ECOSYSTEM NATURAL CAPITAL ACCOUNTS: A QUICK START PACKAGE
For implementing Aichi Biodiversity Target 2
on Integration of Biodiversity Values in National Accounting Systems
in the context of the SEEA Experimental Ecosystem Accounts

Jean-Louis Weber

Consultant to the Secretariat of the Convention on Biological Diversity
Former Special Adviser on Economic-Environmental Accounting to the European Environment Agency,
EEA Scientific Committee Member
Honorary Professor, University of Nottingham
jlweber45@gmail.com
Website: ECOSYSTEM CAPABILITY
http://www.ecosystemaccounting.net/
ENCA: a Quick Start Package

- Meet an urgency (by 2020...)
- Focus on core accounts in physical units and calculation of ecosystem capability and degradation or enhancement.
- Fast track implementation with existing data; learning by doing
- First test accounts:
  ➔ involvement of producers, data holders and stakeholder.
  ➔ policy relevance of results discussed with stakeholders.
  ➔ identification of data gaps and framing of an action plan for regular implementation
- In the last chapter, further steps are described: liability of economic sectors and ecological balance-sheet, restoration costs, valuation of services...
<table>
<thead>
<tr>
<th>Contents</th>
</tr>
</thead>
<tbody>
<tr>
<td>INTRODUCTION</td>
</tr>
<tr>
<td>1. A QUICK START PACKAGE FOR PUTTING THE SYSTEM OF ENVIRONMENTAL-ECONOMIC ACCOUNTING - ECOSYSTEM TO WORK</td>
</tr>
<tr>
<td>2. CHARACTERISTICS OF ECOSYSTEM NATURAL CAPITAL ACCOUNTS</td>
</tr>
<tr>
<td>3. THE DATA INFRASTRUCTURE</td>
</tr>
<tr>
<td>4. THE LAND COVER ACCOUNT</td>
</tr>
<tr>
<td>5. THE ECOSYSTEM CARBON ACCOUNT</td>
</tr>
<tr>
<td>6. THE ECOSYSTEM WATER ACCOUNT</td>
</tr>
<tr>
<td>7. THE ECOSYSTEM INFRASTRUCTURE FUNCTIONAL SERVICES ACCOUNT</td>
</tr>
<tr>
<td>8. THE ECOSYSTEM CAPITAL CAPABILITY ACCOUNT</td>
</tr>
<tr>
<td>9. THE ECOSYSTEM NATURAL CAPITAL ACCOUNTS QUICK START PACKAGE AND BEYOND</td>
</tr>
<tr>
<td>CONCLUSION</td>
</tr>
</tbody>
</table>
0. INTRODUCTION

"Because national accounts are based on financial transactions, they account for nothing in nature, to which we also owe anything in terms of payments but to which we owe everything in terms of balance." Bertrand de Jouvenel, A radicé, 1968

0.1 THE CONTEXT

0.01 This report aims to contribute to the process of testing the System of Economic and Environmental Accounts – Experimental Ecosystem Accounts (SEEA-EEA) endorsed by the UN Statistical Commission in 2013. The publication of SEEA-EEA was an important first step towards accounting for ecosystems, their services and resilience, which to a large extent depend on biodiversity. This volume intends to provide further practical guidance, motivated by the requirements of the Strategic Plan for Biodiversity 2011-2020 and its Aichi Targets, which aims at integrating biodiversity into mainstream policies by 2020.

0.02 Goal A of the Strategic Plan seeks to address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society, and Aichi Biodiversity Target 2, under this goal, reads as follows: "By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems." 3

0.03 These goals and targets reflect the Convention’s ecosystem approach, "a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way", recognizing that “humans, with their cultural diversity, are an integral component of many ecosystems”. 4

0.04 The revision of the System of Economic and Environmental Accounts (SEEA) 5, agreed in 2005 by the UN Statistical Commission, led to the creation of an international statistical standard for accounts for which sufficient experience exists. In 2006, the UN Statistical Commission decided to supplement the standard accounts, now called the SEEA Central Framework, with a second volume on Experimental Ecosystem Accounts.

0.05 The 2011 SEEA Central Framework represents an international statistical standard on a par with the System of National Accounts (SNA), which do not cover accounting for ecosystems. The Central Framework covers physical resource flows, natural assets and their depletion (physical and monetary), and expenditure on environmental protection and resource management. "Accounting for degradation and other measurement topics associated with ecosystems are not covered in the SEEA Central Framework. The relevant material is discussed in SEEA Experimental Ecosystem Accounts.” 6

---

4 These important CBD targets have been endorsed by the United Nations General Assembly’s Open-Working Group on Sustainable Development Goals at its sixth meeting, 19 July 2015. (p. 36).
International statistical context: SNA and SEEA volumes 1 & 2

The System of Environmental-Economic Accounts “Central Framework” (SEEA-CF) adopted by the UN Statistical Commission in 2012 as an international statistical standard on par with the System of National Accounts (SNA 2008). 12) has been supplemented in 2013 by a volume on “Experimental Ecosystem Accounting” (SEEA-EEA). While the SEEA-CF is recommended for implementation, the SEEA-EEA which is a conceptual framework is now tested in various projects for which additional methodologies need to be defined. The CBD TS77 ENCA-QSP is a contribution to the development of such tests.
0. INTRODUCTION

“Because national accounts are based on financial transactions, they account for nothing in nature, to which we also owe anything in terms of payments but to which we owe everything in terms of biodiversity.” Bernhard de Jongerd, A radic, 1968

0.1 THE CONTEXT

This report aims to contribute to the process of testing the System of Economic and Environmental Accounts – Experimental Ecosystem Accounts (SEEA-EA) endorsed by the UN Statistical Commission in 2013. The publication of SEEA-EA provides a first step towards accounting for ecosystems, their services and resilience, which to a large extent depend on biodiversity. This volume intends to provide further practical guidelines, motivated by the requirements of the Strategic Plan for Biodiversity 2011-2020 and its Aichi Targets, which aims at integrating biodiversity into mainstream policies by 2020.

0.02 Goal A of the Strategic Plan seeks to address the underlying causes of biodiversity loss by mainstreaming biodiversity across government and society, and Aichi Biodiversity Target 2, under this goal, reads as follows: “By 2020, at the latest, biodiversity values have been integrated into national and local development and poverty reduction strategies and planning processes and are being incorporated into national accounting, as appropriate, and reporting systems”.

0.03 These goals and targets reflect the Convention’s ecosystem approach, “a strategy for the integrated management of land, water and living resources that promotes conservation and sustainable use in an equitable way”, recognising that “humans, with their cultural diversity, are an integral component of many ecosystems”.

0.04 The revision of the System of Economic and Environmental Accounts (SEEA 2005), agreed in 2007 by the UN Statistical Commission, led to the creation of an international standard for accounts for which sufficient experience exists. In 2006, the UN Statistical Commission decided to supplement the standard accounts, now called the SEEA Central Framework, with a second volume on Experimental Ecosystem Accounts.

ENCA-QSP inherits from the SEEA & from other related accounting projects

Land accounts for Europe (2006)

Comptes du Patrimoine Naturel
[Natural Patrimony Accounts]
(France, 1986)


Experimental ENCA, Mauritius Case Study (2014)

An experimental framework for ecosystem capital accounting in Europe (2011)
DEFINING PRIORITIES

SETTING PRINCIPLES:
Meet the policy demand(s)
Be outcome-oriented
Use existing data
First produce accounts in physical units, then value services and restoration costs

CHOOSING AN OPERATIONAL ACCOUNTING FRAMEWORK:
Integrative
Interoperable with other data and statistics frameworks
Open to developments, extensions

THE CHOICE OF THE ECOSYSTEM NATURAL CAPITAL ACCOUNTS FRAMEWORK

HOW ENCA-QSP RELATES TO THE SEEA?

A RODMAP FOR IMPLEMENTATION
All ecosystems are addressed in ENCA

- Natural, semi-natural, managed, even urban ecosystems; the soil ecosystem is accounted as a sub-system of each surface ecosystem; the atmosphere is also an ecosystem...

- In the context of the QSP, priority is given to inland ecosystems and sea coastal ecosystems.

- Programmes on oceans and atmosphere can be started if sufficient involvement of the respective scientific communities can be found; linkages with IPCC are indispensable.
2. CHARACTERISTICS OF ECOSYSTEM NATURAL CAPITAL ACCOUNTS

2.1 AN INTEGRATED ACCOUNTING FRAMEWORK

2.1.1 Ecosystem capital degradation or improvement, (and their counterparts in terms of ecological debts or credits), are at the core of the ENCA accounting framework.

1.01 The central concept of ENCA is the measurement of the sustainable capacity of ecosystems to supply the services needed by mankind and to assess human accountability for ecosystem degradation by inappropriate or free-rider management, or for ecosystem conservation, restoration or enhancement. Degradation is the sum of depletion of the renewable resource and the loss of other potential services that may affect the owner of the ecosystem asset or the community as a whole. When degradation can be imputed to economic actors, it is a non-paid cost (an externality) that corresponds to a consumption of ecosystem capital. This ENCA approach goes one step further than SEEA-EEA that does not deal with aggregation issues.

1.02 The ENCA approach to degradation starts not from the loss of ecosystem services but from the capability of the ecosystem. Capability encompasses ecosystem productivity as well as health, in terms of robustness, organization, resilience, dependence on artificial inputs, and disease prevalence. For resources used by extraction, capability assessment requires recording the amount that is accessible in a sustainable way, not the stock itself or the total stock plus inflow. It takes into account that part of the resource is needed by the ecosystem for its own renewal and that only part is sustainably exploitable. The accessibility of resources that are not depletable is measured independently, in terms of the integrity and health of the systems which generate them. They are all the intangible services that depend on ecosystem function, integrity and biodiversity, the regulating and cultural services in the SEEA-EEA provisional SICES intermediate classification. In that way, risks of omission or double-counting are avoided.

1.03 Degradation is the decrease, for which human activities are responsible, of capabilities between two dates. This means that a distinction is made between deterioration resulting from natural disturbances and degradation from anthropogenic factors. Increases in ecosystem capability are recorded as enhancement when they result from human activities, natural improvements being recorded separately.

2.04 Breakdown of degradation and enhancement by SNA sectors and industries is carried out in later steps, after QSP. As long as degradation results from an unpaid economic cost (an externality) that is passed to others (current or future generations), it is a debt. In a symmetric way, investment in ecosystem restoration can partly be recorded as a reduction of debt (when considering degradation that has taken place in a recent period) or as a creation of credit, which can be taken into account in mitigation mechanisms. Recording of ecological credits and debts is an adjunct to SEEA-EEA. Currently, SEEA considers ecosystems as assets for which depletion or degradation is recorded as decrease in stock (or increase in the case of a positive change). ENCA follows this treatment only for the depletion of assets that corresponds to a loss for their owner. Ecosystem degradation is more than just a loss for asset owners since it results in a loss of potential services for others and for the community. It is therefore right to record it as a debt created by the unit responsible for the degradation, and a credit in the case of enhancement.

2.05 Since ecosystem degradation is a measure of physical consumption of ecosystem capital, it can be

---

Footnotes:
1. This is consistent with the recording of forest fires in IPCC guidelines (2013), as well as in the SEEA-EEA definition that states that ecosystem degradation “is the decline in an ecosystem asset over an accounting period due to economic or other human activity, is generally reflected in declines in ecosystem condition and/or declines in expected ecosystem service flows”.
2. Chapter 9 in a text on a discussion of how enhancement is recorded in the ecological balance sheet, either as a reduction in debt (in the case of restoration from previously recorded degradation) or as a new credit (in the case of a creation of capability by an acknowledged programme).
3. This treatment echoes the analysis by Graciela Chichilnisky of exceptions to ‘principally productive public goods’ in her article on North-South trade and the global environment (The American Economic Review, 1994).
Need of a common unit for accounting

• Without a common unit, accounts aggregation is not possible.

• Simple physical units don’t do the job...
• Climate change: CO$_2$-equivalents to measure contributions to global warming
• Green Growth: tons (-equivalent) to measure resource use efficiency

• Ecosystem/biodiversity: Ecosystem Capability Unit (ECU) to measure total ecosystem performance in delivering ecosystem services, now and in the future; stability, degradation or enhancement
• Ecological value (in ECU) vs. Economic value (in $)
Ecological Value

The 3 basic accounts

- **Biomass/Carbon**
  - Stocks, Supply & Use
  - Accessible Basic Resource (tons, joules)

- **Water**
  - Stocks, Supply & Use
  - Accessible Basic Resource (m³, joules)

- **Ecosystem Infrastructure Functional Services**
  - Stocks, Formation & Consumption
  - Accessible Basic Resource (weighted ha or km)

Calculation of ecosystem’s ecological value in ECU

- **Ecosystem Capital Capability**
  - Quantity of one resource (e.g. biocarbon)
  - \( \times \) ECU-unit value

Composite index of ecosystem capability (ECU-Unit Value)

- Sustainable use index
- Change in health index (incl. stability of carbon pools)
- Change in health index (incl. pollution)
- Change in health index (incl. biodiversity, diseases...)

Ecosystem Capital Calculation

Jean-Louis Weber – 22 Nov. 2013
Structure of Ecosystem Natural Capital Accounts

- Remediation costs & Adjustment of Final Demand for unpaid degradation
- Economic sectors accountability to ecosystem degradation (in ECU)
- Ecological sustainability of Gross Value Added induced by Ecosystem Services
- Ecosystem degradation embedded in imports and exports
- Ecological Balance Sheet / credits and debts in ECU
- Ecosystem capability (stability, enhancement or degradation)
- C carbon
- W water
- EIFS functional services
- Valuation of ecosystem services
- Social demand for ecosystem functional services
- Use of Natural Resource by sectors
- Mapping and assessing ecosystem services
- Land cover maps & accounts
- Geographical infrastructure (administrative limits, networks, relief...)
- Statistics & monitoring data infrastructure (incl. SNA & SEEA CF)
Structure of Ecosystem Natural Capital Accounts

- Remediation costs & Adjustment of Final Demand for unpaid degradation
- Economic sectors accountability to ecosystem degradation (in ECU)
- Ecological sustainability of Gross Value Added induced by Ecosystem Services
- Ecological Balance Sheet / credits and debts in ECU
- Ecosystem capability (stability, enhancement or degradation)
- Ecosystem degradation embedded in imports and exports

Valuation of ecosystem services
- Social demand for ecosystem functional services
- Use of Natural Resource by sectors
- Mapping and assessing ecosystem services

Core Ecosystem Natural Capital Accounts

- Land cover maps & accounts
- Geographical infrastructure (administrative limits, networks, relief...)
- Statistics & monitoring data infrastructure (incl. SNA & SEEA CF)
Main data flows to compile ecosystem capital accounts

Data input
- Socio-economic statistics by regions
- Monitoring data, rasters
- Monitoring data, samples
- Standard coefficients

Data assimilation (1 ha or 1 km² grid)
- Disaggregate & map
- Aggregate & map
- Extrapolate
- Multiply

Accounts integration, analysis and reporting
3. THE DATA INFRASTRUCTURE

3.01 The SEEA-ENCA Quick Start Package (QSP) aims at starting to implement ecosystem natural capital accounts without delay. The first step will be a double test: of the relevance of the accounts for stakeholders, and of their feasibility for the institution(s) in charge of their production.

3.02 The first test will allow assessment of whether the accounting model delivers the information required for current and future policies, and of whether it can be adopted by players such as ministries of economy and finance and of planning, agriculture, forestry and fisheries, and of course environmental agencies. This is essential for setting the priorities for a second phase of development, in particular regarding functional analysis, which will depend strongly on national circumstances.

3.03 The second test will be of feasibility. Experimental accounts can definitely be produced from existing data but their quality depends on the quantity and quality of the inputs. One high merit of an integrated national accounting framework with double and quadruple accounting is that it requires the cross-checking of data sets compiled by many organizations for many different purposes. When data gaps are not too important, the statistician proceeds to what is called arbitration between two more numbers. When gaps are more serious, an explicit adjustment item can be introduced to balance the table. In both cases, identification of gaps helps to check quality and improve future data collection.

3.04 The following chapters of this report address technical and data issues. They do not pretend to be definitive. Conditions, practices and skills vary from place to place and technological change accelerates obsolescence. Attention should therefore not be on the data as such, but on the capacity of the data to match the requirements of the accounts. Better data, meaning more accurate, quality-assessed and controlled data, will make better accounts, without losing sight of their relevance to the accounting framework.

3.05 It is important to note that the primary user of these guidelines is the person involved in the production of ENCA, who may not be a specialist in the data and their processing. Make a quick start is therefore in the hands of the accountant, who, ideally, will try to establish partnerships with specialists in the various domains involved. The technical guidelines of Chapters 3–7 aim at providing the accountants with a language for expressing their demands to the specialists. And ultimately, if some specialists default, the guidelines enable the accountants to make a start themselves, at least for a first try. In such a case, the initial results will need to be submitted to specialists for review and to help them understand the nature of the demand for data. Therefore, first choice as well as second-best choice (but easier to access) data will generally be required.

3.06 National versus international datasets. Ideally, SEEA-ENCA should be produced using national datasets, validated by national agencies and in use in the country. Access to such data may be a problem if it does not exist in the country or if they exist but are made available at restrictions and be disseminated on a commercial basis at prices beyond the budget of the experimental project. The first stage of putting in place an institutional partnership and governmental decisions may lead to solutions to these problems, albeit with some delays. Therefore, following the rationale of Quick Start implementation of experimental ecosystem accounts, access to data made freely available at the global level by many agencies should be considered. In recent years, such access has been facilitated by programmes such as GEO-GLOSS (Figure 3.01).
Spatial Integration of Environmental & Socio-Economic Data

Mapping

Socio-Economic Statistics

Sampling

Individual Sites Monitoring
4. THE LAND COVER ACCOUNT

4.1 LAND-COVER MAPS, STOCKS AND CHANGES

4.1.1 Specific role(s) of land-cover accounts in the ENCA framework

0.01 Land cover is an observable image of the many processes taking place on the land surface. It reflects land occupation by various natural, modified or artificial systems, and, to some extent, the way land is used by such systems. Land-cover cartographic and statistical information therefore plays a central role in the description and quantification of the interactions between the economy and nature by providing:

- Statistical units: observation of the bio-physical characteristics of land cover provides the basic variables which describe ecosystem composition and structure.
- Data integration: because land cover can be observed in many ways, including by satellite or airborne remote sensing, area sampling, and censuses and administrative data, it provides the foundation of more comprehensive descriptions combining land cover and land use, and land cover and biological data.
- Localisation: land-cover data are generally geo-referenced with high accuracy for use in geospatial systems together with other data. Land-cover data with lower spatial resolution are often used as a proxy or tool to model spatial distribution of less accurate data. An example is the reallocation of statistics to a regular grid, based on the assumed correlation between an observed phenomenon and a particular land-cover class (e.g., population and urban fabric, tree harvest and forested lands).
- Change monitoring: land-cover change is basic information about what has actually happened rather than about emerging issues, but it gives a fair and robust description of major processes such as urban development, extension of agriculture over marginal land, and changes in forest tree cover. The abundance of images provided by Earth observation satellites, and progress in open dissemination and access to image-processing tools, make land-cover change or flow (in the sense of "other flows") in the System of National Accounts (SNA 2008), which describe the "other change in volume" of non-financial assets one of the bases of ecosystem accounts.

0.02 If enough data and maps exist in various organizations in charge of culture, transport, agriculture, forestry, water management, and environment and in research centres, they can be used in a Quick Start of ecosystem natural capital accounting. Indicators are given of possible methods of combining such maps into a first land-cover map. This can usefully be done for defining the statistical units (SEUs) needed to start accounting, as explained in Chapter 2. However, it might be more difficult to monitor land-cover change in that way. Even though thematic maps are updated, the frequency of these updates, the dates and the methodologies used may vary from one domain to another, making a synthesis and the production of reliable land-cover accounts difficult.

0.03 More broadly, the heterogeneity of data poses the challenge of choosing a base or reference year for accounting. Since all ecosystem accounts are connected to some extent to land cover, the baseline land-cover map will play a very important role in structuring the whole information system.

0.04 When it is necessary to produce new land-cover maps of stocks and change for accounting, this will be an investment not only for accounting but also for the national geospatial system as a whole, requiring the involvement of the national mapping agency and other stakeholders. The discussion of land-cover mapping in this chapter will therefore go beyond the strict requirements of a Quick Start of ecosystem accounting and address the issue in a broader context.
Land cover accounts of stocks and **change**

The map background shows the relative importance of savannahs (pale green) and steppes (pale brown), calculated with smoothed land-cover values. In the perimeters of protected areas, overlaid colours indicate land-cover flows: red for urban development, bright green for withdrawal of farming and blue for creation of water bodies.

Sources: Adama; Jaffrain and Adama, op. cit.
Simplified classifications of land cover types and land cover flows, to be detailed according to national/local conditions

<table>
<thead>
<tr>
<th>Land cover types</th>
</tr>
</thead>
<tbody>
<tr>
<td>01 Urban and associated developed areas</td>
</tr>
<tr>
<td>02 Homogeneous herbaceous cropland</td>
</tr>
<tr>
<td>03 Agriculture plantations, permanent crops</td>
</tr>
<tr>
<td>04 Agriculture associations and mosaics</td>
</tr>
<tr>
<td>05 Pastures and natural grassland</td>
</tr>
<tr>
<td>06 Forest tree cover</td>
</tr>
<tr>
<td>07 Shrubland, bushland, heathland</td>
</tr>
<tr>
<td>08 Sparsely vegetated areas</td>
</tr>
<tr>
<td>09 Natural vegetation associations and mosaics</td>
</tr>
<tr>
<td>10 Barren land</td>
</tr>
<tr>
<td>11 Permanent snow and glaciers</td>
</tr>
<tr>
<td>12 Open wetlands</td>
</tr>
<tr>
<td>13 Inland water bodies</td>
</tr>
<tr>
<td>14 Coastal water bodies and inter-tidal areas</td>
</tr>
<tr>
<td>Sea (interface with land)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Land cover flows</th>
</tr>
</thead>
<tbody>
<tr>
<td>If1 Artificial development</td>
</tr>
<tr>
<td>If2 Agriculture extension</td>
</tr>
<tr>
<td>If3 Internal conversions, rotations</td>
</tr>
<tr>
<td>If4 Management and alteration of forested land</td>
</tr>
<tr>
<td>If5 Restoration and development of habitats</td>
</tr>
<tr>
<td>If6 Changes of land-cover due to natural and multiple causes</td>
</tr>
<tr>
<td>If7 Other land cover changes n.e.c. and reclassification</td>
</tr>
<tr>
<td>If0 No observed land-cover change</td>
</tr>
</tbody>
</table>

Land cover flows regroup elementary changes according to land use and natural processes.
5. Ecosystem Carbon Accounts

5.01 Carbon accounting, in the sense in which it is addressed in the ENCA-QSP, is not new in terms of general knowledge and data collection. The greenhouse gas emission inventories and the carbon budgets established by countries and companies for reporting under the UNFCCC Kyoto Protocol are accounts. Not all the information collected in following IPCC Guidelines is directly usable but a large part of it is a valuable input to ecosystem accounting. The IPCC principles take into account a variety of situations and propose an incremental approach. Regarding carbon, data availability therefore varies from one place to another. Since ENCA-QSP recommends using the best available data in countries, there is no one-fits-all solution. This variety of conditions is taken into account in this chapter.

5.02 An ecosystem carbon account records an ecosystem’s sustainable capacity to produce biomass, measured as biocarbon, and the way this is used by crops, harvest and tree removal, sterilized by artificial developments, and destroyed by soil erosion or forest fires. It also records the carbon that is assimilated by the atmosphere and occurs. The account records, in tonnes of carbon, the stocks available in soil, above and below ground vegetation, and in water (fish and vegetal species). The flow of gross primary production (GPP) of biomass by natural and cultivated vegetation, and its use by crops and timber harvests as well as by nature itself. The secondary production of animal biomass is added to the primary production.

5.03 In addition to inland ecosystems, the accounts cover seas – fisheries, sea grass and algae, plankton and net accumulation of calcium carbonate (CaCO₃), produced by corals and other calcifying organisms, and sea-regulating capacity. The atmosphere’s climate regulation ecosystem service is also considered here. For this, the capacity of the system to sequester carbon (in biomass) or to assimilate greenhouse gases (measure in carbon dioxide (CO₂) equivalents) is used. The agreed UNFCCC target of a maximum increase of temperature of 2 °C defines the limits of total carbon use without ecosystem degradation. However, the ENCA quick start package explicitly addresses only issues related to biocarbon (including emissions and sequestration), considering that the comprehensive greenhouse carbon compounds account is covered in IPCC reporting.

5.04 Formally, the biocarbon account is a development of SEEA and connects accordingly to the SNA. This consistency is imposed by the use of official statistics on agriculture, forestry and fisheries. It includes a link to the calculation of the total use of carbon of biological and fossil origin, which corresponds to a subset of the material flow accounts commonly used to support strategies such as resource efficiency (European Union) or green growth (OECD). At the same time, ecosystem biocarbon accounts seek the maximum consistency with IPCC reporting, in particular regarding the LULUCF sector and agriculture, forestry and other land use (AFOLU).

The ecosystem perspective is very specific compared to the economic management of natural resources and the objectives of mitigating greenhouse gas emissions to the atmosphere, but the consistency of ecosystem carbon accounts with national accounts and with the climate-change programme makes them tools easy to integrate into decision-making procedures.

5.05 Accounts are compiled using various data sources available within countries or at the international level. They include various kinds of monitoring data and statistics on the environment and natural resources, meteorology, and official statistics, particularly on agriculture, forestry and fisheries. Earth observation by satellite is an important data source used together with in-situ monitoring and statistics. National data compiled for international programmes such as IPCC-LULUCF/AFOLU, FAO SoilBase and Forest BFR2010 inventories and Fohland are convenient sources to start implementing ENCA-QSP, although their data need improvement.

I. Ecosystem Carbon Basic Balance

<table>
<thead>
<tr>
<th>Stocks</th>
<th>Stocks</th>
<th>Stocks</th>
<th>Stocks</th>
<th>Stocks</th>
<th>Stocks</th>
<th>Stocks</th>
<th>Stocks</th>
<th>Stocks</th>
<th>Stocks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary and secondary production of biocarbon withdrawal</td>
<td>Natural perturbations</td>
<td>Total inflow of biocarbon</td>
<td>Net ecosystem carbon balance</td>
<td>Natural perturbations</td>
<td>Total inflow of biocarbon</td>
<td>Net accessible resource surplus</td>
<td>Total inflow of biocarbon</td>
<td>Accessible stock carried over restrictions of use other accessibility corrections</td>
<td>Total use of biocarbon</td>
</tr>
</tbody>
</table>

---

1. Instead, the accounts established for the same convention relate to debts and credits established according to targets or commitments.
3. Agriculture, forestry and other land use (AFOLU) is a term from the 2006 IPCC Guidelines describing a category of activities that contribute to and/or generate greenhouse gas emissions. Used in national greenhouse gas inventories, the AFOLU category combines biologically distinct sectors – LULUCF and agriculture.
4. The Global Forest Resource Assessment (FRA) is carried out by FAO (with countries and other organizations) every five years.
I. Ecosystem Carbon Basic Balance
   - Stocks
   - Primary and secondary production of biocarbon
   - Withdrawals
   - Natural perturbations
   - Typical indicators:
     - Total inflow of biocarbon
     - Net Ecosystem Carbon Balance

II. Accessible Resource Surplus
   - Total inflow of biocarbon
   - Accessible stock carried over
   - Restrictions of use
   - Other accessibility corrections
   - Typical indicators:
     - Net Accessible Resource Surplus

III. Total Uses of Ecosystem Bio and Geo-Carbon
   - Total use of biocarbon
   - Imports/biocarbon commodities contents
   - Imports/embedded biocarbon
   - Direct use of fossil carbon
   - Fossil carbon embedded into commodities
   - Typical indicators:
     - Direct use of biocarbon
     - Biocarbon requirement
     - Total carbon requirement

IV. Table of Indexes of Intensity of Use and Ecosystem Health
   - Sustainable intensity of ecosystem carbon use
   - Composite ecosystem biocarbon health index
   - Typical indicators:
     - Biocarbon ecological internal unit value
6. THE ECOSYSTEM WATER ACCOUNT

6.1 ACCOUNTING FOR WATER

6.1.1 Background

Water accounts have been produced in France1 and in Spain2 since the early 1980s, using largely similar and complementary methodologies. Both accounts covered water quantity at the river-basin level and were aggregated nationally: the relationships between stocks and flows were described on the basis of systems analysis of the interaction between the water system itself, which includes natural assets and flows as well as in-stream uses, and a use system, defined restrictively in relation to water abstraction, transport and return. Both approaches considered both water quantity and quality. On the quality issue, while the French accounts attempted to use quality indicators to present flows, the Spanish accounts developed an approach based on thermodynamic measurements of water quality losses, integrating quantity and quality aspects into one number. Both programmes included accounts of water expenditure. The water accounting methodology has been used in Chile3 and Moldova4. Development of energy-based water accounts has continued in Spain at the University of Zaragoza in the context of an overall approach to environmental accounting based on the calculation of energy physical costs, with several regional applications developed; and preliminary tests carried out jointly with the European Environment Agency. 6.1.2 Water accounts have been implemented by the Australian Bureau of Statistics (ABS) since the early 1990s with a focus on the use of water by economic sectors. The ABS methodology follows the SEEA-AKS: it contributed to its development and in particular the WARR Water (see below). Water Account Australia (WAA) "presents information on the supply and use of water in the Australian economy in 2011-12 in both physical (i.e. volumetric) and monetary terms. The focus of Water Account Australia (WAA) is on the interactions between users within the economy and the environment. The economy extracts water for consumption and production activities. The infrastructure to mobilize, store, treat, distribute and return water back to the environment forms part of the economy". Water Account Australia (WAA) has been available since 1993 and has been updated annually since 2008.5

---

<table>
<thead>
<tr>
<th>Accounts</th>
<th>Main items</th>
<th>Typical indicators</th>
</tr>
</thead>
</table>
| I. Ecosystem Water Basic Balance             | Stocks  
Primary and secondary production of water  
Transfers between water bodies and basins  
Actual Evapotranspiration  
Abstraction of water, supply and use  
Returns to waste water and losses       | Total inflow of water  
Net Ecosystem Water Balance               |
| II. Accessible Resource Surplus              | Total renewable water resources  
Accessible stock carried over  
Restrictions of use  
Other accessibility corrections  | Net Accessible Water Resource Surplus                 |
| III. Total Uses of Water                     | Total use of ecosystem water: blues, grey & green water  
Imports/water commodities contents  
Imports/embedded water  | Total use of ecosystem water  
Direct use of water  
Total water requirement               |
| IV. Table of Indexes of Intensity of Use and Ecosystem Health | Sustainable intensity of ecosystem water use  
Composite ecosystem water health index  | Water internal ecological unit value                    |
7. THE ECOSYSTEM INFRASTRUCTURE FUNCTIONAL SERVICES ACCOUNT

7.01 Accounts of ecosystem infrastructure and related functional services measure the sustainable capability of ecosystems to produce services such as biomass or water which are not directly measurable as material resources. These intangible services correspond to regulating and cultural services in the provisional Common International Classification of Ecosystem Services (CICES).

7.1 ACCOUNTING FOR ECOSYSTEM INFRASTRUCTURE FUNCTIONAL SERVICES

7.1.1 Physical flows of functional services cannot be measured directly because they are intangible.

7.02 Ecosystems are multifunctional and potentially deliver a bundle of material and intangible services which are used in various proportions according to the natural or socio-economic contexts. Services may be delivered directly to final users, protection from floods by forests, for example, or indirectly through intermediate inputs to services such as agricultural products or timber from managed forests. Uses can be either exclusive or synergistic. Uses can take place in the same ecosystem accounting unit (EAU: SEAU, MCU or RSU) as their generation, or in a different zone. In the absence of complete modelling of these interactions, including input-output analysis and imports-exports between EAUs, attempts to describe ecosystem capital capability by summing of ecosystem services would result in overestimates and/or double counting.

7.03 The SEEA-EA system acknowledges the accounting issue in paragraphs 3.45, “If a choice is made to use an alternative boundary for the measurement of ecosystem services related to crops and other plants, then some adaptation of the CICES would be required. It is noted that if ecosystem services are measured using flows of harvested crops, then it is necessary to exclude flows relating to the growth of these plants such as pollination, abstraction of soil water, etc. Put differently, both pollination and harvested crops should not be combined in a measure of ‘final’ ecosystem services. This would represent a ‘double count’ in accounting terms.”

7.04 The EU-CA-QISP approach to ecosystem services follows the option given in SEEA-EA paragraphs 3.45 where harvested crops are all included. This is done in the biocarbon account, where crops are considered as a joint economy-ecosystem outcome. This approach is consistent with the common definition of ecosystem services in the Millennium Ecosystem Assessment. In The Economics of Ecosystems and Biodiversity (TEEB) or in the EU Mapping and Assessment of Ecosystems and their Services (MAES) accounting project. As a consequence, no sum total of ecosystem services is presented – which would be difficult to achieve anyway in physical terms.

1 SEEU: Socio-ecological ecosystems unit; MCU: Marine ecosystem unit; RSU: River system unit.

2 The TEEB project is steered by UNEP: http://www.teebweb.org (accessed 31 July 2018)

3 MAES refers to the COGI 6.4 version. Provisioning services include “All material and biosphere-dependent energy outputs from ecosystems; they are tangible things that can be exchanged or traded, as well as consumed or used directly by people in manufacturing”, Mapping and Assessment of Ecosystems and their Services (MAES), an analytical framework for ecosystem assessments under Action 3 of the EU Biodiversity Strategy to 2020. Discussion paper – Final, April 2012 http://ecofinverses.com (accessed 14 July 2016)
<table>
<thead>
<tr>
<th>Accounts</th>
<th>Main items</th>
<th>Typical indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Basic Balances</td>
<td>Stocks of land cover (km²)</td>
<td>Net change/ land cover</td>
</tr>
<tr>
<td>1.1 Basic land cover account</td>
<td>Formation &amp; Consumption of land cover</td>
<td>Net change/ river systems</td>
</tr>
<tr>
<td>1.2 Basic river account</td>
<td>Stocks of rivers (SRMU)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Change in rivers stocks</td>
<td></td>
</tr>
<tr>
<td>II. Accessible ecosystem infrastructure potential</td>
<td>Stocks of Landscape Ecosystem Potential</td>
<td>Change in LEP</td>
</tr>
<tr>
<td></td>
<td>Stocks of River Ecosystem Potential</td>
<td>Change in REP</td>
</tr>
<tr>
<td></td>
<td>Total Ecosystem Infrastructure Potential</td>
<td>Change in TEIP</td>
</tr>
<tr>
<td>III. Overall access to ecosystem infrastructure potential</td>
<td>Population local access to TEIP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Agriculture local access to TEIP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nature conservation local access to TEIP</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Basin access to water regulating services</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Regional access to TEIP [tourism]</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Global nature conservation access to TEIP</td>
<td></td>
</tr>
<tr>
<td>IV. Table of Indexes of Intensity of Use and Ecosystem Health</td>
<td>Ecosystem infrastructure intensity of use index</td>
<td>Annual change in ecosystem infrastructure services ecological internal unit value</td>
</tr>
<tr>
<td></td>
<td>Composite ecosystem infrastructure health index</td>
<td></td>
</tr>
</tbody>
</table>
8. THE ECOSYSTEM CAPITAL CAPABILITY ACCOUNT

8.01 The ecosystem capital capability account aims at producing an aggregate summarizing the various charges recorded in the accounts of ecosystem carbon, ecosystem water and ecosystem ecological integrity and functional services. This aggregate measures the capacity of the ecosystems to deliver multiple services in a sustainable way. The aggregate has to reflect the real availability of each resource for use, and possible depletion or degradation, but accounting for such individual natural asset separately does not provide a full picture since they are part of systems ecosystems. Natural assets interact with each other and what happens to one is generally of consequence to all. They also interact with human communities.

8.02 Regarding the services potentially supplied by the ecosystems, some can be appropriated, traded, and analysed using conventional market-based economic tools. Others are common or public goods which are more difficult to assess in this framework because of different value systems or because of consideration of long-term perspectives which are not all properly addressed by economic calculations. In other words, ecological values should be distinguished from economic values. This distinction is clearly made in The Economics of Ecosystems and Biodiversity (TEEB) whose glossary of terms states:

- ecological value: non-monetary assessment of ecosystem integrity, health, or resilience, all of which are important indicators to determine critical thresholds and minimum requirements for ecosystem service provision;
- economic evaluation: the process of expressing a value for a particular good or service in a certain context (e.g. of decision-making) in monetary terms.

8.03 Nature conservation can bring short-term economic benefits, which are often neglected, but that is not the only motivation for conserving ecosystems. Other important motivations, which relate more to ecological values, include minimizing future risks to economies or humans, and the need to adapt to uncertain consequences of climate change and to secure food in the long term for an overpopulated planet. In the last resort, decisions have to be taken which will involve trade-offs between multiple options, opportunities, benefits and beneficiaries. Such decisions – at national as well as local, business or citizen levels – require comparisons between values and costs. To some extent, but not always, decision processes rely on data and, in that case, what is not measured risks not being taken into account.

A first attempt to calculate Ecosystem Capital Capability (in ECU) for Mauritius

Ecosystem Capital Capability:
ECU value by Socio-Ecological Landscape Units, 2010

Ecosystem Capital Capability (inland):
Change in ECU value, % by Socio-Ecological Landscape Units, 2000-2010

Provisional results

Experimental ENCA, Mauritius Case Study (IOC, 2014)
THE BALANCE SHEET OF ECOLOGICAL CREDITS AND DEBTS

CALCULATION OF RESTORATION COSTS AND POSSIBLE ADJUSTMENTS IN RELATION TO THE SNA

ASSESSMENT AND VALUATION OF ECOSYSTEM SERVICES AND DERIVED ASSESSMENTS OF WEALTH:

Mapping and assessment of ecosystems services in Europe (MAES)

Guidelines for valuing ecosystem services by:
UNEP (Green Economy/ TEEB/ DEPI – Ecosystem Services Economics)
The World Bank / under WAVES
SCBD TS 4, 27, 71
<table>
<thead>
<tr>
<th></th>
<th>Domestic physical assets [a]</th>
<th>Ecological credits [b]</th>
<th>Ecological debts [c]</th>
<th>Net Ecological Worth = [b]-[c]</th>
</tr>
</thead>
<tbody>
<tr>
<td>I - Short term assets and liabilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening balance sheet/ short term</td>
<td>100</td>
<td>100</td>
<td>12</td>
<td>-12</td>
</tr>
<tr>
<td>Degradation by activities</td>
<td>-12</td>
<td></td>
<td>12</td>
<td>-12</td>
</tr>
<tr>
<td>Natural losses</td>
<td>-9</td>
<td></td>
<td>-9</td>
<td>-9</td>
</tr>
<tr>
<td>Restoration from previous degradation</td>
<td>2</td>
<td>-2</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Ecosystem creation/ enhancement</td>
<td>7</td>
<td>7</td>
<td>7</td>
<td>4</td>
</tr>
<tr>
<td>Natural gains</td>
<td>4</td>
<td></td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Net change in short term assets and liabilities</td>
<td>-8</td>
<td>2</td>
<td>10</td>
<td>-8</td>
</tr>
<tr>
<td>Closing balance sheet/ short term</td>
<td>92</td>
<td>102</td>
<td>10</td>
<td>92</td>
</tr>
<tr>
<td>II - Long term assets and liabilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening balance sheet/ long term</td>
<td>63</td>
<td>85</td>
<td>-22</td>
<td></td>
</tr>
<tr>
<td>Ecosystem restoration commitments</td>
<td>50</td>
<td>50</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Accumulated ecological credits/ allocations</td>
<td>13</td>
<td></td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>Accumulated ecological debts</td>
<td></td>
<td></td>
<td>-35</td>
<td>-35</td>
</tr>
<tr>
<td>Change in ecosystem restoration commitments</td>
<td>0</td>
<td></td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Change in accumulated ecological credits/ allocations</td>
<td>8</td>
<td></td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>Change in accumulated ecological debts</td>
<td></td>
<td></td>
<td>11</td>
<td>-11</td>
</tr>
<tr>
<td>Net change in long term assets and liabilities</td>
<td>8</td>
<td>11</td>
<td>-3</td>
<td></td>
</tr>
<tr>
<td>Closing balance sheet/ long term</td>
<td>71</td>
<td>96</td>
<td>-25</td>
<td></td>
</tr>
<tr>
<td>III - International liabilities</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening balance sheet/ Embedded ecosystem degradation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acquisition of embedded ecosystem degradation</td>
<td>30</td>
<td></td>
<td>-30</td>
<td></td>
</tr>
<tr>
<td>Compensation of embedded ecosystem degradation</td>
<td></td>
<td></td>
<td>15</td>
<td>-15</td>
</tr>
<tr>
<td>Compensation of embedded ecosystem degradation</td>
<td>-5</td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Net change in ecosystem degradation embedded in trade</td>
<td></td>
<td></td>
<td>10</td>
<td>-10</td>
</tr>
<tr>
<td>Closing balance sheet/ Embedded ecosystem degradation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Consolidated balance sheet (I + II + III)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Opening balance sheet</td>
<td>100</td>
<td>163</td>
<td>115</td>
<td>48</td>
</tr>
<tr>
<td>Net change</td>
<td>-8</td>
<td>10</td>
<td>31</td>
<td>-21</td>
</tr>
<tr>
<td>Closing balance sheet</td>
<td>92</td>
<td>173</td>
<td>146</td>
<td>27</td>
</tr>
</tbody>
</table>
A roadmap and 5 steps:

1. **collection of reference geographical datasets and creation of a database of ecosystem accounting units (EAUs);**
2. **collection of basic datasets: monitoring data and statistics;**
3. **production of core accounts: measurement of total ecosystem capability, assessment of degradation or enhancement;**
4. **functional analysis of ecosystem capital and services in physical units;**
5. **functional analysis of ecosystem capital and services in monetary units: measurement of unpaid degradation costs; valuation of ecosystem services.**

Steps 1 to 3 correspond to the QSP. Steps 4 and 5 are additional developments.

Quick start with available data and progressive development.
Thank you for your attention!

여러분의 관심에 감사드립니다!

ENCA-QSP is downloadable from