NATURAL CAPITAL ACCOUNTING AND WATER QUALITY: COMMITMENTS, BENEFITS, NEEDS AND PROGRESS

The Economics of Ecosystems & Biodiversity

A Briefing Note

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KEY MESSAGES

- **Effective water management, water policy and biodiversity policy can benefit from the collection and systematisation of information on water quantity and quality, and their relationship to biodiversity. Natural capital accounts can provide an important contribution to this objective.** They collect information in a structured and coherent way, in order to allow for monitoring of trends over time and for different geographical areas. In addition, accounts can help shed light on the links between environmental and economic factors and between different environmental areas (e.g. land cover and water use).

- **While there is already considerable experience with accounting for water quantity, there is less experience with accounting for water quality.** The System of Environmental-Economic Accounting (SEEA) – Water includes a general discussion on key methodological challenges related to accounting for water quality and some examples, but it does not provide a standard for water quality accounts. SEEA-Experimental Ecosystem Accounting also addresses water quality in the broader context of ecosystem accounting.

- **Water emission accounts and ecosystem accounts can also provide useful information on water quality.** The former measures pressures on water quality but not water quality per se. The reason for that is that water quality can be influenced by other factors than the emission of pollutants into water, like for example the level of dilution, which depends, in turn, on water quantity as well as on interactions within ecosystems. Water emission accounts are prepared by many countries and SEEA-Central Framework provides guidance on how to develop them.

- **Ecosystem accounts** measure the biotic component of natural capital, i.e. the extent and condition of ecosystems and the flows of ecosystem services. They cover information on the ecosystem services that benefit society and the economy, including water purification. Since water quality plays a key role in ensuring healthy ecosystems and ecosystem services, **ecosystem accounts can give useful information on water quality.**

- SEEA-Experimental Ecosystem Accounting offers a synthesis of the current knowledge of ecosystem accounting and serves as a platform for its testing and experimentation at the national and sub-national level. Complementary guidance and work is taking place at the EU level (the Ecosystem Capital Accounts that are being developed by the European Environment Agency and the Mapping and Assessment of Ecosystems and their Services process), at the national level (e.g. Canada's MEGS and Wetland Asset Accounts), regional level (e.g. the Experimental Ecosystem Accounts in Victoria, Australia) and globally (e.g. within the World Bank-led WAVES initiative).

- **Many challenges remain in developing water quality accounts, including methodological development, terminology, data collection, systematisation and sustained production of the accounts.** For example, water quality depends on local conditions, and for this reason scaling up data in order to create national accounts requires a set of assumptions and methodological choices. Challenges to be addressed in the coming years include: **scale** (how to translate information from the landscape and river basin scale to national accounts); **data** (how to increase data availability and quality); **ground-truthing and relevance** (how to calibrate accounts with real world measurements); **coverage and representativeness** (which services are included and what is the meaning of the results of accounts); **added value for decision making** (when an accounting approach provides more added value than other tools supplying evidence to decision making); **trade** (how to deal with resources and impacts embedded in imports); and **monetary valuation** (to what extent it is appropriate and feasible, and how to develop it).

- **National and international commitments and experimentation will be important to develop natural capital and water quality accounts**, in order to clarify which kind of information they can provide and how they can support the different decision-making processes. While progress is needed on environmental-economic accounting in general, additional attention on water quality aspects will be particularly important in light of growing concerns of access to clean water, appreciation of the links between ecosystems and water quality and wider sustainable development objectives.

INTRODUCTION: A GROWING GLOBAL FOCUS ON NATURAL CAPITAL ACCOUNTING

There is growing momentum on natural capital accounting at the international, national and corporate level, including:

- The adoption of the Strategic Plan for Biological Diversity 2011-2020, by which countries committed to integrate the values of biodiversity into national accounting (the Aichi Target 2); associated commitments for accounting in National Biodiversity Strategies and Action Plans (NBSAPs);
- The EU Biodiversity Strategy to 2020[i], which requires Member States to map and assess the state of ecosystems and their services by 2014, to assess their economic value and to promote the integration of these values into accounting by 2020 (Target 2, Action 5);
- The 2012 Gaborone Declaration by 10 African Nations, which called for support for green accounting;
- A communiqué issued on the occasion of the 2012 'Rio+20' Conference, supported by 57 countries and the European Commission, that called on governments, the UN system, international financial institutions and other international organizations to strengthen the implementation of natural capital accounting around the world and factor the value of natural assets into national accounting. The outcome of the 'Rio+20' conference will be taken into consideration by the High-Level Panel on the Post-2015 Development Agenda (set up by the United Nations to advise on the global development framework beyond 2015, the target date for the Millennium Development Goals).

Moreover, activities on natural capital accounts are evolving with increasing application and experimentation. For example, the WAVES initiative (see Box 1) launched at the tenth meeting of the Conference to the Parties of the Convention on Biological Diversity (CBD COP-10), encourages the development of natural capital accounting across the world.

Box 1: WAVES

WAVES (Wealth Accounting and the Valuation of Ecosystem Services) is a global partnership that aims to promote sustainable development by ensuring that natural resources are mainstreamed in development planning. It promotes the development of environmental economic accounting according to the guidelines provided by the System of Environmental-Economic Accounting (SEEA). WAVES is funded by the European Commission, Denmark, France, Germany, Japan, the Netherlands, Norway, Switzerland, and the United Kingdom and it is being overseen by a steering committee. At the moment, the core WAVES countries - Botswana, Colombia, Costa Rica, Guatemala, Indonesia, Madagascar, the Philippines and Rwanda- are developing natural capital accounting.

Source: http://www.wavespartnership.org

EU Regulation No 691/2011[ii] has introduced the requirement for Member States to develop three modules of environmental-economic accounts: air emission accounts, accounts on environmental taxes and material flow accounts. The Regulation establishes a window of opportunity every three years to add more modules to respond to key policy needs. Water accounts (in quantitative and qualitative terms) are listed among the potential new modules to add in the next revision processes (art.10). In addition, proposals have been put forward to develop the following kinds of accounts by 2017: a) Environmental protection expenditure accounts; b) Environmental goods and services accounts; c) Energy flow accounts. In addition, Member States are developing a range of accounts beyond those required by the EU Regulation 691/2011, progressing on different fronts.

The EU Water Framework Directive (WFD) in practice encourages natural capital accounting. It requires Member States to prepare River Basin

[i] EU 2020 Biodiversity Strategy (COM(2011) 244 final. http://ec.europa.eu/environment/nature/biodiversity/comm2006/pdf/2020/1_EN_ACT_part1_v7%5b1%5d.pdf
[ii] http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2011:192:0001:0016:EN:PDF

Management Plans (RBMPs), which include an assessment of the ecological and chemical status of water bodies. This implies collecting data in a systematic and comparable way across EU river basins, which could be used to build water quality and quantity accounts (see Box 5).

The System of Environmental-Economic Accounting (SEEA) is the main guidance on environmental-economic accounting developed by the United Nations Statistics Division. Within the EU, guidance on natural capital accounting is to be provided by the MAES process (see Box 2).

Box 2: MAES

The EU initiative 'Mapping and Assessment of Ecosystems and their Services' (MAES), established by the European Commission with EU Member States, aims to support the mapping and assessment of ecosystems and their services, both in biophysical and monetary terms, in order to support the EU 2020 Biodiversity Strategy. MAES is to provide a coherent analytical framework for use at EU and Member State level in order to ensure consistent approaches. A guidance document is to be published by the end of 2014, based on six pilot studies: 1) Nature pilot; 2) Forest ecosystems; 3) Freshwater ecosystems; 4) Agro-ecosystems; 5) Marine ecosystems; 6) Natural Capital Accounting.

Source: European Commission (2013)

The momentum on natural capital accounting is also growing at the corporate level, as highlighted by the innovative Environmental Profit & Loss (EP&L) accounts published by the company PUMA, the Natural Capital Declaration of the financial sector, recent endeavours by the World Business Council for Sustainable Development (WBCSD) in ecosystem valuation, as well as the launch of the TEEB for Business Coalition.

The importance of water and the role of nature in its provision are not always fully accounted for in policy making, investment decisions and consumption choices. A poor information base risks leading to unsustainable decisions and the erosion of natural capital, with knock-on implications on wellbeing, welfare and the economy.

This problem is exacerbated as we live in a world of increased water challenges. In certain regions there is increased water scarcity, whereas in others there are water surpluses, and both have an impact on water quality (e.g. regarding dilution of pollutants). Moreover, water quality is low in the water bodies of many countries. Water challenges are expected to increase in the coming years due to increased population levels and resulting urbanisation processes, economic growth and climate change, and for this reason it is urgent to improve our evidence base and governance.

Measuring the effects of water quality on nature, ecosystem functions and their ability to provide ecosystem services and taking account of nature's role in the provision of clean water are key research challenges. There is a wide and growing evidence base on the multiple values of nature and the contribution to society and the economy[iii], but many gaps remain and integration of this evidence base in policies and decision making is still far from adequate.

In this context, there is a need to complement the existing System of National Accounts (SNA), with environmental-economic accounts, which provide a framework for organizing information on water flows, water stocks and water quality, as well as the interactions between water, ecosystems and the economy.

Accounting for water quality can include the following:

- Water quality accounts per se;
- Emissions to water, which represent a pressure on water quality;
- Ecosystem accounts, which can shed light on the interaction between ecosystems, ecosystem services and water quality.

This briefing note explores these three typologies of accounts.

[iii] For a discussion on the multiple values of water and wetlands see Russi et al., 2013, as well as Ghermandi et al., 2010; Barbier, 2011; Brander et al., 2012; de Groot et al., 2012; Troy and Wilson, 2006); Brander et al., 2006.

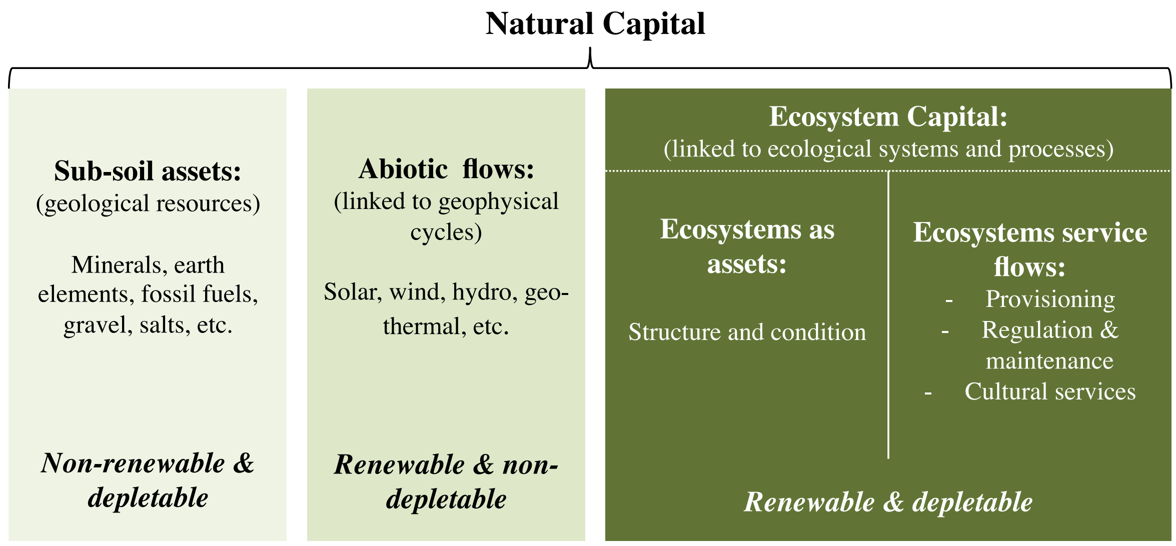
SEEA AND WATER ACCOUNTS

Environmental-economic accounts offer a systematic tool to measure, inter alia, the state of the natural capital and changes therein[iv] (see Box 3 for a definition of natural capital). Accounting allows raw data to be translated into policy-relevant information. They provide an important evidence base to decision makers, which can be useful to define priorities, design and evaluate policies, and discuss synergies and trade-offs between policy objectives and tools.

Box 3: Natural Capital

Natural capital is defined as the stock of natural assets that provide society with renewable and non-renewable resources and a flow of ecosystem services, the latter being the benefits that ecosystems provide to people. It includes abiotic assets (e.g. fossil fuels, minerals, metals) and biotic assets (ecosystems that provide a flow of ecosystem services). The biotic component of natural capital is defined as ecosystem capital (European Commission, 2013) (see Figure 1).

Figure 1: Conceptual representation of the components of natural capital



Source: MAES analytical framework, European Commission (2013)

Water accounts are a key component of natural capital accounts, and they can cover quantity and quality aspects. Water quantity accounts measure water stocks and water flows from the environment to the economy, within the economy and from the economy into the environment. Water quality accounts aim to measure the changes in some key properties that are related to water quality (e.g. the concentration of key pollutants).

The **System of Environmental-Economic Accounting** (SEEA) provides detailed methodological guidance on how to prepare environmental-economic accounts. The development of SEEA has undergone a wide

[iv] Environmental economic accounts include also kinds of accounts that do not measure the natural capital, i.e. environmental expenditure accounts.

consultation process led by the UN Committee of Experts on Environmental-Economic Accounting (UNCEEA), a body consisting of countries and international agencies under the auspices of the UN Statistical Commission. The revised SEEA includes three volumes.

- The SEEA **'Central Framework'** (SEEA-CF) was adopted as an international statistical standard for environmental-economic accounting by the United Nations Statistical Commission at its 43rd session in 2012. It has been prepared jointly by the United Nations, the European Commission, FAO, IMF, OECD and the World Bank. It provides an accounting framework that is consistent and can be integrated with the structure, classifications, definitions and accounting rules of the System of National Accounts (SNA), thereby enabling the analysis of the changes in the natural capital, its contribution to the economy and the impacts of economic activities on it. SEEA-CF focuses on the stock of natural resources and the flows that cross the interface between the economy and the environment. It includes:

a) Accounts of flows in physical terms for energy, water, material flows, air emissions, waste water and solid wastes. The accounts for material flows also include emissions to water;

b) Asset accounts[v] (which can be in physical and monetary terms) for mineral and energy resources, land, soil resources, timber resources, aquatic resources, other biological resources and water resources;

c) Environmental activity accounts and related flows for environmental protection expenditures, the environmental goods and services sector, environmental taxes and environmental subsidies. This third category of accounts is not part of natural capital accounts, as it does not measure environmental resources;

d) Combined physical and monetary accounts, providing the framework for the derivation of indicators such as resource efficiency and productivity, and linking the physical flows with the monetary flows.

- The SEEA **'Experimental Ecosystem Accounting'** (SEEA-EEA) has been published as a white cover publication in 2013. It aims to measure the ecosystem conditions (with a particular focus on carbon and biodiversity) and the flows of ecosystem services into economy and other human activities.

  SEEA-EEA offers a synthesis of the current knowledge of ecosystem accounting and serves as a platform for its development at national and sub-national level. It provides a common set of terms, concepts, accounting principles and classifications, and an integrated accounting structure for ecosystem services and characteristics of ecosystem condition, in both physical and monetary terms. It also includes a chapter on the main challenges and methodological options for the monetary valuation of ecosystems and ecosystem services.

- The SEEA **'Applications and Extensions'** is currently under development. It will provide compilers and users of SEEA-based environmental-economic accounts with examples showing how the collected information can be used in decision making, policy review and design, analysis and research.

In order to contribute to the process of developing ecosystem accounts, the European Environment Agency is developing simplified 'Ecosystem Capital Accounts' (ECA) at the European level. The methodological framework was published in 2011 (European Environment Agency, 2011) and the first practical application is to be published soon.

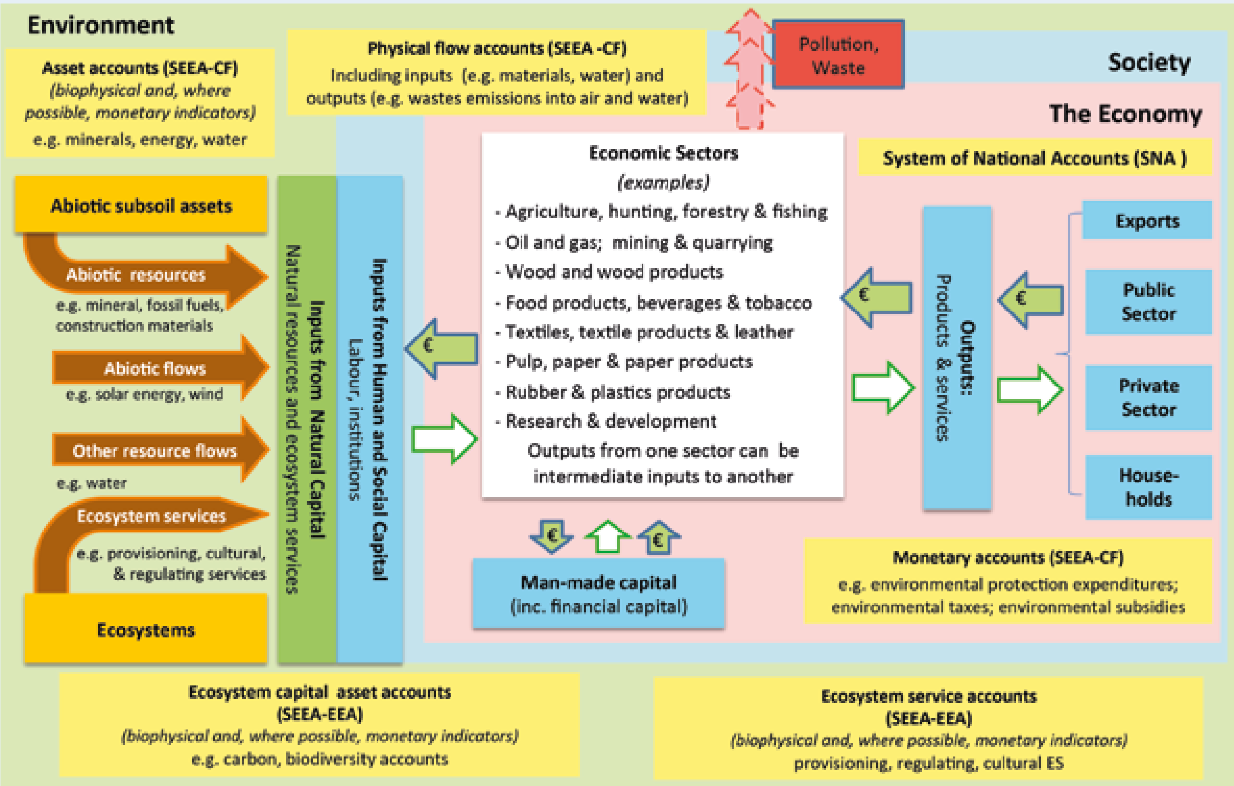
Figure 2 summarises where the different kinds of accounts included in SEEA can contribute to improve the measurement of the interactions between nature, society and the economy[vi]. The asset accounts measure the stock of natural capital - generally in biophysical terms, but they can be also complemented by

[v] Asset accounts measure the stock of natural resources.

[vi] The interactions between nature, society and the economy are complex. The economy benefits from inputs of what is sometimes termed man-made capital (e.g. factories and finance), social capital (labour, skills, knowledge) and natural capital (land, biodiversity, air, water and associated flows of ecosystem services). Economic activities produce a series of outputs to respond to demand (intermediate demand by different sectors of the economy and final demand by households, the private sector, public sector and markets abroad). In doing so, the economic activities (and private use that fall outside the formal economy) make demands on nature (resource abstraction and use; as well as land-use change) and put pressure on nature (pollution to water, air, soil; production of waste). The inputs from nature come from biotic assets (i.e. biodiversity), abiotic assets (i.e. materials), and abiotic flows (i.e. sunshine). The flow of clean water results from interactions between biodiversity and the 'non-living' elements of nature.

monetary information, if appropriate and where methodologies and data allow. The flow accounts show the flows of natural resources from the environment to the economy (i.e. inputs) as well as from the economy to nature (i.e. waste, water pollution and air pollution). Monetary accounts can be self-standing ones (e.g. environmental protection expenditure accounts) or elements within other accounts (e.g. value of assets or flows). Environmental-economic accounts also include ecosystem accounts, which collect information on the stock and the state of ecosystems and the flows of ecosystem services.

Figure 2: Environmental-economic accounts and the natural capital



Source: own representation[vii]

SEEA-Water, a subsystem of SEEA, was adopted as an interim standard in 2007, awaiting the adoption of the SEEA-CF in 2012. It is expected to become a standard with some slight changes in the next future. It includes two parts:

- Part I provides a set of standard tables that countries are encouraged to compile, in order to prepare accounts that follow an internationally standardised methodology and are comparable across countries:

a) Physical supply and use tables (SUT) and emission accounts, which account for water flows from the environment to the economy, within the economy and from the economy to the environment;

b) Hybrid and economic accounts, which describe the economy of water, and collect information on the use and supply of water, the associated costs, income and investments. This type of accounting combines information provided by the physical SUTs with the monetary SUTs provided by the SNA;

c) Asset accounts (measured mostly in physical terms), which measure water stocks at the

[vii] This figure was developed in the context of a framework contract with the EEA, building on ten Brink et al. (2012).

beginning and at the end of the accounting period, thereby allowing changes therein to be measured.

- Part II includes:

a) A discussion on how to account for water quality;

b) A chapter on the main methodological challenges and choices regarding economic valuation of water resources;

c) Some examples.

Part II is not part of the standard. It does not provide recommendations on how to compile water quality accounts nor on how to perform a monetary valuation of water resources. Rather, it offers a general discussion on the main methodological issues and some country examples. This is due to the fact that both water quality accounts and monetary valuation of water resources are still at an experimental stage.

Finally, the **Guidelines for the Compilation of Water Accounts and Statistics**, which are currently being coordinated by the UN Statistics Division, will elaborate on how the SEEA accounts can support water policies, besides providing practical guidance on how to compile accounts and strategies to institutionalize the accounts in order to increase the detail and quality of the data.

ACCOUNTING FOR WATER QUALITY

Water quality accounts

Water quality is a complex issue and can be defined in different ways, e.g. as chemical quality (concentration of pollutants) or in a more comprehensive manner. In this briefing note, we take a broad definition and consider water quality with regard to three categories of factors: physicochemical factors (e.g. level of nitrates and phosphorus, amount of dissolved oxygen, salinity, concentration of pollutants), hydromorphological factors (e.g. river continuity, water flow and substrate) and biological factors (e.g. number and species of fish, flora, algae). Many different indicators (or a combination of indicators) can be used to assess water quality, in one or more of the above-mentioned dimensions.

Water quality accounts can provide a valuable support to policy making because they can help set standards and objectives, check compliance and assess the efficacy of policy measures (although only indirectly). Water quality accounts, in fact, provide information on trends across time and allow for comparability across river basins. They can also be used in assessments of the impacts of pollution, including accidental pollution, and together with water quantity accounts, can support risk assessment procedures.

In addition, water quality accounts can measure the effects of environmental policies targeted at improving water quality, even though the relation between policies and water quality may not be straightforward and generally takes many years to take full effect. This is because water quality depends on many factors (e.g. levels of precipitation and abstraction, combined effects of pollutants, characteristics of the biota). Despite the indirect link between implemented policies and measured water quality, water quality accounts can give a measure of the effectiveness and cost-efficiency of the policies aiming at reducing pollution or improving the state of water bodies. For example, where an improvement in water quality is observed, while other key factors have not changed significantly (e.g. no changes in the level of precipitation or water abstraction), this provides a possible indication of the effectiveness of the environmental policy. In the same way, water quality accounts can provide valuable information to contribute to the assessment of the cost-efficiency of environmental expenditures.

If combined with information on economic activities, water quality accounts may also provide insights on the role of the different sectors in determining water quality. However, they cannot be directly linked to economic accounts. The reason for that is that in many cases human activities and natural phenomena interact in a complex way, making it impossible to establish a clear and linear relationship between the economy and water quality. For example, the change in the concentration of nitrates and phosphates in a water body can be associated with the use of fertilisers in nearby agricultural areas. However, this kind of analysis should be carried out with caution, as changes in water quality may depend not only on changes in the discharge of pollutants but also on natural processes (i.e. ecosystem functions, hydrological dynamics), change in dilution levels due to variations in levels of abstraction or precipitation and combined effects with other pollutants. It is important that such complexity is correctly understood, and that the information provided by water quality accounts is explained transparently and used correctly.

Despite recent efforts in providing guidance on water quality accounts through the SEEA process, there is still little standardisation on the choice of metrics to be used, the threshold levels to define quality classes and the measurement methodologies. Different countries tend to use different indicators, based on their specific problems and needs. In general, there is a trade-off between comparability across river basins and countries and level of detail of the analysis. In fact, if the objective of water quality accounts is to have standardised and widely used indicators, then only a low level of detail and focus on local, specific problems can be expected.

The choice of the methodology will depend on the objectives of the assessment and the available means. In general, water quality can be assessed on the basis of (actual or desired) water uses/ functions or against general standards. An example of assessment based on functions is the pilot water quality accounts developed by Statistics Netherlands (2011) (see Box 4).

Box 4: The experimental water quality accounts of the Netherlands

Statistics Netherlands has undertaken a feasibility study on water quality accounts, which entailed an analysis of possible data sources, the definition of a methodology and the compilation of pilot accounts, which used data from the 2009 report for the Water Framework Directive (WFD). The chosen approach consisted in determining the chemical and ecological status of the Dutch water bodies, which is assessed with the 'one out, all out' rule, as required by the WFD. The data sources are the Aquatic Base Map, developed by Wageningen University and PBL, and the WFD Portal (http://krwportaal.nl/portaal).

Water bodies are classified according to functions assigned by managers. Since 2009, Dutch provinces are no longer required to report water functions as before. Therefore, in the pilot quality accounts, functions are approximated based on the type of protection granted to the different area type: 1) bathing water; 2) drinking water; 3) shellfish water; 4) Birds Directive; 5) Habitats Directive. The protected area type 'bathing water' can be considered a proxy for the function 'recreation', the 'Natura 2000' (i.e. Birds and Habitats Directives) and 'Shellfish water' areas as proxies for the function 'nature' and the protected areas for 'drinking water' as a proxy for the function of drinking water. The categories of functions are not mutually exclusive, as a body of water can belong to one or more categories. Functions do not necessarily coincide with uses (e.g. people can swim in water bodies without an official protected area status).

Results of the feasibility study show that most of Dutch water bodies were in a bad chemical status and in a moderate or inadequate ecological status in 2009, as Figure 3 and Figure 4 show.

Figure 3: Chemical status of protected area types in the Netherlands (km²)

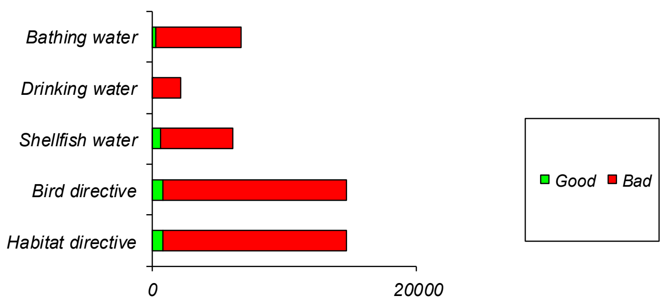
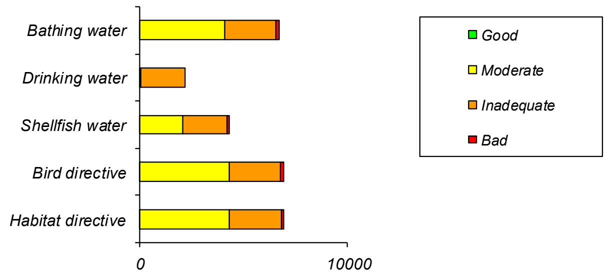


Figure 4: Ecological status of protected areas types in the Netherlands (km²)



Source: Statistics Netherlands, 2011

Alternatively, water quality can be assessed in general, without a clear link to uses. An example of this approach is provided by the European Water Framework Directive (WFD), whose assessment of water quality is based on the deviation from the reference state of each kind of water body (see Box 5).

Box 5: Water quality in the European Water Framework Directive

The WFD defines surface water quality as 'ecological status', and it requires all Member States to reach a 'good ecological status' in all their surface waters (rivers, lakes, transitional waters, and coastal waters). Groundwaters are required to meet 'good status' and heavily modified water bodies are required to meet 'good ecological potential'.

The ecological status of each water body is assessed according to biological, physicochemical and hydromorphological factors. Each parameter included in the assessment is given a score between 0 and 1, where 1 represents the reference condition for the water body. The interval 0-1 is then divided in five subcategories, which represent a 'high', 'good', 'moderate', 'poor' and 'bad' ecological status. The parameters can be aggregated only if they are impacted by the same pressure, otherwise the worst assessment of all parameters is attached to the water body (rule 'one out, all out').

The WFD requires all Member States to develop River Basin Management Plans (RBMPs), which are reviewed every six years. The RBMPs include a gap analysis, which identifies any discrepancy between the status of each water body and the status required by the WFD. Also, the RBMPs contain a programme of measures that will be put in place to achieve the desired status for each water body.

The RBMPs and the related data are being collected in the Water Information System for Europe (WISE) database. WISE is an electronic data and information system on water resources, managed by the European Environment Agency, DG Environment, the EU Joint Research Centre and Eurostat (see http://www.eea.europa.eu/data-and-maps/data/wise_wfd and http://water.europa.eu).

The information contained in WISE is still incomplete, but it will represent a good basis for the development of water quality accounts in the European Member States. In fact, as more information is collected, WISE will provide data and indicators on the ecological status of all major water bodies in the EU, allowing for comparison and analysis.

Source: European Parliament and Council, 2000

The use of indicators to monitor water quality requires a choice on whether and how to aggregate different indicators. Aggregation requires establishing a normalisation and weighting procedure, which inevitably introduces a degree of subjectivity in the process.

The WFD, for example, avoids aggregation by requiring river basin authorities to attribute to each water body the lowest score of all the indicators used to measure the ecological and chemical status (known as the 'one out, all out' rule). This avoids the use of weights, which would require the determination of the relative importance of each indicator with respect to all others. However, this rule may penalise water bodies where one of the indicators cannot improve (e.g. due to hydromorphological conditions) but an effort has been made to improve other indicators.

Temporal and spatial scales are important issues when developing water quality accounts. As regards the spatial scale, standards against which to assess water quality can be set at the water body, river basin or national level. This choice will obviously depend on the objective of the standard, the kind of indicators used and the policy objectives. Developing standards at the national level can help achieve a minimum level of water quality in all national territory, and allows for comparability across river basins. Water quality accounting at the national level is important for setting standards, discussing priorities and allocating the available funding among the national river basins. It also provides an overview of the severity of the problems related to low water quality, which may be useful, for example, to negotiate the budget to be assigned to water quality improvement.

Setting standards and developing accounts at the water body or river basin level allows local characteristics, needs and problems to be considered. This can play an important role in supporting decision-making at the local and regional level, because pressures on water quality can vary across different water bodies and areas. Also, the same level of pollutants may have different impacts in different contexts, depending on synergies with other pollutants, the chemical characteristics, the hydromorphology of the water body and the species that populate it.

In general, a river-basin approach is considered the most appropriate for water policies, because it allows more detail on the specific characteristics and needs of each river basin. All water resources in a river basin are interlinked, and for this reason considering the whole river basin is helpful for an appropriate assessment and management.

Finally, water quality accounts require agreement on how to aggregate measurements taken in different locations, which may introduce a degree of variability if different rules are adopted by different countries.

As regards the temporal scale, accounting is generally carried out on a yearly basis. However, water quality can be characterised by considerable variations during a year, due to variations in water stocks and flows, which in turn have an impact on the concentration of pollutants. In order to overcome this problem, quarterly water accounts can be developed, but this results in higher costs. In general, the more detailed, complex and resource-intensive the measurement process is, the less frequent it is applied.

Additionally, while the changes in the stock of water in each accounting year depend on human activities (water uptake and discharges into water) and natural phenomena (e.g. precipitation levels) of that year, water quality can also be influenced by activities carried out in previous years. Because of this, multi-year average figures could be used for the opening and the closing stocks, which requires an agreement on what years are to be included.

Other alternative approaches can be used to measure some aspects of water quality, including exergy (see Box 6) and the concepts of 'exploitable water' and 'accessible water' (see Box 7).

Box 6: The exergy approach as a way to address some water quality aspects

The discipline 'Exergoecology' was developed by Valero (1998) as a way to use exergy indicators for natural resource accounting. The 'exergy cost' of a natural resource is defined as the minimum work required to produce such resource, starting from its constituent elements (e.g. carbon, hydrogen, etc.) in the most abundant forms in which they are available in the 'reference environment' (composed of the atmosphere, lithosphere and seawater), using 'best available technologies' (BATs). It is a concept derived from thermodynamics, which shows how the consumption of natural resources implies a 'degradation' of matter from more to less organized (or, in technical terms, more entropic) forms. For the same reason, the 'exergy cost' of a resource can be used to describe the thermodynamic value of natural capital.

In the context of water accounting, the reference environment is seawater, as it is the most common form in which water occurs in nature. Therefore, from a chemical point of view, the water contained in a given water body has a maximum specific (i.e. per unit of mass) exergy when it is in the form of pure rain water; its exergy then decreases as the water flows downstream and it is eventually at its minimum when it reaches the sea. The 'specific exergy cost' of pure (drinking) water is thus defined as the work (in physical terms) necessary to purify seawater back to the level of the original rain water (i.e. removing the dissolved salts). Besides the chemical exergy described above, the total exergy of water resources also includes other forms of exergy, such as: thermal exergy (due to differences in temperature), kinetic exergy (due to the speed of the water stream), and potential exergy (due to altitude).

Finally, it is noteworthy that a decrease in the specific (i.e. per unit of mass) exergy cost of freshwater as it flows downstream (because of its decreasing purity and altitude) is typically accompanied by a progressive increase in its flow. Therefore, the extensive (i.e. overall) exergy cost of a freshwater body (calculated as its specific exergy cost times its gross quantity in terms of mass) tends to peak mid-way along its course. Thus, by combining measures of specific and extensive exergy cost, both the intrinsic quality and overall quantity of the natural capital associated to a given water body can be captured.

Source: Valero et al, 2009; Martinez et al. (2010)

Box 7: Exploitable water and accessible water

Two concepts of importance for water quality are those of 'exploitable water' (as used by FAO) and 'accessible water' (as used by the EEA).

The 'exploitable water' concept focuses on that part of water resources that is available for use. This can take into account the physical ability to catch the water (e.g. abstraction, storage by dams) and the economic costs. Similarly, water quality can be taken into account in the definition, as water below certain quality standards may not be exploitable for all uses (e.g. grey water might not be suitable for agriculture; freshwaters that mix with saline waters in coastal aquifers or in karst regions may not be useable as drinking water).

'Accessible water' refers to the share of the total or available resource that can be used without damaging the ecosystems beyond a certain threshold (EEA, 2011). This definition can take into account the ecosystem conditions needed to maintain ecosystem functions or protect biodiversity.

Sources: http://www.fao.org/docrep/005/y4473e/y4473e06.htm and European Environment Agency (2011)

Water emission accounts

Water emission accounts can also provide some indication on water quality, even though they measure one type of pressure on water quality and not water quality per se. In fact, the concentration of pollutants in the water depends on a variety of issues, including the level of dilution (which in turn depends on water quantity and seasonality), synergies with other pollutants and biota, ecosystem functions and hydromorphology. Also, it should not be forgotten that pollution is only one of the factors influencing water quality, and that the latter includes not only the chemical dimension but also the biological and hydromorphological ones. For all these reasons, emission accounts may be seen as a first step towards water quality accounts.

SEEA Central Framework (SEEA-CF) and SEEA-Water include accounts of emissions into water (see Figure 2). As all accounts included in SEEA-CF and SEEA-Water Part I, water emissions accounts can be directly linked to SNA accounts, as they are presented in an input-output format. In this way, the contribution of the different economic sectors to water emissions can be analysed and the changes in the trends can be monitored.

Also, water emission accounts can be linked to SEEA-CF monetary accounts for environmental protection expenditures, in order to analyse the link between policies aiming at reducing pollution and their achievements. Many countries have water emission accounts, but the indicators and the methodologies used are very different.

At the European level, the European Pollutant Release and Transfer Register (E-PRTR)[viii] includes reports of the emissions of 67 different pollutants (or pollutant groups) to water, while WaterBase[ix] (the EEA's database on the quantity and quality of European water bodies) covers 56 pollutants. However, the level of information provided by the two databases varies enormously for the individual pollutants. In some cases, only one reported value may be given, while for others the data are extensive for a number of activities and of Member States. The EU Priority Substances Directive (2008/105/EC) requires Member States to establish an inventory of emissions, discharges and losses of the substances in Annex I – 33 substances in total. This includes maps, if available. It is expected, therefore, that far more detailed data will become available on the specific sources of these substances across all relevant categories of activity once EU Member States have implemented this requirement.

Ecosystem accounts

As mentioned before, ecosystem accounts include accounts of the state of ecosystems and the flows of ecosystem services. They are a subset of natural capital accounts (see Figure 2).

Ecosystem services were defined by the Millennium Ecosystem Assessment (2005) as "contributions that ecosystems make to human well-being". Accounting for ecosystem services can provide useful information on water quality. In fact, the provision of ecosystem services by water bodies can be reduced or hampered if water quality does not reach a certain level. The Common International Classification of Ecosystem Services (CICES) provides a classification for ecosystem services in the context of the SEEA revision process[x]. This includes provisioning ecosystem services (e.g. biomass, water and fibre), regulation and maintenance ecosystem services (e.g. pest and disease control, soil formation and composition, climate regulation) and cultural ecosystem services (physical, intellectual, spiritual interactions with ecosystems and land/seascapes).

A particularly important ecosystem service linked to water quality is that of water purification. Ecosystems in watersheds, in particular wetlands and forests, have been shown to play an important role in providing clean water. This allows significant cost savings as regards water pre-treatment and provision (Russi et al., 2013; TEEB, 2011; TEEB 2012). Understanding the functional relationships between ecosystems and their ability to provide clean water is of high policy importance, and ecosystem accounting can play a role in this sense.

As mentioned before, ecosystem accounts are still at an early stage, with experimentation taking place in different countries and regions. Two relevant examples are the Victorian Experimental Ecosystem Accounts in Australia (see Box 8) and the initiative on Measuring Ecosystem Goods and Services (MEGS) in Canada (see Box 9). At the EU level, the Simplified Ecosystem Capital Accounts are being developed (EEA, 2011) and the MAES process aims to provide guidance on mapping and assessing ecosystem services (Box 2). With time, ecosystem accounts will progressively provide a tool that integrates the relationship between land cover, land use and clean water provision to population centres. Also, they will provide information on connections between ecosystems and measured water quality, as well as on the importance of water quality to ecosystems. This will also be useful for local, regional and national management.

However, it is important to keep in mind that there is not necessarily a straightforward link between water quality and all types of ecosystem services. In some cases, the same ecosystem service can be provided by water bodies with very different levels of water quality, or wetlands with different ecological status. The recreation potential of a river or a lake may not change significantly for a small loss of water quality (but it can obviously change dramatically after a noticeable change in water quality). In other cases, there may be little or no linkage between water quality and ecosystem service provision. For example, the erosion control potential of a wetland forest is generally not very sensitive to water quality changes.

In addition, it should be kept in mind that the unsustainable use of one ecosystem service can lead to negative impacts on biodiversity, thus affecting the ecosystem's ability to improve water quality. For example, if a wetland faces pollution loading that is beyond its absorptive capacity and an ecological threshold is passed (as for example seen in the Baltic sea), biodiversity degradation worsens and the flow of ecosystem services is reduced or compromised.

[viii] http://prtr.ec.europa.eu
[ix] http://www.eea.europa.eu/data-and-maps/data/waterbase-emissions-3.
[x] http://cices.eu/

For all these reasons, ecosystem accounts can help provide some insight on the relationship between land-use, ecological condition and service flows, including water purification, but need to be complemented by other approaches.

Box 8: Victorian Experimental Ecosystem Accounts, Australia

Victorian Experimental Ecosystem Accounts have been developed by the state of Victoria, building on the methodological guidance of SEEA-EEA. They comprise:

- Ecosystem Asset Accounts, which provide a record of the stock of ecosystem assets at a given point in time. They measure the Victorian terrestrial extent and condition across major vegetation groups (e.g. forests, grasslands, woodlands, scrublands) for the years 1750 and 2005. These cover 24 native vegetation groups and 3 categories of land not classified as native vegetation. The latter are 1) sea and estuaries; 2) inland aquatic (freshwater, salt lakes and lagoons); 3) cleared, non-native vegetation and buildings; 4) unclassified area.
- Asset Flow Accounts, which record the changes in the stock of ecosystem assets between 1994 and 2004, showing both additions (e.g. growth in terrestrial extent, whether via managed revegetation or unmanaged regeneration) and reductions (e.g. extractions, normal loss of stock and catastrophic events).
- Physical Flow Accounts, which record the expected flows between ecosystem assets and the services that contribute to human benefits.
- Environmental Payment Accounts, which record the economic transactions that affect the stocks and flows of ecosystem assets, including the expenditures for improvement and maintenance of ecosystem assets. Of particular importance to water quality are payments on wastewater management, protection and remediation of soil, groundwater and surface water, and protection of biodiversity and landscapes.

Work is ongoing on these accounts and their developments.

Source: Eigenraam et al., 2013

Box 9: Canada's Measuring Ecosystems Goods and Services (MEGS)

Measuring Ecosystem Goods and Services (MEGS) is a Canadian inter-departmental project to develop the statistical infrastructure to support the valuation of ecosystem goods and services and create pilot ecosystem accounts. The MEGS builds on previous work of Statistics Canada, which has been developing ecosystem accounts for the past 15 years. Statistics Canada produces accounts on resources, such as water, subsoil assets and timber, as well as energy-related accounts. They have also developed land accounts. Most of the developed accounts are expressed in physical terms and only a few are both in physical and monetary terms. All of the above are linked to the economic national accounts. One of the objectives of MEGS is to create experimental accounts to measure extent and quality of ecosystems.

As regards natural capital accounting and water quality, a key initiative is the development of draft Wetland Asset Accounts, which include different biophysical and monetary values for services from different classes of wetlands. This includes, for example, water purification and waste treatment services. Areas of experimentation include assessment of the potential benefits of phosphorous mitigation by wetlands, and information on the population potentially receiving ecosystem services from wetlands.

Sources: Mazza et al., 2012 and Soulard et al., 2012

SUMMARY AND NEXT STEPS

Water quality accounts can support policy-making by collecting and systematising information on the state of water resources and their variations across years. They can help set standards and check compliance, and allow comparability across river basins and countries in order to prioritise restoration activities or water policies. They can be used to measure the impact of policies. However, the linkage of policy impacts to outcome measures may be indirect, as water quality is influenced by a variety of other factors, e.g. concentration of pollutants due to variations in precipitation or abstraction.

Water emission accounts can also provide insights on water quality, because the emission of pollutants is one of the key pressures on water quality. They are more widely used than proper water quality accounts, and the System of Environmental-Economic Accounting - Central Framework (SEEA-CF) provides methodological guidance and standards on how to develop them.

Ecosystem accounts can also offer valuable information on water quality. The link between ecosystems and ecosystem services is critically important for water quality. Management practices and changes in land use have an impact on the ecological quality of the ecosystems and their ability to provide ecosystem services like water purification and provision of drinking water. The SEEA - Experimental Ecosystem Accounting offers a synthesis of the current knowledge in ecosystem accounting and serves as a platform for its testing and experimentation at national and sub-national levels.

The various types of accounts – ecosystem, water quality and emissions accounts – all provide information that, in principle, can be linked. Furthermore, they can also be linked to water quantity accounts which, in turn, can be linked back to the activity of economic sectors, as measured by the System of National Accounts. The potential added value of these links will benefit from experimentation, data collection and method development.

Several methodological challenges and data gaps remain, for example on which indicators and measurements to use, on whether to base the assessments on uses or functions and on the temporal and spatial scale at which the accounts should be built (see Box 10).

Ongoing national and international experimentation will help clarify which kind of information natural capital accounting and water quality accounting can provide and how they can support the different decision-making processes. Experimentation and dialogue between those developing the accounts and those seeking to make use of them will be essential in the coming years to improve the quality and policy use of natural capital and water quality accounts.

Box 10: Challenges for the development of natural capital and water quality accounting

A range of important challenges remain in the development and application of natural capital and water quality accounting, including:

- **Scale.** Accounting approaches require moving from local relevance and specificity (e.g. at river basin level) to national meaning and relevance, which entails significant methodological challenges.

- **Data.** Accounts need the collection of appropriate and sufficient data, which requires reliance on both measured and modelled data.

- **Ground-truthing and relevance.** Accounts use a mixture of data and outcomes of modelling exercises. Therefore, data obtained through modelling should be compared, if feasible, with measurements taken in situ. Furthermore, higher level accounts (e.g. EU or country levels) may need to be complemented by regional and/or local data.

- **Coverage and representativeness.** Not all ecosystem services can be integrated into accounts, due to lack of data availability and methodological difficulties. For this reason, ecosystem service accounts are unlikely to fully represent all ecosystem services. It is important to be transparent as to what they cover, clear on how to interpret the results, and provide the wider context for any individual analysis.

- **Added value for decision making and resource intensity.** The added value of accounts for policy making needs to be checked against alternative approaches, such as indicator sets. The degree of added value will be country specific, depending on data availability, kinds of indicators and accounts.

- **Trade and indirect flows.** In principle, the environmental resources and the environmental impacts that are embedded in trade flows should be reflected in accounts. However, this represents an important methodological challenge for accounts and requires the collection of a high amount of data at the international level. At this stage, the ecosystem accounts do not aim to account for these variables.

- **Monetary valuation.** Monetary indicators can only represent a subset of the multiple values of nature, but under certain circumstances they can provide useful evidence on the importance of nature in human wellbeing. However, there are multiple methodological challenges related to monetary valuation in natural capital accounting, considering that many ecosystem services are not transacted and most of the valuation that is generally applied is not consistent with market valuation principles used in national accounts. For example, there is an on-going debate as to whether to use methodologies based on costs, which employ market prices to indirectly estimate the monetary value of ecosystem services[xi], or methodologies based on individual preferences[xii]. other relater issues are whether and how to aggregate results obtained with different methodologies and how to scale up results obtained through valuations at the local level. Also, lack of data and the high costs related to their collection and processing usually represent an obstacle for monetary valuation of natural capital. Furthermore, experts do not agree on the discount rate[xiii] to be used for the valuation of natural resources and of natural capital degradation[xiv].

[xi] Examples of assessment based on costs are estimates of the avoided economic damages from floods ensured by sustainable floodplain management or estimates of avoided water pre-treatment costs for municipal drinking water provision.

[xii] Estimates based on individual preferences are for example based on surveys that investigate people's willingness to pay for improved environmental conditions.

[xiii] A discount rate is used to translate future benefits and costs into present values. The question of the discount rate, which attributes more relevance to costs and benefits in the present than to the ones in the future, has caused an animated debate among researchers, and the choice of a discount rate is one of the most disputed subjects of economic theory (see TEEB 2010 and 2011).

[xiv] Monetary valuation is also mentioned in the debate on how to adjust GDP to integrate the value of the depreciation of natural capital into the System of National Accounts, similar to the way the depreciation of fixed capital stock (i.e. man-made capital) is included. This is, however, beyond the focus of natural capital and water quality accounts.

ACRONYMS

CBD: Convention on Biological Diversity

CICES: Common International Classification of Ecosystem Services

ECA: Ecosystem Capital Accounts

EEA: European Environment Agency

NBSAPs: National Biodiversity Strategy and Action Plans

RBMP: River Basin Management Plan

SEEA: System of Environmental-Economic Accounting

SEEA-CF: System of Environmental-Economic Accounting- Central Framework

SEEA-EEA: System of Environmental-Economic Accounting - Experimental Ecosystem Accounts

SEEA-Water: System of Environmental-Economic Accounting - Water

SNA: System of National Accounts

SUT: Supply and Use Tables

UNCEEA: United Nations Committee of Experts on Environmental-Economic Accounting

WAVES: Wealth Accounting and the Valuation of Ecosystem Services

WFD: Water Framework Directive

WISE: Water Information System for Europe

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The aims of this briefing note are (1) to outline existing guidance on natural capital and water quality accounting; (2) to identify on-going challenges facing the development of accounting; and (3) to encourage debate and commitment to help find answers to the challenges.

It builds on recommendations on natural capital accounting as noted in the TEEB for Water and Wetlands report (2013) as well as in The Economics of Ecosystems and Biodiversity in National and International Policy Making (2011).

The Economics of Ecosystems & Biodiversity