institutional set-up, external factors that are difficult to decouple, etc.). Attributing an observed effect on the sole impact of an EPI (or a bundle of EPIs) can be very difficult since in many cases a mix of measures may have led to that effect. This can only be analysed within an integrated economic water resources model as discussed in Section 4.3 and 4.5. Such models are also necessary to analyse ex ante the total economic and aquatic environmental consequences of using a specific EPI.

However, conclusions on whether water accounts could be a help in designing EPIs are really difficult to draw. Especially if we want to take into account the scale effect - i.e. designing a certain EPI that might only be of local relevance in a specific context determined by regional particularities - it will be difficult to base a detailed design of an efficient EPI on national water accounts. Such design requires coupling of robust regional models (hydrological, economic, water quality, ecosystems services) cutting across the society and the aquatic environment. Model simulations coupled with information gained in the stakeholders participatory processes is necessary to pre-assess the potential impacts following the implementation of EPIs both on the economy and the aquatic environment and on this basis guide the design of EPIs. In this direction the water accounts as such can only support the provision of organised and harmonised datasets.

This judgment is reflected in the lacking use of national water resources accounts in the case studies of the EPI water project. The main reason for this may be that national water accounting systems like SEEAW have not been drawn up in the respective countries. Relevant data may available, but they have not been incorporated in a national accounting context. Another reason is that water accounts are not relevant for the regulating problems analyzed.

Kossida et. al. (2013) is the only case study that directly refers to SEEAW. The integrated economic water resource model used to analyze regulation of water use by EPI is not developed on the basis of data from a national water resources accounting system. The model is developed and adapted to analyze use of EPI in relation to a specific water catchment area - the Pinios river Basin in Greece. Therefore, specific economic, water resource and climate data for this area have been used to develop the model. However, the results of the model simulations have been used to compile SEEAW Asset Accounts and Physical Supply and Use. "The output of the model has been further used to fill in the SEEAW Asset Accounts and Physical Supply and Use tables" - cf. Kossida et. al. (2013).

Thus, in this case study model results are used to fill in national water resources accounts. As mentioned above this is a very informative way to present the results of analyses of changes in the use of water resources. By contrast, as far as possible results of model simulations should not be used to draw up annual water resources accounts. These should reflect actual conditions based on observations, but of course, in special cases where no observations are available model simulations or other kinds of calculations can be used to estimate the missing data.

The other three EPI water case studies - cf. Ungvàri & Kis (2013), Gómez et. al. (2013) and Defrance et. al. (2013) - do not make any reference to SEEAW and do not use national water resources account in their analyses.

Ungvàri & Kis (2013) analyses how flood and water logging problems in the Tisza River Basin in Hungary can be solved in the most cost effective way including use of EPI. For this kind of cost effective analysis water resources accounting is not relevant, except perhaps as part of the description of the basic scenario. But, to be a sufficient basis for analyses the basic scenario should also be characterized by other factors than those that are stated in water resources accounts - e.g. flood frequencies and costs of floods.

Gómez et. al. (2013) analyses the problems of water resources distribution in the Tagus (Central Spain & Portugal) and Segura (SE Spain) interconnected river basins that are heavily affected by droughts and water scarcity. The problem analyzed in this study is similar to the one studied in Kossida et. al. (2013) and of course, the same recommendations with regard to the use of water resources accounts that was advanced in relation to that study do also hold good for the Spanish study. It is a prerequisite that water resources accounts could be drawn up for the specific study area and if this is the case the accounts could be used both to describe the basic situation and to present the results of using EPI to solve the scarcity problems. In the longer run information from annual water resources accounts covering several successive years could be used as part of the basis for estimating integrated economic water resources models.

Finally Defrance et. al. (2013) analyses how EPIs can be used in solving problems in relation ecosystem services and conservation in the Seine-Normandie River Basin (France). This is neither an obvious case for use of national water resources accounts even if accounts can be drawn up for the specific river basin. However, the way that the whole DPSIR chain is reflected in the structure of the water resources accounts may form a reference for explanation of the causes of changes in the supply of ecosystem services and also for modelling the consequences for the supply of using different EPIs. It may also be a part of the problem to prioritize between EPIs because these have different consequences for the supply of different ecosystem services. In this case there is a need for valuation of the services and in this connection the valuation methods used in national ecosystem services accounting may be relevant. Of course, there may be differences between more general prices used in national accounting and those that should be used I relation to a specific river basin, but the valuation principles and methods should be the same,

In summing up it must be emphasized that national water resources accounting first of all are directed against **recording** of actual water resources conditions at a national level as well as at a water catchment level. The recording includes water flows, water stocks, emissions to water, water quality and supply of water resources related ecosystem services. These recordings can be used for many different analytical purposes explained above of which none are especially directed against EPIs. However, consequences of EPIs can be analyzed ex-post on the basis of information from the national water resources accounts and the information can also be used to develop models that can support ex-ante analyses of the consequences of considered EPIs.

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