European Commission

Ecosystem and ecosystem services accounts: time for applications. Book of Proceedings

Thematic Working Group 17: Ecosystem Services Accounting and Greening the economy

Ecosystem Service Partnership World Conference, 21-25 October 2019, Hannover, Germany

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2021

Joint Research Centre

EU Science Hub
https://ec.europa.eu/jrc

JRC123667

Ispra: European Commission, 2021

How to cite this report: La Notte Alessandra, Grammatikopoulou Ioanna, Grunewald Karsten, Barton David N., Ekinci Beyhan, *Ecosystem and ecosystem services accounts: time for applications. Book of Proceedings*, Publications Office of the European Union, Luxembourg, 2021, JRC123667.

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Foreword

In a 'full world' with finite space and resources, humankind is well-advised to take care for its natural capital and the multiple and highly valuable services that biodiversity and ecosystems provide to us. Hence, healthy, biodiverse and functional ecosystems concern all of us – everyone on Earth benefits from clean water, fresh air, food, nature-based recreation and many other goods and services that sustain our life and make it pleasant. Therefore we have to protect our natural capital and ecosystems; and in areas where management is needed, it has to be done carefully, sustainably and based on scientific evidence. Only science-based decision making will safeguard the long-term availability of natural resources that is mandatory to safeguard the quality of life for current and future generations within our planetary boundaries.

Ecosystem services are a concept that integrates aspects of nature appreciation, sustainability and transdisciplinary science-policy-society interactions and capacity building. Closely integrated in local (e.g. ecosystem-based urban planning), regional (e.g. ES-based watershed management), national (e.g. national ecosystem assessments), continental (e.g. the EU Biodiversity Strategies 2020 and 2030) and global (such as the 17 Sustainable Development Goals) initiatives, ecosystem services provide an operational approach and a highly valuable tool for systematic integrative assessments of the multiple ecological, social-cultural and economic values that nature offers. In this context, ecosystem accounting offers an excellent framework and methodological guidance to quantify these values, so that – optimally - nothing relevant remains unseen or uncounted. In the sense of *you can only manage what you can measure*, accounting for ecosystems and ecosystem services provides a sound base for the management of our environment, considering its multiple values (including intrinsic and less tangible values), value systems, various social-cultural contexts, traditions and trends.

The contributions in this impressive collection "Ecosystem and ecosystem services accounts: time for applications" excellently reflect the state-of-the-art of ecosystem and ecosystem services accounting and highlight at the same time the high diversity of respective implementations. This is well-reflected in the reports on the experience in ecosystem services accounts in the European Union and from individual countries all over the world, including Bulgaria, Canada, Czech Republic, Germany, Norway and Uganda as well the regional example from Andalusia in Spain. The different initiatives refer to the different types of ecosystem accounts such as extent, thematic and (selected) ecosystem services accounts that were mostly carried out on national scales or related to specific ecosystem types. It is inspiring to read about the manifold current and past activities, lessons learnt, their policy and decision making implications and highly ambitious future plans.

The obvious diversity of the used frameworks, accounting approaches and their implementation is inherent to the addressed key topic: highly complex dynamic adaptive human-environmental systems in constantly changing environments. This poses of course enormous challenges on scientific applications and ecosystem and ecosystem services accounting implementations. There is a legitimate reason to hope that the currently ongoing globally supported revision of the UN System of Environmental-Economic Accounting – Experimental Ecosystem Accounting (SEEA EEA) will provide the necessary conceptual and technical guidance to further promote ecosystem accounting all over the world, so that the notion of 'experimental' can probably be omitted soon. Still many exciting challenges related to the integration of accounts across various spatial and temporal scales, concerning data availability, necessary funding, implementation capacity, political, societal as well as scientific support and respective policy and decision making mandates are waiting for the ecosystem accounting community.

The Thematic Working Group 17 on "Ecosystem Services Accounting and Greening the economy" of the Ecosystem Services Partnership ESP is successfully unifying global efforts in a very sound, efficient and - last but not least – pleasant manner. The latter one may or may not have been one more reason for an overwhelmingly high number of interested people who attended the dedicated thematic session "Accounting for ecosystem services: time for applications" organised at the 10th ESP World Conference in Hannover in October 2019. The strongly application-oriented focus of the session and the resulting Proceedings fit excellently to the overall ESP 10th World Conference's theme "10 years advancing ecosystem services science, policy and practice for a sustainable future". One key outcome of this Conference was that ecosystem services science has certainly come of age and that it is now time for practical applications in sustainable policy, society and business decision making.

I want to congratulate Alessandra La Notte, Ioanna Grammatikopoulou, Karsten Grunewald, David Barton and Beyhan Ekinci and their team for their very successful organisation of the thematic session at the 10th ESP World Conference and the resulting book of proceedings. I wish all contributors and readers an inspiring reading and learning experience!

Hannover, December 2020

Benjamin Burkhard

Chair of the 10th ESP World Conference in Hannover 2019 and ESP Co-Chair

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Abstract

This report outlines the ecosystem accounting applications that have been presented in the Ecosystem Services World Conference in Hannover, Germany in 2019. Eight cases are summarized here; applications of ecosystem accounts in Europe, Canada, Czech Republic, Germany, Uganda, Bulgaria, Andalusia-Spain and Oslo-Norway. Most of these applications are in line with the System of Integrated Environmental and Economic Accounts (SEEA) framework and the outcomes are regarded as pilot attempts concluding in interesting messages that should be accounted for in next development steps. All cases discuss the compilation process of certain type of ecosystem asset or ecosystem services accounts either at regional, national or local level depicting the methodological process as well as the main outcomes. They also report the policy priorities that these accounts attempted to address and the policy implications that may follow given the accounts' results. Some of the strong highlights emerged from these cases are summarized as follows: countries should initiate the development of accounts using currently available data and then evolve this attempt based on pilot accounts. It is imperative that collaboration between institutes is ensured as ecosystem accounting is a complex process that demands strong joint forces between different experts as well as stakeholders. Demand for ecosystem accounts should be systematically developed if ecosystem accounting is to be institutionalized. Accounts need to demonstrate clear messages and be linked to certain policy needs even in this primary stage to foster policy support.

1 Introduction

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The theoretical guidance on ecosystem services is the System of integrated Environmental and Economic Accounts – Experimental Ecosystem Accounts (SEEA EEA) proposed and developed by the United Nations Statistical Division (UNSD) through a series of guidance documents (UN et al. 2014, UN 2017). Based on on-going applications and experiences around the world, a revision of SEEA EEA is currently taking place.

Applications and experiences are in fact the engine of development and enhancement for such a complex field, ecosystem accounting, that requires to combine the essence of ecological functioning with the rules of economic accounts. It is in fact on applications that we would like to focus to show the multifaced ways they can take place.

Applications could consider:

- Scales that ranges from global to local, although the SEEA EEA is in principle addressing national level – this report is framing all the contributions according to "supra national", "national" and "sub-national" applications.
- Macroeconomic and microeconomic perspective – most of the contribution reported here follow the macroeconomic perspective underpinning the System of National Accounts (SNA), but one case study (ref. Andalusia) works with enter the microeconomic perspective of farms.
- The role of science "versus" accounting – there is no real contrast between science and accounting in all the applications reported, but there is a "starting point": in some cases it is the research side that has to find its way throughout the accounting frameworks (e.g. Germany, Norway), in other cases it is the accounting side that looks for appropriate research content to fill its tables (e.g. Canada, Uganda).
- Thematic "versus" overall perspective – some applications are meant to provide comprehensive accounting tables without focusing on specific themes (e.g. Europe, Czechia), while some other applications focus on specific services (e.g. Bulgaria, Uganda).

These transversal features can be recognized in each of the applications described in the following chapters, and readers can identify additional features that characterize the different ways applications can take place that may be influenced by the institution that is leading the process (national statistical offices, research centres, environmental protection agencies), by the nature of projects (institutional partnership, *ad hoc/una tantum* funding, H2020 project, ordinary activity), by the expected outcomes and policy uses (ref. the Conclusion chapter). The one element that remains confirmed is that in ecosystem accounting the empirical application is crucial to confirm or force changes in recommendations and guidelines that theoretically may sound correct but that in practice can be not feasible or (in the worst case) misleading.

Finally, when dealing with ecosystem accounting, we should never forget that this remains a human-made framework meant to convey ecological information to conventional policy/economic understanding, like a sandcastle that we can shape (following the established aesthetic canons) until it gets perfect: the content is natural, but the shape is artificial.

References

UN, EC, FAO, OECD & World Bank (2014) System of Environmental-Economic Accounting 2012. Experimental Ecosystem Accounting, United Nations, New York, USA.

UN (2017) Technical Recommendations in support of the System of Environmental-Economic Accounting 2012 - Experimental Ecosystem Accounting.

Supra national accounts

2 Ecosystem services accounts in Europe

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2.1 Introduction

In Europe, the EU Biodiversity Strategy to 2020 acknowledges the importance to maintain and restore ecosystems and their services (EC, 2011). Specifically, Action 5 of Target 2 of the EU Biodiversity Strategy endorses the mapping and assessment of the state and economic value ecosystem services (ES) in the entire EU territory, as well as their integration in accounting and reporting systems across Europe. The Knowledge and Innovation Project on an Integrated system for Natural Capital and ES Accounting (KIP INCA) was set up in 2016 by several services of the European Commission (the Directorate-Generals of Environment and Research and Innovation, the Joint Research Centre and the EU's statistical office) and the European Environment Agency. The purpose of INCA is to design and implement an integrated accounting system for ecosystems and their services in the EU by testing and further developing the technical recommendations provided by the UN SEEA EEA (UN et al. 2014, UN 2017). KIP INCA builds in the first phase of the EU initiative on Mapping and Assessment of Ecosystems and Services (MAES), which aims to map and assess ecosystems and their services in the EU (Maes et al. 2012, Maes et al. 2013). The different modules of the UN SEEA EEA include accounts of ecosystem extent, ecosystem condition, ES , and thematic accounts. The Joint Research Centre (JRC) specifically considers ES accounts by developing supply and use of ES in physical and monetary terms, which helps integrate the results of ecosystem accounting with other economic indicators derived from SNA. In KIP INCA, the JRC has developed so far the experimental accounts of six ecosystem services at the EU level: crop provision, timber provision, carbon sequestration, crop pollination, flood control and nature-based recreation. The results for all these ecosystem services include maps of different components of ecosystem services, the supply and use tables and the analysis of changes over time.

2.2 The accounts

Until the end of 2019, the JRC has developed seven ES accounts, including two provisioning services, four regulating and maintenance services, and one cultural ecosystem service. All technical details concerning the biophysical assessment and monetary valuation of the services are reported in La Notte et al. (2017), Vallecillo et al. (2018) and Vallecillo et al. (2019).

ES accounts are provided for the years 2000, 2006 and 2012, matching the years in which CORINE land cover (CLC) maps were available at the beginning of the project (CLC 2018 was not available yet). For consistency with the ecosystem extent accounts carried out by the European Environment Agency, the accounting layers of CLC are used as reference data (ref. https://www.eea.europa.eu/data-and-maps/data/corine-land-cover-accounting-layers). When data were not available for a given year, interpolation took place to fill the gap, assuming a constant trend. The framework adopted in KIP INCA for ES accounts follows three main steps: biophysical assessment of the ecosystem service, translation in monetary terms, and compilation of the supply and use tables. This framework is consistent with the accounting structure of SNA and the UN SEEA EEA (UN et al. 2014, UN 2017).

About the biophysical assessment, two different approaches were adopted:

- the first approach is based on official statistics. Data (used as proxies) on the use of the ecosystem service are available. Example of data sources are Eurostat and FAO;
- the second approach requires spatially explicit biophysical models. No raw data exist to measure ecosystem service use. The development of spatially explicit models becomes thus essential for ES accounting. Moreover, the application of spatial models allows the calculation of different ES indicators such as ES potential, demand, use and unmet demand that are not available when making use of official statistics (Vallecillo et al. 2019b).

As defined in La Notte et al. (2019), the ES potential is the service that ecosystems can potentially provide depending on their extent and condition, the ecosystem service demand is the need for ES by socio-economic systems (i.e., economic sectors and households). To map ES potential is necessary but not sufficient to determine the actual flow, which is required for ES accounts. The role of the ES demand becomes a key concept for accounting since it helps establish the linkage to the economy. ES potential, the ES demand and their spatial relationship will determine the amount of actual flow mobilised from ecosystems to socio-economic systems.

About the monetary valuation, different approaches are applicable:

- a first approach uses available datasets, by adapting as appropriate the already available monetary values. Examples are the use of market prices, carbon rates and the employment of value transfer methods.
- a second approach requires to model the valuation step by using as key variables the outcomes of the biophysical assessment. The monetary value is created *ad hoc*.

Table 2.1 summarises how the different approaches were used for the seven ES accounts already available and are going to be applied for the additional accounts that will be completed by the end of 2020.

Table 2.1 Summary table reporting released and planned accounts for ecosystem services in INCA

Ecosystem services	Release year	Biophysical assessment	Valuation technique
PROVISIONING			
Crop provision	2018	Based on official stastistics	Adapted market price
Timber provision	2018	Based on official stastistics	Adapted market price
REGULATING AND MAINTENANCE			
Crop pollination	2017	Modelled	Adapted market price
In-situ soil retention	2020	Modelled	Replacement cost
Water purification	2019	Modelled	Replacement cost
Carbon sequestration	2018	Based on official statistics	Carbon rates
Species maintenance	2020	Modelled	Choice experiment
CULTURAL			
Nature-based recreation	2017	Modelled	Travel cost method

The results generated by the accounts are reported in Table 2.2 (Supply) and Table 2.3 (Use) in monetary terms.

The accounting of the seven ES assessed so far shows that the ecosystem “asset” woodland and forest as the ecosystem types providing the highest monetary value per unit area, followed by wetlands and sparsely vegetated land. On the other hand, the “asset” urban ecosystem shows the lowest value; however, this value is absolutely not negligible given that most of the extent of urban ecosystems are built-up land cover types (i.e., residential areas, industrial and commercial areas) with no ES provision. Therefore, the value obtained in the accounts is mainly due to the presence of green urban areas, which are the key suppliers of ES in this ‘ecosystem’ type. Table 2.2 also reports relative values per km^2 which may be useful to compare findings across case studies.

The use table shows households as the main users of ecosystem services, mainly due to the high value of nature-based recreation (Table 2.3). In this case households are the final consumers: no further processing, no transformation, and no trading take place. For all the other ES there might be intermediate consumption and further processing which may increase value added of orders of magnitude. The agricultural sector is the second most important user, mainly for crop provision and crop pollination. Differently from households, the agricultural sector can generate products for intermediate and final consumption to other economic sectors, both for domestic economy and international trade. The food industry is one of the key sectors determinant for the wealth of any country.

Table 2.2 Supply table for seven ecosystem services in Europe, in 2012

Year 2012, million EUR / Ecosystem service	Ecosystem type: Urban	Cropland	Grassland	Heathland and shrub	Woodland and forest	Sparsely vegetated land	Wetlands	Rivers and lakes	Coastal and intertidal areas	Total
Crop provision		20,790								20,790
Timber provision					14,740					14,740
Carbon sequestration					9,190			NA	NA	9,190
Flood control	90	1,020	3,130	360	11,390	0	330	NA	NA	16,320
Water purification	1,110	31,040	4,130	310	15,370	170	330	3,110		55,570
Crop pollination		3,330								3,330
Nature-based recreation	80	4,070	7,480	3,100	30,720	1,350	2,300	1,020	280	50,400
Total	170	29,210	10,610	3,460	66,040	1,350	2,630	1,020	280	170,340
Euro/km^2	6.030	37.480	29,070	20,850	51,200	25,920	30,260	37,900	14,530	

NA: not assessed

Values rounded to the nearest ten

Table 2.3 Use table for seven ecosystem services in Europe, in 2012.

Year 2012, million EUR	Economic units						
	Primary sector						
Ecosystem service	Agriculture	Forestry	Industry	Services	Households	Global society	Total
Crop provision	20,790						20,790
Timber provision		14,740					14,740
Carbon sequestration						9,190	9,190
Flood control	800	0	2,400	1,380	11,730		16,310
Water purification	38,620			16,960			55,580
Crop pollination	3,330						3,330
Nature-based recreation					50,400		50,400
Total	63,540	14,740		82,870		9,190	170,340

Values rounded to the nearest tens

2.3 Policy uses

There are many ways ecosystem accounts can be used to support policy decisions: from the descriptive analysis (direct use and interpretation of the accounting outcome and derived information that do not require further processing) to the integration with economic modelling tools (that requires from moderate to intensive processing).

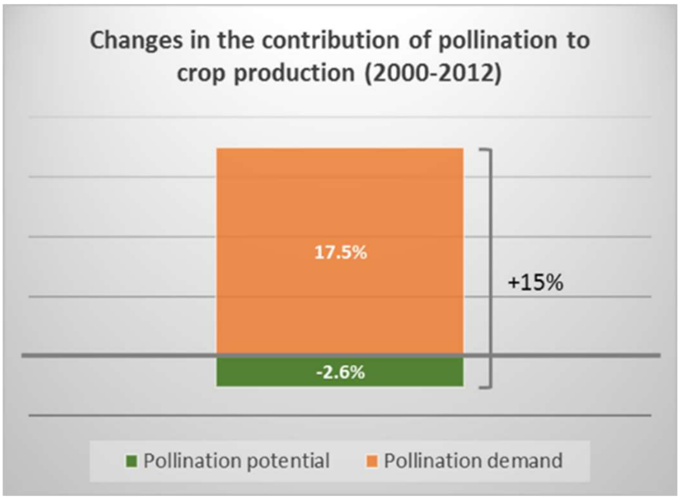
In terms of descriptive analysis, the outcome of ES accounts can already answer a variety of relevant questions, such as:

- What is the contribution of each ecosystem type to provide a service?
- What is the value of each service and by ecosystem?
- Who and how much is primarily benefiting from them?
- How did it change over time?
- How can this contribution be enhanced?

The answer to the first two questions can be read on the last rows of the supply table (Table 2.1) in both absolute and relative terms. The message to policy makers is very clear in terms of how valuable some ecosystem types could be (such as for example woodland and forest which account for almost 56% of total flows[1]) by providing many service flows, otherwise hidden in conventional economic accounts. The answer to the third question can be read on the last row of the use table (Table 2.2), that highlight how the agricultural sector remains one of the economic sectors that mostly benefit from ecosystem service flows. Although the flows allocated to households may seem much higher, we need to keep in mind that, while for the primary sectors the transaction from ecosystems is only the first step of a transformation process within the economic system (e.g. from agriculture to food industry and in turn to wholesale) that will lead to some other transactions (with increased value added at each step), in the case of households and global society we only have one transaction that will no go further in the economic system.

The answer to the fourth question can be illustrated by few INCA results. Figure 2.1 refers to crop pollination. The actual flow of this service from 2000 to 2012 increases by 15% which seems to be a positive change. However, if we consider what is the driver of change, a criticality emerges: there is more demand for pollinator-dependent crops (17,5%) but no increase in the availability of suitable habitat for pollinators. On the contrary, habitat suitability for pollinators decreases by 2,6%. This is a strong message for policy makers in charge of deciding whether and how to restore ecosystems.

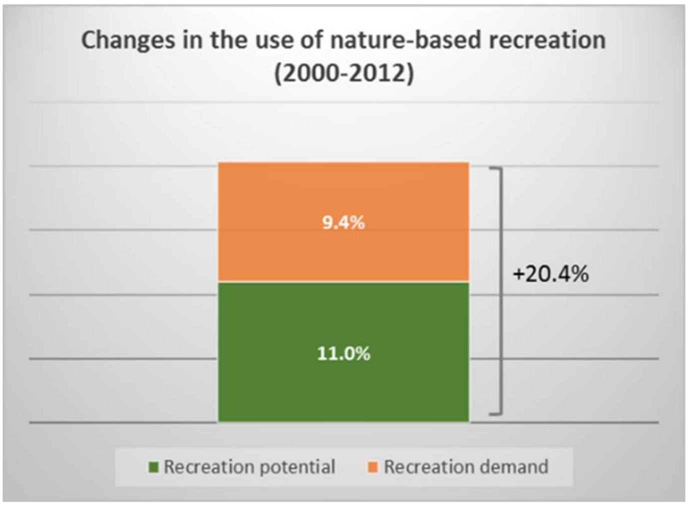
Figure 2.1 Changes in crop pollination actual flow from 2000 to 2012 in EU and UK



1 Please, keep in mind that here we report data in absolute terms; it implies that extent (size) plays a major role. Relative values may provide a different ranking among ecosystem types.

Another example is shown in Figure 2.2 on nature-based recreation. Once again to clearly identify ES potential and ES demand helps understanding the real drivers of the change. In fact, the overall change in the actual flow is 20,4%, but almost half of this change (9,4%) has been driven by the fact that new settlements have been built close to natural sites. At the end of the day only the 11% is due to an increase of natural sites (accessible for recreation).

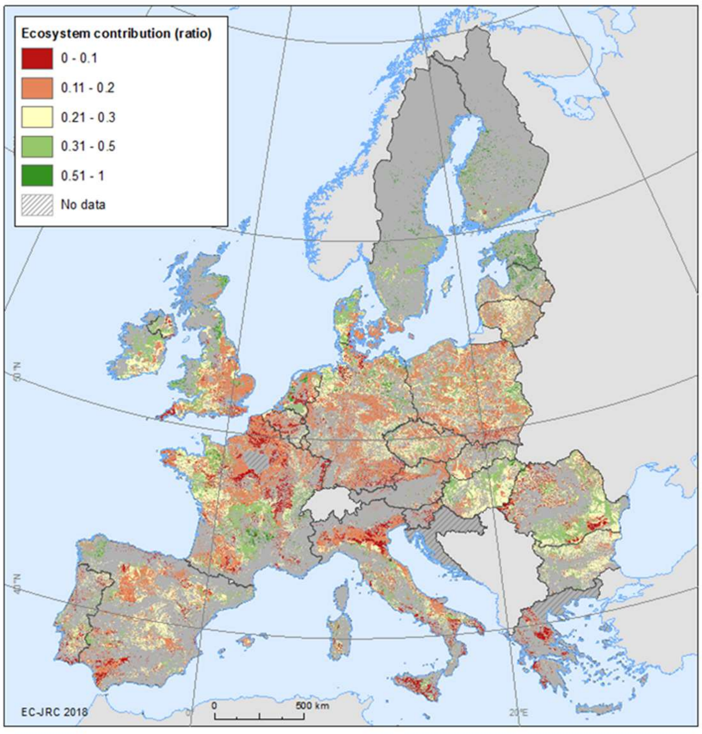
Figure 2.2 Changes in nature-based recreation actual flow from 2000 to 2012 in EU and UK



Again, the possibility to identify the ecological (ES potential) and human (ES demand) shares within the total service flow is a precious information for a strategic policy making in planning the territory.

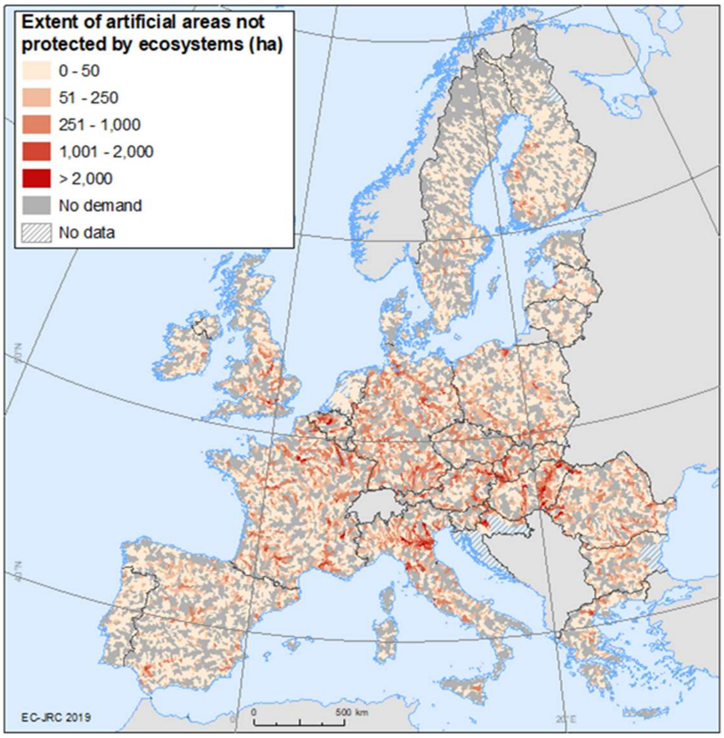
Crop provision (Figure 2.3) provides a good example on how to address the fifth question. Where the ecosystem contribution is very low (red areas in the map), it likely happens that intensive agricultural practices take place; this is a good indication to understand where (and for which crops) rural development programs meant to increase sustainable practices are needed.

Figure 2.3 Ecosystem contribution ratio applied to the crop provision actual flow in EU and UK, year 2006.



Another example on how to tackle the fifth question is provided by the flood control service. The ES potential may show a mismatch with the ES demand and this implies that a part of the demand remains uncovered (Figure 2.4). Policy makers responsible for the planning of the territory and for ecosystem restoration would know how to make use of this information that (i) quantify how much service coverage would be needed and (ii) where service coverage is missing.

Figure 2.4 Flood control unmet demand in EU and UK, year 2012.

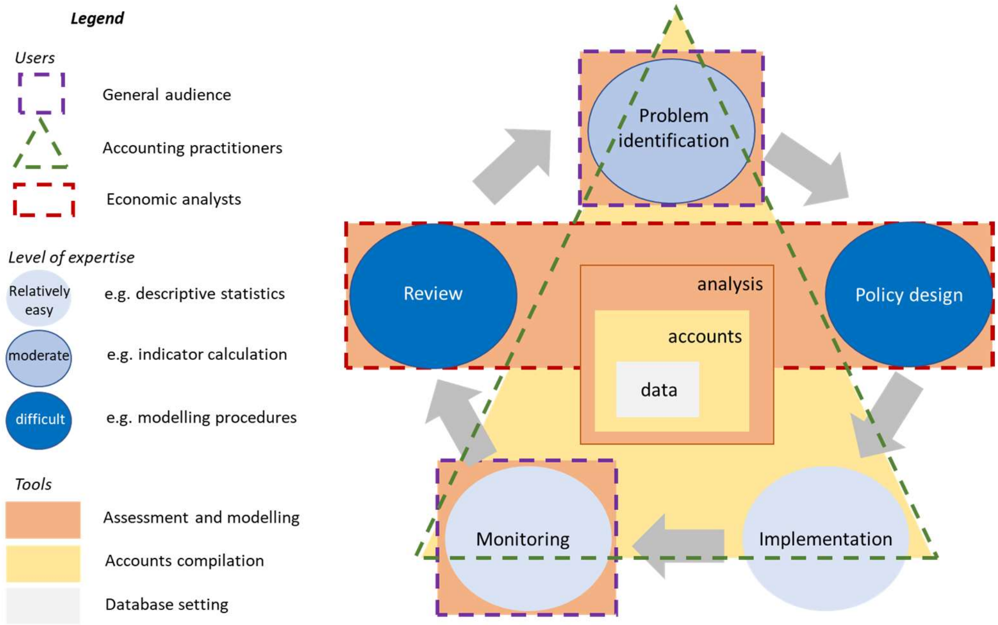


In terms of integration with economic modelling tools, the advantage of building accounts for ES lies in the consistency of rules and mechanisms with the System of National Accounts. ES accounts are intrinsically harmonized with economic accounts and can thus be easily bridged to those tools and models that are already part of economic analysis. Based on INCA, the LISBETH (LInking accounts for ES and Benefits to the Economy THrough bridging) project specifically looks at how to bridge with economics and finance. In its first attempt (La Notte et al., 2020), LISBETH presents three possible applications:

- the first application shows how to combine the ES account with the conventional accounts related to agricultural products and their trading, specifically through the joint SEEA AFF (by FAO) and INCA (by JRC) accounts. The main findings from combined presentations can be easily processed to raise and communicate relevant policy issues;
- the second application shows how ES accounts can be used in combination with input-output tables to build consumption-based accounts. The purpose is to supplement production-based accounts that show the flow from ecosystems to the SNA, with consumption-based accounts that address (at least a part of) the real end-users;
- the third application shows how to link ES accounts to general equilibrium models to assess economic impacts generated by ES changes. Thanks to the rigorousness of the accounting framework, when the benefit of an ES is part of an SNA product, the linkage is straightforward.

All the details concerning these applications are available on the LISBETH report (La Notte et al., 2020), with the indication of when, along the policy cycle, it would be feasible to make use of these tools by whom and for which purpose (Figure 2.5).

Figure 2.5 Use of ES accounts through the policy cycle



The next foreseen development of LISBETH is to set the bases to integrate ES account and finance.

2.4 Lessons learned and conclusions

To make 'good' robust accounts, it is required time, data, modelling, expertise. In INCA experimental accounts have been developed for six ES for the years 2000, 2006 and 2012. **To develop tools in Geographic Information Systems to model ES indicators (potential, demand, use and unmet demand) would contribute to a more regular update and systematic modelling of ecosystem services**.

There are key data gaps for the ecosystem services. The understanding of data gaps can help **target future research and monitoring priorities to improve knowledge on ecosystem services**. In general terms, this assessment has shown that more representative time series of environmental data are needed to better assess changes over time. However, it is also important that time series available can ensure data consistency to make robust comparisons over time, which it is sometimes not so straightforward. ES assessment would also benefit from statistical data at a more detailed spatial resolution, ideally at 1 x 1 km. For example, the assessment of crop pollination clearly points out that further knowledge is needed in relation to the abundance and quality of different pollinators. Data at the EU level on different species of pollinators is scarce. There is also a need to improve the knowledge of the role of ecosystems sequestering CO_2, including also unmanaged ecosystems.

The analytical linkage between ecosystem condition and ES is still weak. Most ecosystem service models are mainly based on land cover data, with only a limited number of ecosystem condition indicators integrated. More work is needed on the integration between condition and accounts.

Given the experimental character of these accounts, values reported here are susceptible to be changed in the future before the method for the accounts can be consolidated. This work presents a sound methodology to be further discussed and readjusted to contribute to the experimental development of the SEEA EEA. **We have shown the application of two different approaches for ecosystem service accounts**. The fast-track approach can be mainly applied for those ES related to biomass production, where the ecosystem service flow is more easily measurable than the flows of energy or information. Data for these ES are more easily available on official statistics. The advantage of this fast-track approach is the immediate application and simplicity. The disadvantage lies in the lack of underlying information to understand the changes over time and the cause-effect relationship that should be contrasted with available literature or other complementary indicators. On the other hand, the approach based on the use of spatial models for ES accounts provides data about the key drivers of change in the service used. This facilitates a detailed assessment of the key drivers determining the actual flow: ES potential and demand. It also provides complementary information, such as maps of the unmet demand that show areas where ecosystem restoration may enhance the ecosystem contribution to human well-being. A drawback of this approach is that the development of spatial models requires skill and expertise, and these models are not easily usable or accessible for practitioners or policymakers. **A solution could be to develop tools in Geographic Information Systems, which can be used by practitioners to take advantage of the modelling techniques developed by experts**, and at the same time to use their own detailed database.

The KIP INCA project is allowing the implementation and development of the SEEA EEA guidelines (UN, 2017; UN et al., 2014b) suggested by the United Nations Statistical Division. SEEA EEA offers a good basis to experiment. As extensively explained in previous publications (Vallecillo et al. 2019b) the concrete application of ES flow accounts made it possible to reach conceptual advancements otherwise not achievable: (i) the need to disentangle ES contribution from SNA benefits, (ii) the definition of ES actual flow as the result of ES potential and ES demand, (iii) the importance of correctly building ecosystem types as assets.

The development of the experimental ecosystem service accounts under KIP INCA highlights the complexity of developing these accounts, both, conceptually and methodologically. In this context, there is a need to develop accounts for more ecosystem services, since each of them presents very different characteristics. Actually, ES accounts cannot be generalizable since the assessment of each ecosystem service is very different and the accounts need to be matched accordingly. ES accounts based on spatial models add another level of complexity. The development of tools to assess ecosystem services, but including also the whole accounting workflow would contribute to make ES accounts more accessible to practitioners.

Finally, a wide range of policy uses is possible: from the descriptive statistics to integrated modelling to serve a variety of users with different needs and skills.

Future releases under KIP INCA will present the accounts for water purification, in-situ soil retention and species maintenance. The addition of new ES to the accounting tables may result in important changes in the “asset” value and the relative importance of each ecosystem type. **Further efforts should be paid for to accounting of a comprehensive list of ES allowing a robust analysis of synergies and trade-off between them**.

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3 Statistics Canada's application of ecosystem accounts

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3.1 Introduction

Statistics Canada has been producing environment-economic accounts, including natural resource stock, material and energy flow, and environment protection expenditure accounts data since the mid-1990s (Statistics Canada, 2006). This work also includes accounting for ecosystems. Although the United Nations System of Environmental-Economic Accounting – Experimental Ecosystem Accounting (SEEA - EEA) has not yet been adopted as an official international standard, work on ecosystem accounting, including development of pilot data and analyses, as well as methodological development and international collaboration, has been ongoing since 2010.

3.1.1 Past and current work on ecosystem services

The results achieved during an initial two-year project to find and develop information on ecosystem goods and services (EGS) were published in Human Activity and the Environment: Measuring ecosystem goods and services in Canada (MEGS) (Statistics Canada, 2013). This report laid out concepts relevant to the development of ecosystem accounts, presented initial results on ecosystem assets and condition including changes in land cover, landscape modification, as well as ecosystem services (ES) including water purification potential, biomass extraction, marine and coastal goods and services and wetland services.

The value of ES were quantified in several different ways. Biomass extraction from Canada's terrestrial and aquatic ecosystems was reported in physical measures (tonnes) for agricultural crops, livestock and poultry, milk, maple and honey, forestry and freshwater and marine fisheries. For coastal and marine services, monetary values were reported for commercial fish landings on the Pacific and Atlantic Coasts and beneficiaries of these ecosystem services—the labour force employed in fishing industries—were mapped. Recreational anglers' direct expenditures on fishing trips were reported as an estimate of a cultural service (though a portion of these expenditures would be attributable to other aspects of the recreational fishing experience). In addition to reporting some examples and ranges of monetary values of ES provided by specific Canadian wetlands found in the academic literature, the relative importance and demand for wetland services was illustrated through the use of contextual characteristics such as population density, agricultural land use, livestock density, land modification, fertilizer application and manure production.

In addition, a case study for the Thousand Islands National Park, Canada's smallest national park, provided two approaches to estimate monetary values for ES generated by the park. The first approach applied monetary estimates of the aggregate value of ecosystem goods and service flows per hectare of land cover type. Tests using multiple land cover compilations resulted in estimates of the value of EGS (including atmospheric regulation, water quality, nutrient and waste regulation, water supply regulation, soil retention and erosion control, habitat and biodiversity, pollination and dispersal services, disturbance avoidance, recreation, aesthetic and amenity and other cultural services) ranging from $12.5 million to $14.7 million per annum, for 2012. The second approach transferred values for specific ecosystem services, resulting in estimates of $3.9 million associated with the park's recreation services and from $434,000 to $530,800 for the option, bequest and existence cultural service values associated with the park's wetland areas.

Since MEGS, work on various aspects of ecosystem accounts has largely been reported in subsequent issues of Human Activity and the Environment – on Agriculture (2014), metropolitan landscapes (2016), freshwater supply and demand (2017) and forestry (2018). These reports were structured in such a way as to identify ecosystem assets, related services, beneficiaries and impacts. While data was not presented in the form of supply and use tables, data on select services and beneficiaries were presented in text and in tables and charts where it was available. For example, the 2014 report included data on provisioning services from agriculture and aquaculture, carbon sequestration on farms, and select agri-tourism service values. Identified beneficiaries include society as a whole, farmers, people living close to farms and consumers. The 2016 report on metropolitan landscapes included data on access to nature. The 2017 report identifies freshwater use and users. The 2018 report includes provisioning services in the form of timber harvest and non-timber products, carbon sequestration from managed forests, and beneficiaries including contributions to employment, wages and communities.

More recently, funding has been dedicated to explore the development of ocean accounts, with work currently ongoing to identify the range of data available. Work has also occurred to produce some basic spatial data infrastructure for ecosystem accounting, bringing in various ecosystem asset and condition data sets, including data on land cover, climate and other data such as fragmentation and human modification. Improvements are being made to urban asset delineation by integrating optical and radar satellite earth observation data with socio-economic information.

Statistics Canada is also collaborating with other groups including involvement with McGill University-led ResNet: A network for monitoring, modeling and managing Canada's ES for sustainability and resilience.[2] International collaboration is occurring, through involvement with the SEEA EEA 2020 revision process. These efforts include working on issues such as spatial units and ecosystem types classification, and work on the United Nations' Big Data Platform that will enable sharing of algorithms and Earth Observation (EO) data to support the production of official statistics, including those related to ecosystems.

3.2 The accounts - Future plans and challenges

Statistics Canada plans to improve reporting on ecosystem accounts through several avenues. Firstly, the next version of the Human Activity and the Environment report, planned for 2021, will focus on ecosystems and will include preliminary data and tables for ecosystem extents, selected characteristics, conditions and services. Activities to further develop these data and develop accounting tables are planned.

The following ES are targeted for potential inclusion or for future development and reporting: provisioning services (e.g., biomass of fisheries, timber, agricultural and aquaculture harvests); carbon sequestration (e.g., from managed forests, agricultural land, urban trees); and recreation services (e.g., access to and use of parks and green space such as national parks, urban parks) (Table 3.1, Annex). Data on other services would be added as it becomes available.

Table 3.1 ES targeted for potential future reporting in supply use tables.

Data availability						**Sector**					**Ecosystem type**						
Geography			**Unit of measure**														
Canada	**Province**	**Ecozone**	**Physical**	**Monetary**	**Ecosystem services supply**	**Total including exports**	Total, industries and households	Total, industry	Total, households	Exports	**Total area**	Built-up	Arable	Natural pasture	Forest	Other natural and semi-natural	Coastal and marine
					Provisioning services												
√	√		√		Timber production										√	√	
√	√		√	√	Peat extraction											√	
√	√		√	√	Agricultural biomass								√	√			
√	√		√	√	Aquaculture biomass												√
√	√		√	√	Commercial fisheries biomass											√	√
√	√	√	√		Water abstraction (excluding						√						

(2) https://www.nsercresnet.ca/index.html

		hydro)		
		Regulating services		
√ √	√	Carbon sequestration		√ √ √
		Temperature regulation (i.e. heat island mitigation)		?
		Air filtration		?
		Others		
		Cultural services		
		Recreation		
		Ecosystem services use		
		Provisioning services		
		Timber production	√ ?	
		Peat extraction?	√	
		Agricultural biomass	√	
		Aquaculture biomass	√	
		Commercial fisheries biomass	√	
		Water abstraction (excluding hydro)	√ ?	
		Regulating services		
		Carbon sequestration	√	
		Temperature regulation (i.e. heat island mitigation)	?	
		Air filtration	?	
		Others		
		Cultural services		
√ √	√	Recreation	√ √	

Note: Data availability indicates that sources of information are readily available (i.e. published data) to report on an aspect of the ecosystem service (including proxy values) for the geography and unit of measure indicated. Some data may be available at other levels of geography.

3.2.1 Reporting issues and limitations

Some challenges related to a full accounting of the above ES include the fact that recommendations are not yet fully developed for the SEEA EEA on how to account for these services. For provisioning services, tabulation of physical values is relatively straightforward (e.g., Table 3.2, Annex) since production data is available and the latest recommendations indicate it is reasonable to report full value of harvests as a proxy for the ecosystem services, even though this includes economic production inputs (Hein, L. et. al., 2019).

For carbon sequestration (e.g., Table 3.3, Annex), the recommendation in Hein et al. (2019), is to report the net ecosystem carbon balance (NECB) (or net biome production [NBP]) in tC/ha/year, and to estimate monetary values by multiplying the NECB by the country's GHG emissions trading system. Where NECB values from ecosystems are negative (i.e. air emissions, such as methane emissions from peatland or emissions from natural disturbance), it indicates that these emissions can be reported in the air emissions account. However, this instruction needs clarification since emissions resulting from soil respiration and other natural processes on unmanaged lands are not within the scope of the SEEA Central Framework (2014, p. 82). Given the significant area of peatland in Canada (estimated at 12% of the landmass) and the significant impact and inter-annual fluctuation of natural disturbances on the forest carbon balance, this clarification will affect how carbon sequestration and emissions in and from ecosystems are reported. Recommendations on the treatment of harvested wood products (HWP) are also not clear—whether these should be netted from carbon sequestration (which assumes instant oxidation) or not. The ongoing discussion of whether carbon storage should be considered a service or not is also an important issue to resolve.[3]

(3) Since the time of writing, the discussion on carbon sequestration and storage in ecosystem accounting has evolved, with convergence around reporting the carbon retention service of ecosystems

Data availability is also an issue. While data exist for many of the provisioning services, for at least some levels of geography, significant data development is needed for other services. For example, significant gaps exist for carbon sequestration, a service for which there already exist robust modeled data for Canada, reported annually to the UNFCCC through the **National Inventory report (NIR) and Common Reporting Format (CRF) tables.** Data for forests cover only the managed portion of Canada's forest, leaving an addition 121 Mha of forests in the north of the country (also approximately 12% of the landmass) unaccounted for (Kurz, W.A, 2018). There are also gaps in the model. For example, the carbon balance for peatlands is not covered in the emission models for forests, which currently are modeled for upland forests. Scientists at Natural Resources Canada are actively engaged on research in this area and have now developed modeled data by ecozone for peatlands (Webster, K.L, et. al,. 2018), but this information is not yet integrated into the NIR.

Data on heat mitigation in urban areas is an identified area of interest and there is much work ongoing that could potentially be replicated in Canada in future (e.g., Heris, M. et al, 2019). While work in this area has commenced, it is far from being completed at the national level. Similarly, there is interest in using and replicating other work e.g., the air filtration services provided by vegetation in urban areas (e.g., Nowak, D. et al, 2018).

Data on recreation services (e.g., Table 3.4, Annex) currently make use of national park visitation statistics. Additionally, survey-based data provide high-level information on access to and use of parks and green space nationally, by province or by metropolitan area (Statistics Canada, n.d.). An indicator reporting on the proximity to neighbourhood parks (i.e. municipal parks located within 1 km walking distance) has been developed by Statistics Canada and is searchable by dissemination block and census subdivision in an online map viewer (Statistics Canada, 2020). While there is interest in developing further indicators of access, such as the number of people living within a specific distance to a public green space available for recreation services, this work has not yet occurred.

There is currently no specific national policy driver for the work on ecosystem accounting. The intention is to develop accounts that are compatible with the international SEEA. Ideally, the ecosystem accounts would then be available to inform policy at national and regional levels, for example in measuring climate change impacts and ecosystem resilience.

3.3 Lessons learned and conclusions

Despite an ongoing commitment to developing ecosystem accounts at Statistics Canada, progress and timeliness are inherently tied to the amount of human and monetary resources, as well as limitations with respect to the availability of suitable data. There is also a need for better coordination and integration between departments responsible for producing and using ecosystem-related data. It has been demonstrated that the interdepartmental collaboration required to generate the data for environmental accounts in general, and ecosystem accounts in particular, benefits from a dedicated funding approach. Otherwise these efforts are likely to lead to results that are not comprehensive or timely.

Developing ecosystem accounts is an active component of Statistics Canada's Environment Accounts and Statistics Program. Current work includes contributions towards the international effort to revise the SEEA EEA framework, in addition to work developing, testing methods and compiling ecosystem extent, condition and service accounts.

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Annex. Preliminary tables

Table 3.2 Preliminary ecosystem services supply and use account - Provisioning services, Canada

Supply - Ecosystem services	Built-up	Arable	Natural pasture	Forest	Other natural and semi-natural land and freshwater		Coastal and marine			
		Agricultural production[1,2]		Roundwood harvested	Peat extracted	Freshwater fishery landings[3]	Seafisheries landings[3]	Aaquaculture production[4]	Marine plants harvested[2]	Total supply
		kilotonnes		thousand m³	kilotonnes					
2005	.	..		205,665	1,304	32	1,077	156	42	.
2006	.	..		185,359	1,217	31	1,043	171	43	.
2007	.	125,653		165,921	1,282	32	990	154	19	.
2008	.	137,440		141,397	1,246	30	917	156	18	.
2009	.	128,579		118,935	1,214	30	914	157	43	.
2010	.	128,848		144,274	1,286	27	905	163	43	.
2011	.	130,476		150,483	1,139	26	836	171	19	.
2012	.	134,552		153,185	1,277	29	787	185	14	.
2013	.	157,986		155,531	1,173	28	820	167	15	.
2014	.	142,341		155,110	1,178	27	832	139	14	.
2015	.	140,197		160,541	1,297	28	823	190	12	.
2016	.	156,184		156,164	1,452	30	832	201	13	.
2017	.	155,422		156,718	1,459	29	806	191	13	.
2018	.			..	1,244	..	..	..	..	.

1. Includes food and fodder crop (grain, oilseed, pulse, tame hay, potato, vegetable, fruit, greenhouse vegetable and mushroom) production, meat production (cold dressed weight) of poultry, cattle, hog, sheep and lamb including edible offal; production of honey and maple syrup (expressed as syrup), wool and fur-bearing animals. Excludes tobacco, sod, nursery production, Christmas trees, and other livestock (horses, goats, llamas and alpacas, rabbits, bison, elk, deer).
2. Provincial data that is unavailable or data that is suppressed to meet confidentiality or data quality standards are not included in total. May include some data assessed at data quality standard E (use with caution).

3. Landings are defined as the part of the catch that is put ashore.
4. Total aquaculture production of finfish and shellfish, excluding hatcheries and processing. Shellfish includes some wild production. Includes restocking of lakes and freshwater fisheries (e.g. trout, steelhead). Data not available is not included in total.

Sources: Statistics Canada, Tables 32-10-0456-01, 32-10-0365-01, 32-10-0364-01, 32-10-0353-01, 32-10-0354-01, 32-10-0113-01, 32-10-0117-01, 32-10-0356-01, 32-10-0119-01, 32-10-0359-01, 32-10-0142-01, 32-10-0116-01, 32-10-0053-01, 32-10-0107-01 (accessed September 2019); National Forestry Database, 2017, Industrial roundwood production, http://nfdp.ccfm.org/en/index.php (accessed September 15, 2019); Natural Resources Canada, Mineral Production of Canada, by Province and Territory, http://sead.nrcan.gc.ca/prod-prod/ann-ann-eng.aspx (accessed October 1, 2019); Fisheries and Oceans Canada, Commercial fisheries: Landings, https://www.dfo-mpo.gc.ca/stats/commercial/sea-maritimes-eng.htm (accessed October 2, 2019).

Table 3.3 Preliminary ecosystem services supply and use account - Regulating services, Canada

Supply - Ecosystem services	Built-up[1]	Arable[2]	Natural pasture	Forest[3]	Other natural and semi-natural land and freshwater	Coastal and marine	Total
Carbon sequestration	kilotonnes C						
2005	656	3,334	.	-25,265	.	.	.
2006	656	3,623	.	-27,793	.	.	.
2007	656	4,320	.	-25,735	.	.	.
2008	657	3,564	.	-4,970	.	.	.
2009	657	3,550	.	-2,858	.	.	.
2010	657	3,537	.	-26,997	.	.	.
2011	657	3,513	.	-32,848	.	.	.
2012	657	3,332	.	-28,197	.	.	.
2013	657	3,084	.	-10,708	.	.	.
2014	657	2,841	.	-40,850	.	.	.
2015	657	2,601	.	-63,218	.	.	.
2016	657	2,368	.	-33,209	.	.	.
2017	657	2,146	.	-60,878	.	.	.

1. Estimates of carbon sequestration for urban areas account only for above ground living tree biomass in urban areas. Includes 69 population centres in Canada with a population over 30,000 (of 947 population centres), capturing major Canadian cities representing 62% of 1990 urban area and 79% of 1990 population. Does not include growth of urban areas.

2. Currently reporting net carbon stock change as reported in the CRF tables to the UNFCCC.
3. Sum of ecozone carbon sequestration for managed lands (including both the anthropogenic and the natural partition) reported as the net ecosystem carbon balance (NECB). It excludes unmanaged lands—i.e., 12% of landscape. The carbon model used by CFS to develop carbon estimates for the NIR report to the UNFCCC is created for upland mineral soil forestland and therefore does not fully account for peatland and organic soils (12% of Canada's landscape). Negative NECB is a carbon emission and therefore is not a carbon sequestration service. Recommendations in Hein et al, 2019, indicate to report it in Air emission accounts. However, emissions from unmanaged land and from natural disturbance are out of scope in the SEEA CF—reporting in Thematic carbon accounts may be more appropriate, but this is to be determined.
Sources: Environment and Climate Change Canada, 2019, CRF Tables, Canada's National Inventory Submissions 2017 to the UNFCCC, https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/greenhouse-gas-inventories-annex-i-parties/submissions/national-inventory-submissions-2017#fn1 (accessed September 16, 2019); McGovern, M. and J. Pasher, 2016, "Canadian urban tree canopy cover and carbon sequstration status and change, 1990-2012," *Urban Forestry and Urban Greening,* Vol. 20, pp. 227-232, https://dx.doi.org/10.1016/j.ufug.2016.09.002; Canadian Forest Service, Carbon Accounting, personal communication with Mark Hafer, August 20, 2019.

Table 3.4 Preliminary ecosystem supply and use account table - Cultural services, Canada

Use - Ecosystem service	Total, including exports		Total, households			
	National parks visitation	National historic sites visitation	Households that had a park or green space close to home[2]	Households that visited a park or green space close to home[2]	Households that visited a park or green space that was not close to home[2]	Total use
Recreation services	person-visits[1]		percentage of households			
2011	..	..	86	84	70	.
2012	..	..	..	..	..	.
2013	..	..	85	85	69	.
2014	13,520,886	8,255,118	..	..	..	.
2015	14,469,008	8,853,089	87	87	72	.
2016	15,449,249	9,288,024	..	..	..	.
2017	16,833,896	10,419,484	87	85	71	.
2018	15,898,110	9,198,126	..	..	..	.

1. Person visits represent each time a person enters the land or marine part of a reporting unit for recreational, educational or cultural purposes during business hours. Through, local and commercial traffic are excluded. Same day re-enties and re-entries by visitors staying overnight in the reporting unit do not constitue new person-visits. Reporting is for fiscal years starting April 1.
2. Survey-based reporting of whether households had a park or green space located close to home and whether or not they visited a park or green space close to or not close to home. The denomininator of those visiting a park or green space close to home is households reporting having a park or green space close to home. Close to home is defined as a ten-minute journey.
Sources: Parks Canada, 2019, *Parks Canada Attendance 2018-19,* https://www.pc.gc.ca/en/docs/pc/attend (accessed September 6, 2019); Parks Canada, personal communication with Brenda Jones, September 6, 2019; Statistics Canada, Table 38-10-0020-01, Parks and green spaces, https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810002001, September 23, 2019.

Use	**Total, including exports**		**Total, households**		Total use
Ecosystem service					
Recreation services	national parks person-visits[1]	national historic sites person-visits[1]	% of households that visited a park or green space close to home[2]	% of households that visited a park or green space that was not close to home[2]	
2011-2012	..	..	84	70	.
2012-2013	..	..	..	..	.
2013-2014	..	..	85	69	.
2014-2015	13,520,886	8,255,118	..	..	.
2015-2016	14,469,008	8,853,089	87	72	.
2016-2017	15,449,249	9,288,024	..	..	.
2017-2018	16,833,896	10,419,484	85	71	.
2018-2019	15,898,110	9,198,126	..	..	.

1. Person visits represent each time a person enters the land or marine part of a reporting unit for recreational, educational or cultural purposes during business hours. Through, local and commercial traffic are excluded. Same day re-enties and re-entries by visitors staying overnight in the reporting unit do not constitue new person-visits.

2. Survey-based reporting of whether households had a park or green space located close to home and whether or not they visited a park or green space close to or not close to home. The denomininator of those visiting a park or green space close to home is households reporting having a park or green space close to home.

Sources: Parks Canada, 2019, *Parks Canada Attendance 2018-19,* https://www.pc.gc.ca/en/docs/pc/attend (accessed September 6, 2019); Parks Canada, personal communication with Brenda Jones, September 6, 2019; Statistics Canada, Table 38-10-0020-01, Parks and green spaces, https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3810002001, September 23, 2019.

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National accounts

4 Progressing with ecosystem accounting at national scale; the case of Czech Republic

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4.1 Introduction

Czech Republic has been actively developing environmental statistics and accounts. Though and despite the growing interest in the state of the nature, ecosystem services (ES) and biodiversity, Czech government has not yet progressed much on the development of natural capital or ecosystem accounting. The policy need has been recently highlighted in the updated version of the National Biodiversity Strategy of the Czech Republic 2016–2025.

In light of these, several activities were launched under the aim, first, to initiate a discussion with respect to ecosystem accounting and, second, to proceed to applications of accounts in line with the System of Environmental-Economic Accounting (SEEA) framework. Based on some preliminary discussion with the Czech Statistical Office agricultural and ecosystem asset accounts especially in the context of declining arable land formed the main priorities in the area of ecosystem accounting. In addition, water thematic accounts and supply and use of forest ES accounts were also indicated as top priorities in light of climate change and its consequences for the state.

CzechGlobe (Global Change Research Institute of the Czech Academy of Sciences) has been leading the activities on ecosystem accounting in Czech Republic. Ecosystem accounting initiatives were rather research-driven, with the aim to provide research support to decision-makers. To this end several partners were involved such as the Czech Statistical Office, the Ministry of Environment and the Czech Nature Conservation Agency.

4.1.1 Past and current project initiatives related to ecosystem accounting

Up to date the ESMERALDA (Enhancing ES mapping for policy and decision making) EU H2020 and OMEGA (Developing and testing experimental ecosystem accounting in CR) projects were fulfilled focusing on testing and initiating discussion on the usefulness of SEEA EEA. During the ESMERALDA project (2015-2018) we presented a case study of pilot national assessment of ecosystem services. This pilot assessment developed a database of economic ES values named EKOSERV, to be used for unit value transfers at the national level (Frélichová et al. 2014). Also, a special dataset called Consolidated Layer of Ecosystems of the Czech Republic (CLES) for ecosystem extent was developed for ecosystem accounting. OMEGA project (2017-2019) was funded by the Technology Agency of CR. Our team in CzechGlobe managed to partly update the EKOSERV database (Vackaru and Grammatikopoulou, 2019; Grammatikopoulou and Vackaru, under revision). Also, a methodological protocol for ecosystem accounting was developed which provided an overview of the accounting process and the types of accounts in line with SEEA EEA framework (Vackaru et al., 2018). The protocol put emphasis on the ecosystem extent and condition accounts (land and ecosystem accounting), supply and use tables (in physical and monetary units) and valuation for ecosystem services.

Currently CzechGlobe is a partner of MAIA (Mapping and Assessment for Integrated Ecosystem Accounting) H2020 project. The objective of the project is to develop and implement natural capital accounts in EU Member States following the SEEA Ecosystem Accounting Framework and the methodological work and guidance of the KIP-INCA. The team in Czechglobe is planning to further test different types of ecosystem accounts (details below), approaches to valuation of ecosystem assets, supply and use tables including biophysical and monetary. CzechGlobe is also involved in Integrated LIFE project which could further support mainstreaming of ES and ecosystem accounting into decision-making.

4.2 The accounts

To date Czech Statistical Office has been assembling all major components of national accounts (https://www.czso.cz/csu/czso/5-national-accounts-7yg4aukg34). Concerning the SEEA modules, the following accounts have been published (usually in line with Eurostat regulations):

- Air Emissions account;
- Material Flows account;
- Physical Energy Flow account;
- Environmental Protection Expenditure account;
- Environmental Goods and Services account;
- Environmentally-related taxes account.

Table 4.1 presents the pilot accounts in line with SEEA EEA framework that have been accomplished up to now as well as the accounts which are planned to be compiled within the framework of MAIA project. Pilot accounts were compiled with special focus on ecosystem extent and condition accounts, and monetary asset accounts. Ecosystem extent accounts were constructed based on the methodology of Land and Ecosystem Accounting while for the condition accounts the Mean Species Abundance (MSA) was used as indicator that reflects the divergence from the original natural state. Monetary asset accounts were investigated by applying the value transfer method to estimate the value of future flow of ES from ecosystem assets.

Table 4.1 Pilot/ accomplished and planned accounts in Czech Republic

Type of accounts	**Ecosystems**	**Scale**	**Units**	**Techniques**
Pilot (drafted)				
Ecosystem extent	All	National	Physical	Land and Ecosystem Accounting in line with SEEA CF
Ecosystem condition	All	National	Physical	Mean Species Abundance indicator, SEEA EEA
Monetary asset accounts	All	National	Monetary	Value transfer (unit), SEEA EEA
ES supply and use accounts	Forest	National	Monetary	Value transfer (meta-analysis), SEEA EEA
Planned				
Ecosystem extent	All	National, protected areas	Physical	Update existing account using Corine Land Cover data
Ecosystem condition	Agriculture	National	Physical	Under consideration
Carbon asset account	Agriculture	National	Physical and Monetary	Under consideration
Supply and Use ecosystem service account: water regulation, carbon sequestration, recreation	Agriculture, (all)	National, protected areas	Physical and Monetary	Under consideration
Thematic: Biodiversity, recreation	All	National, protected areas	Physical and Monetary	InVest, remote sensing but mainly under consideration

Table 4.2 Land and Ecosystem Account for the Czech Republic, 2006 – 2012. Consumption of land cover presents the loss of area of original land cover, while formation of land cover presents new land cover created by human activity or natural processes classified in land cover flows types. Consumption and formation of land cover is balanced.

	Artificial surfaces	Arable land	Permanent crops	Pastures	Mosaic farmland	Forest and transitional woodland shrub	Natural grassland and heathland	Open space with little or no vegetation	Wetlands	Water bodies	Total (ha)
Consumption of land cover											
LCF1 Urban land management	2 021										2 021
LCF2 Urban residential sprawl		2 785	41	339	376	20					3 561
LCF3 Sprawl of economic sites and infrastructure	380	6 482	76	1 080	678	1 200	137			2	10 035
LCF4 Agricultural internal conversions		95 639	3 685	7 595	428						107 347
LCF5 Conversion from forested and natural land to agriculture	2 528				354	445	115			12	3 454
LCF6 Withdrawal of farming		2 569	621	2 048	604						5 842
LCF7 Forests creation and management	485					56 080	462		120		57 147
LCF8 Water bodies creation and management	737	200		174	28	6					1 145
LCF9 Changes of Land Cover due to natural and multiple causes						87				11	98
Total consumption of land cover	6 151	107 675	4 423	11 236	2 468	57 838	714		120	25	190 650
Total area 2006	500 540	3 010 914	46 411	700 797	754 140	2 777 748	28 874	265	10 368	56 686	7 886 742
Formation of land cover											
LCF1 Urban land management	2 021										2 021
LCF2 Urban residential sprawl	3 561										3 561
LCF3 Sprawl of economic sites and infrastructure	10 035										10 035
LCF4 Agricultural internal conversions		10 697	4 501	92 070	79						107 347
LCF5 Conversion from forested and natural land to agriculture		950	154	2 241	109						3 454
LCF6 Withdrawal of farming					2 482	3 337	23				5 842

LCF7 Forests creation and management						57 126	21				57 147
LCF8 Water bodies creation and management										1 145	1 145
LCF9 Changes of Land Cover due to natural and multiple causes								87	11		98
Total formation of land cover	15 617	11 647	4 655	94 311	2 670	60 463	44	87	11	1 145	190 650
Total area 2012	509 739	2 899 131	45 873	794 393	758 698	2 782 861	27 478	294	10 636	57 561	7 886 663

Ecosystem extent pilot accounts revealed, for the period 2006-2012, a shift towards more "natural" land cover types. The dominant trend is represented by the increase in the pasture area changed for the arable land or the increase in forested area (Table 4.2). For the same period ecosystem condition improved as measured by MSA changes. The most profound change in the improvement of ecosystem condition is the increase of pastures and meadows (Table 4.3). In monetary terms ecosystem assets presented a net gain of EUR 4 billion in present value terms during 2006–2012. The positive change was caused mainly by the transformation of arable land into pastures and by the increase of forested areas (Table 4.4). Supply and Use tables (Tables 4.5 and 4.6) for forest ES accounts showed a value of 2,992 million $ in 2016. Most of this value is generated by the regulation of liquid flows, which is being mostly used by the agricultural sector.

Table 4.3 Mean Species Abundance (MSA) changes as indication of ecosystem condition. Table presents balance of changes in MSA induced by land cover change

	Artificial surfaces	Arable land	Permanent crops	Pastures	Mosaic farmland	Forest and transitional woodland shrub	Natural grassland and heathland	Open space with little or no vegetation	Wetlands
Artificial surfaces	0	25,28	3,2	325,08	8,82	329,8	0	0	0
Arable land	-370,64	0	167,84	12790,82	160,3	956,8	0	0	0
Permanent crops	-9,36	-134,56	0	32,1	21,1	246	0	0	0
Pastures	-255,42	-1025,36	-26,2	0	0	413,5	16,1	0	0
Mosaic farmland	-189,72	-33,6	-15,7	0	0	302	0	0	0
Forest and transitional woodland shrub	-829,6	-49,92	0	-158	-25	0	15,8	-24	0
Natural grassland and heathland	-120,56	0	0	-80,5	0	-92,4	0	0	0
Open space with little or no vegetation	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0
Total	-1775	-1218	129	12910	165	2156	32	-24	0

Table 4.4 Monetary value of change in future flows of ES based on land cover changes (thousand EUR).

	Artificial surfaces	Arable land	Permanent crops	Pastures	Mosaic farmland	Forest and transitional woodland shrub	Natural grassland and heathland	Open space with little or no vegetation	Wetlands	Water bodies
Artificial surfaces	0	11 823	3 555	73 230	2 435	478 353	0	0	0	12 472
Arable land	-172 650	0	294 375	1 995 383	35 473	1 446 543	0	0	0	-357
Permanent crops	-10 397	-236 005	0	-15 509	-8 266	367 947	0	0	0	0
Pastures	-57 538	-159 957	12 659	0	10 951	782 133	89	0	0	-4 111
Mosaic farmland	-52 372	-7 435	6 150	-3 519	0	565 710	0	0	0	-917
Forest and transitional woodland shrub	-1 203 280	-75 472	0	-298 856	-46 830	0	-74 410	-29 589	0	-5 816
Natural grassland and heathland	-6 083	0	0	-443	0	435 156	0	0	0	0
Open space with little or no vegetation	0	0	0	0	0	0	0	0	0	0
Wetlands	0	0	0	0	0	0	0	0	0	0
Water bodies	-34	0	0	71	0	0	0	0	1 867	0
Total	-1 502 354	-467 046	316 739	1 750 357	-6 238	4 075 843	-74 321	-29 589	1 867	1 270

Table 4.5 Supply table for forest ES

Supply (mil US$, 2016)	**Ecosystem types**										
Ecosystem services	Artificial surfaces (urban green)	Arable land	Permanent crops	Pastures	Mosaic farmland	Forest and transitional woodland shrub	Natural grassland and heathland	Open space with little or no vegetation	Wetlands	Water bodies	Total
Provisioning:											
Provision of timber						94.868					94.868
Provision of non timber						18.250					18.250
Regulating:											
Air quality											
Climate regulation						102.350					102.350
Habitat maintenance											
Liquid flows						2,570.563					2,570.563
Mass flows											
Cultural:											
Leisure						206.238					206.238
Total						2,992.268					2,992.268

Table 4.6 Use table for forest ES

Use (mil US$, 2016)	Type of economic unit									
Ecosystem services	Agriculture	Forestry	Manufacturing and construction	Electricity, gas supply	Transport	Waste management	Other tertiarry sector	Households	Global society	Total
Provisioning:										
Provision of timber		94.868								94.868
Provision of non timber								18.250		18.250
Regulating:										0.000
Air quality										0.000
Climate regulation									102.350	102.350
Habitat maintenance										0.000
Liquid flows	2,096.700		62.851		242.389	9.987	1.137	157.499		2,570.563
Mass flows										0.000
Cultural:										0.000
Leisure								206.238		206.238
Total	2,096.700	94.868	62.851	0.000	242.389	9.987	1.137	381.986	102.350	2,992.268

4.3 Policy

4.3.1 Policy priorities

The anticipated accounts have been decided in light of a consultation with stakeholders and the outcomes of a workshop that took place in 11th of June 2019 as part of MAIA deliverables. Stakeholders highlighted the following priorities:

1) Agricultural ecosystem accounts have been discussed in the context of the Common Agricultural Policy pointing out the role of biodiversity (via e.g. organic farming), water retention in the landscape, and the number of inputs / intensities in the agricultural landscape (e.g. fertilizers, herbicides)

2) Water accounts (e.g. lakes, rivers, dams) and surrounding landscapes; the participants agreed on the importance of the accounts and the wetland account (significant ecosystem services)

3) Accounts for urban areas (e.g. Prague, Brno) mainly from the carbon point of view, and the role of greenery in adapting to climate change and other benefits (e.g. recreation, health)

4) A protected landscape area account that could be significant for both biodiversity and other ES (e.g. tourism).

Subsequently, thematic accounts were discussed, which either monitor important ES or environmental / human-related issues / interests:

1) Water account in terms of quality, quantity and specifically water retention in the landscape

2) Carbon account for ecosystems and residential areas;

3) Biodiversity account.

4.3.2 Policy implications

Besides the policy relevance of ecosystem accounting initiatives towards international policy targets (such as Strategic Plan for Biodiversity 2011-2020, Aichi target 2 as well as Target 15.9 of Sustainable Development Goals) Czech Republic through accounting will attempt to a) keep a record on land use and land cover changes and b) disentangle the contribution of ecosystems and ES in the economy.

Ecosystem accounting should be applied to all policies that address the management of natural resources. Agriculture, water management and forestry are perceived as the most important sectors in which ecosystem accounting should be applied.

4.4 Lessons learned and conclusions

During the time involved in the process of developing the accounts specific remarks have been detected and should be accounted for in future applications;

a. It is imperative to start developing pilot examples of accounts based on existing data flows. These case study accounts may incentivize further actions and dedicated resources and, hopefully, advocate further the use of accounts.

b. SEEA EEA is a complex framework and demands inter and trans disciplinary efforts. Projects (such as MAIA) offer a good platform for developing synergies that could possibly assist on knowledge transfer and close collaboration among partners. To this end it is also proper to keep close collaboration with the Czech Statistical Office and other relevant actors.

c. Certain challenges are marked and need to be addressed in the future:

- Non-existing political demand for ecosystem accounting.
- Low capacities, knowledge and awareness about ecosystem accounting in general
- Perception of low usefulness and urgency of ecosystem accounting.
- Data gaps; insufficient harmonization of existing data sources and data flows, including also missing a common unified database.

The progress remains still at an immature state although there has been a good progress in identifying policy needs and priorities and realizing the challenges ahead. In pragmatic terms, the state of data availability as well as the methodology of compiling the accounts, are yet to be defined and reported. The participation of CzechGlobe in MAIA project offers a great opportunity in data integration and in improving the information on the state and trends of nature. Already within MAIA project policy needs and priorities have been clarified and a work plan has been decided regarding the anticipated accounts to be implemented. Key bottlenecks include the non-existing political demand for ecosystem accounting, low capacities, knowledge and awareness about ecosystem accounting generally, and perception of low usefulness and urgency of ecosystem accounting.

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5 National accounting of ecosystem extents and services in Germany: a pilot project

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5.1 Introduction

The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) together with the Federal Agency for Nature Conservation (BfN) initiated the pilot project "Integration of ecosystems and ecosystem services (ES) into the Environmental-Economic Accounting". An interdisciplinary team was set up involving experts from the Technische Universität Berlin (specialization: land use and environmental economics), the Leibniz Institute of Ecological Urban and Regional Development (IOER) in Dresden (specialization: mapping and assessment of ecosystems and their services) and the Freie Universität Berlin/Environmental Policy Research Centre (specialization: policy integration, alternative welfare concepts). The BfN also participated in the research itself, assisting in biotope evaluation and valuation of urban greening.

The objectives of the project were: (1) to give an overview of the current discussion as well as the problems that would have to be solved to enable ecosystems and ES to be integrated into the SEEA; (2) to prepare exemplary physical and monetary accounts for selected ES and discuss the underlying methodology; and (3) to summarize lessons learned and identify possible elements of a roadmap for a reporting system to record Germany's ecosystems and their services (Grunewald et al. 2019).

The project was accompanied by an advisory board, which included scientists and representatives of various federal authorities as well as the Federal Statistical Office. In March 2020, the first "National Workshop for a Future Ecosystem Accounting in Germany" was held in Hannover in cooperation with the EU Horizon 2020 Project MAIA (Mapping and Assessment for Integrated Ecosystem Accounting).

The complete results of the pilot project will be presented in a comprehensive report to be published later in 2020.

5.2 The accounts

Being a pilot study, the project did not aim for complete accounts as outlined in the SEEA-EEA. Instead, on the basis of an ecosystem extent account, it concentrated on three exemplary ecosystem service accounts, namely:

a. Food production on agricultural land,
b. Amenity services of urban green,
c. Services for biodiversity conservation.

The cases were selected according to the following criteria:

- coverage of different ES classes (provisioning, regulating and cultural);
- data availability for physical and monetary accounting;
- relevance for the political discussion in Germany (land conversion, citizen's well-being relevance of biodiversity);
- use of methods that may be relevant for the further development of SEEA-EEA (natural soil fertility, experienced preferences, cost spent on biotope restoration).

Although no separate ecosystem condition account was made, a great deal of information about ecosystem condition (proportion of green areas in cities, (loss of) natural soil quality, naturalness and ecological/conservation status of ecosystems) was integrated in the service accounts.

5.2.1 Ecosystem extent account

To create a nationwide "ecosystem accounting", it is first necessary to develop a standard classificatory system of ecosystems that can consistently deal with diverse nationwide data sources on the extent and condition of ecosystems, which often use their own forms of classification. In the Federal Republic of Germany, comprehensive field mapping for ecosystems according to an uniform mapping system is currently unavailable.

Our initial step was to make a concrete proposal on how to combine and blend geospatial land-use and ecosystem data so as to generate a complete, updateable picture of the state of Germany's ecosystems, one compatible with EU-wide approaches as well as with other regularly collected data sources (e.g. sample-based surveys) (Grunewald et al. 2020).

We utilized the CLC classification system to define those ecosystem classes that, on the basis of the Digital Land Cover Model for Germany (Digitales Landbedeckungsmodell für Deutschland or LBM-DE), can be delimited with sufficient clarity. Of the 44 existing classes of land cover in Europe identified in the CLC nomenclature, 37 are relevant to Germany). These CLC classes can be aggregated into 14 sub-types or five main ecosystem types (Grunewald et al. 2020).

However, the CLC classes are not ideally suited to assessing the state of ecosystems with regard to various private and public goals and, specifically, the protection of biodiversity. From the outset, therefore, we structured the ecosystem extent account in such a way that additional information on the area (and status) of further ecosystem subtypes can be integrated, some of which are only collected on a sample basis. Currently this is data collected as part of the nationwide reporting on the extent and conservation status of habitat types according to Annex I of the Habitats Directive (Deutschlands Natur 2018), the survey of high nature value (HNV) farmland (which is regularly carried out on 1,375 sample areas of 1 km^2 size within the nationwide monitoring of breeding birds; for details see Hünig & Benzler 2017), the Federal Forest Inventory and the classification of the ecological watercourse/body status according to the EU's Water Framework Directive (WFD).

We calculated the area and ratios of main ecosystem types and subtypes in the LBM-DE land cover model for the years 2012, 2015 and 2018. Linear elements such as small structural features and infrastructurelines from the "Official Topographic-Cartographic Information System" (ATKIS Basis-DLM) were added to the land cover model. The results were maps of ecosystem types and allocation tables showing different classes or levels (layers), which can be used to draw up balances (area balance, status balance, service balance) and may be expanded depending on the task at hand (see figures and tables in Grunewald et al. 2020).

5.2.2 Ecosystem services for crop and grass production

Through human activity, agricultural land and its soils are used to grow crops as well as provide raw materials or fodder for livestock. These are provisioning services according to the classification of CICES 5.1 (EEA 2020). The services are reduced, in particular, when agricultural land is converted into settlement and transportation areas (UBA 2020a). The BfN project used the asset 'accounting of agricultural land' to estimate the cost of converting agricultural land to settlement area. Furthermore, while restricted to one ecosystem service, the accounting takes the various soil qualities in Germany as an indicator of asset quality. A GIS-based approach was adopted to measure land use/cover and changes to these. The project thus measures agricultural land understood as an ecosystem (and thus an asset) while crop production is an ES as developed by UN 2014a (Annex A3, p.62). The ES of agricultural soil is referred to as 'agricultural potential' in the following. Furthermore, 'agricultural land' is used as a collective term that encompasses both arable land (i.e. for the growing of crops, including vineyards and fruit plantations) as well as grassland used as meadows and for pasture.

The extent of the ecosystem (here, agricultural land) is measured and mapped for one particular dimension, namely in terms of land area (i.e. ha or km^2), its quality is measured and mapped by its soil characteristics according to the German Soil Quality Rating (BGR 2013a, Mueller et al 2007). While other characteristics of the ecosystem condition (such as vegetation, biodiversity, water and carbon sinks, cp. UN 2014a, ch. 4.3) are not further elaborated, the soil quality index includes parameters indicative of water retention. Changes in the soil quality index can be used as a measure to reflect changes in the asset quality.

The German Soil Quality Rating (SQR) can be used to define the productive potential of agricultural land. It has the dual benefit of measuring the quality of land as an asset as well as the ES of the productive potential. As an index, however, it cannot be aggregated. The SQR could be employed as a measurement device if translated into some physical measure, e.g. the productive potential in tons. As the SQR covers the various types of agricultural land found in Germany, all crops can be measured, and it would be possible to aggregate across their production potential. The unit of measurement would be in biomass tons or the energy content. Hence the SQR could serve as a good indicator for the aggregate and spatially disaggregated quality of agricultural land as well as a relatively good indicator for the spatially disaggregated ES of crop production, and thus for mapping up to the national scale. The SQR can also be used to differentiate the economic valuation of the ES of agricultural land. Agricultural land is traded in sale and rental markets, providing a broad range of transaction values for land as a productive factor in agriculture. The SQR valuation rates soil in terms of type, climate and topography using a point scale ranging from 15 to 100. The scale was validated on a data-pool of winter wheat and winter rye yields. Data are provided by the Federal Institute for Geosciences and Natural Resources (BGR) as a raster dataset of 250 x 250 m pixel size at a map scale of 1 to 1,000,000 (BGR 2020, 2013a, Mueller et al. 2007). The original SQR dataset of the BGR only includes ratings for arable areas (but not grassland) for the year 1990 (BGR 2013b, c).

The resulting dataset created from the SQR raster and the LBM-DE gave an average SQR value of 57.9 for all agricultural land (totaling 18,379,565 ha) in 2012. This value is somewhat below the average SQR value of 61.6 from the original SQR dataset due to the consideration of lower-quality grassland. The resulting distribution of soil quality is presented in Fig. 5.1, showing the relatively large differentiation of natural factors that influence the ecosystem service for crop and grass production.

For the German political discussion about the reduction of land take by settlement and transportation it would be relevant to know, if the agricultural land converted to settlement and transportation has an average, a smaller or a higher value for crop and grass-production than the mean value for this service. Historically, settlements were often founded on good soil. To test the hypothesis, that land take may reduce the ES for crop and grass production disproportionally, we selected the agricultural areas that had been converted to settlements and transport on GIS-basis and calculated their average SQR. We found that the average SQR values of the consumed land between 2012 and 2018 was 58.2. This basically corresponds to the average SQR value of 57.9 for all soils in Germany in 2012, suggesting that the developed agricultural land was "only" of slightly higher quality.

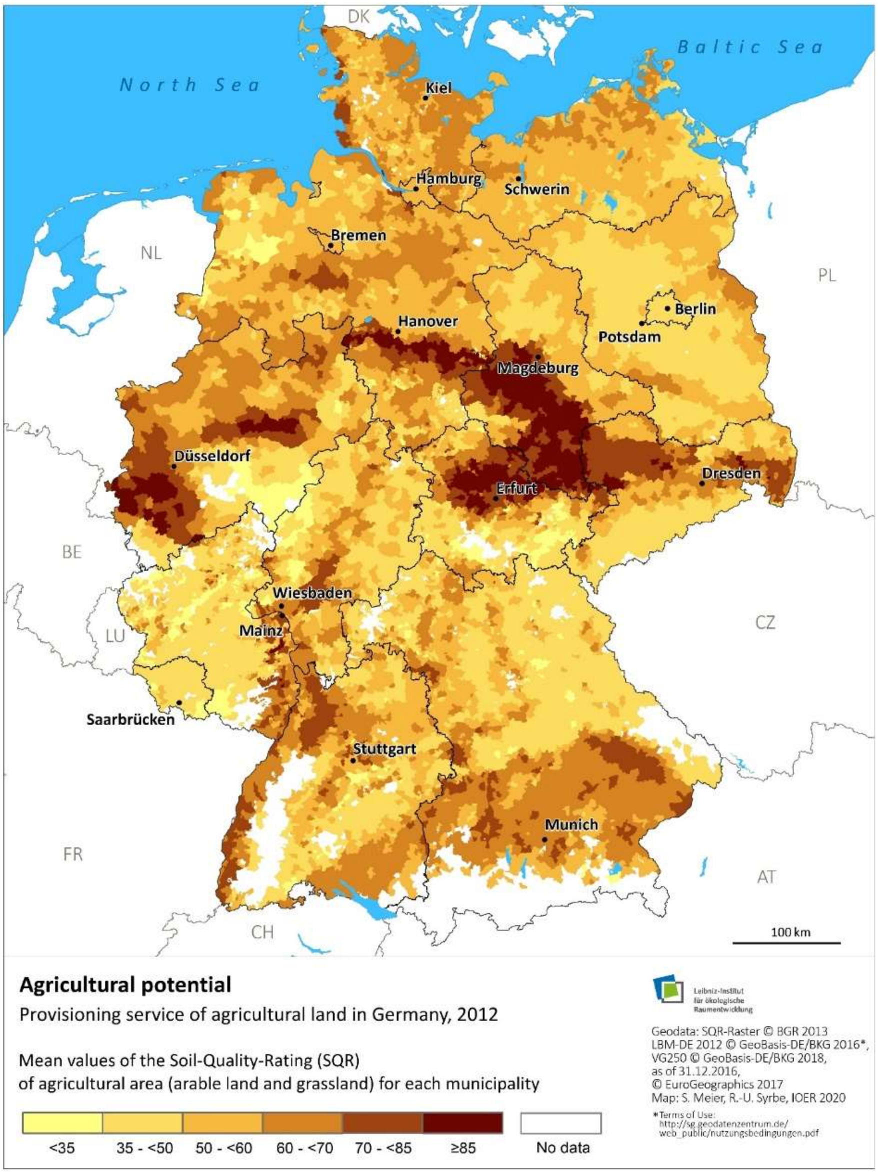
Ideally, the monetary valuation of agricultural land as an environmental asset is based on the resource rent, as suggested by UN (2014b). This is generally calculated by subtracting the depreciation of fixed capital and the return to produced assets from the gross operating surplus. While the gross operating surplus is available from the national accounts, the other figures are not. Taken as a proxy economic indicator for the value of the provisioning service of agricultural land, the gross operating surplus is understood to be an overestimate. Furthermore, data on agricultural rents in Germany are only available nationwide on the basis of different crops/ farming systems.

As the sale prices and market prices of agricultural land are co-determined by a number of non-agricultural considerations, the BfN project chose lease prices as a monetary indicator for the value of the provisioning services of agricultural land. In Germany as in the other EU countries, lease prices are determined not only by the productivity of the land and the price elasticity of food and fibre crops but also by various governmental subsidies and agri-environmental programmes. A number of studies have already been conducted to investigate their size and impact on land prices (sales and rental), for example Garvert (2017), Habermann & Ernst (2010) and Grau et al. (2019).

Although the estimates by Garvert (2017) are based on data from 2008-2010, these figures are the best available for the whole of Germany. Utilizing the results of these three studies, we can state that the SQR values of the soil quality-map we used as a physical measure for the ecosystem service explain only 46-72 % of the value of agricultural land on the lease market.

Using soil quality indices as indicators of the ES of agricultural land, the relative quality differences can be described and mapped, but a bio-physical indicator of the production potential cannot be estimated as the physical yield varies with the crops planted (a human decision) and harvested (joint effort of man and nature). This figure can only be used for valuing the flow of the ES. In the studies quoted above, the variation of rental prices was explained by the variation of soil quality among all other contributing factors via regression analysis. These studies used the soil quality index in Germany which was developed for tax purposes: SQI tax (Bayr LA Steuern 2009). For this reason, the values of the SQR in Germany had to be converted into the values of SQI tax in order to calculate the lease income based on the estimates of Garvert (2017).

Figure 5.1 Mean SQR values for German municipalities. Data derived from the Soil Quality Raster (BGR 2013a) and the German land cover model LBM-DE for the time period 2012 (BKG 2016a); the municipality boundaries refer to 2015 (BKG 2016b).



For agricultural land that has been transformed into settlement and transportation areas, we translated (via regression analysis) the SQR values into the required quality parameter SQI tax (German: 'Ackerzahl') based on data of three German federal states (SLL 1999, STMUV 2014, TLUBN 2011).

$$\text{SQI tax } [Ackerzahl] = \frac{SQR}{0.8674} - 20.448$$

For calculating the lease income we referred to result estimates (x-values) of Garvert (2017) for both Eastern and Western German federal states:

$$value\ of\ the\ ecosystem\ services: [Euro\ per\ year] = area\ [\text{ha}] * soil\ quality\ [SQI\ tax] * x$$

Euro per SQI tax and area [ha]:

Eastern German federal states: x = 2.74

Western German federal states: x = 4.81

This figure can be used for valuing the flow of the ES. Due to the different estimates (x-values), the economic valuation does not linearly reflect the change in physical agricultural potential between the Western and Eastern federal states.

The economic agricultural potential for Germany in terms of lease income for the year 2012 was 3.493.439.872 Euro. The loss of lease income due to conversion of agricultural areas into building areas, transportation areas and construction sites was in total 12.677.964 Euros between the six-year time span of 2012 and 2018, which is 2.112.994 Euros per year.

5.2.3 Services of urban green spaces

Urban green is a vital element in the quality of life of city residents. Therefore, the development of a knowledge base and objectives for action on green infrastructure as well as empirical research to better understand its impact are central to sustainable development. One of these components is environmental accounting as applied to urban ecosystems and ES. This can be described as an innovation in the context of national accounting. For this purpose, two indicators of ES are used. The first of these is “access to urban green”, developed by Grunewald et al. (2017) and Hartje et al. (2016). This has been proposed as a central indicator for sustainable development by the Federal Institute for Research on Construction, Urban and Regional Development (BBSR) and the Federal Office for Construction and Regional Development (BBR) (BBSR 2017). In the following, we use a second indicator for ES, namely “share of public green in a 1 km radius around the housing site”, developed by Bertram & Rehdanz (2015) and Krekel et al. (2016), as the basis for an economic valuation.

The base dataset is georeferenced data from the German ATKIS-Basis-DLM (cf. Sect. 5.2.1) on public green space and waterfronts in 182 German cities with more than 50,000 inhabitants classified according to their quality (size, usability) and accessibility (distance to the home of each inhabitant).

The economic valuation is derived from studies employing the life satisfaction (experienced preference) method (Bertram & Rehdanz 2015; Krekel et al. 2016) and hedonic pricing (Kolbe & Wüstemann 2015). Under the life satisfaction method, the contribution of urban green areas to life satisfaction is identified via multiple regression. Life satisfaction is regularly measured by the German Institute for Economic Research (DIW) through its dataset, the Socio-Economic Panel (SOEP), which uses a Likert scale from 0 to 10. Explanatory variables are income, marital status, health, etc. Krekel et al. (2016) added an additional variable, namely the supply of urban green (in hectares) within a 1 km radius of each home. Based on the coefficients of the multiple regression function for the influence of income, on the one hand, and urban green for life satisfaction, on the other, they derived the willingness of panelists to pay for additional green coverage within the 1 km radius, taking this as the willingness to pay per household.

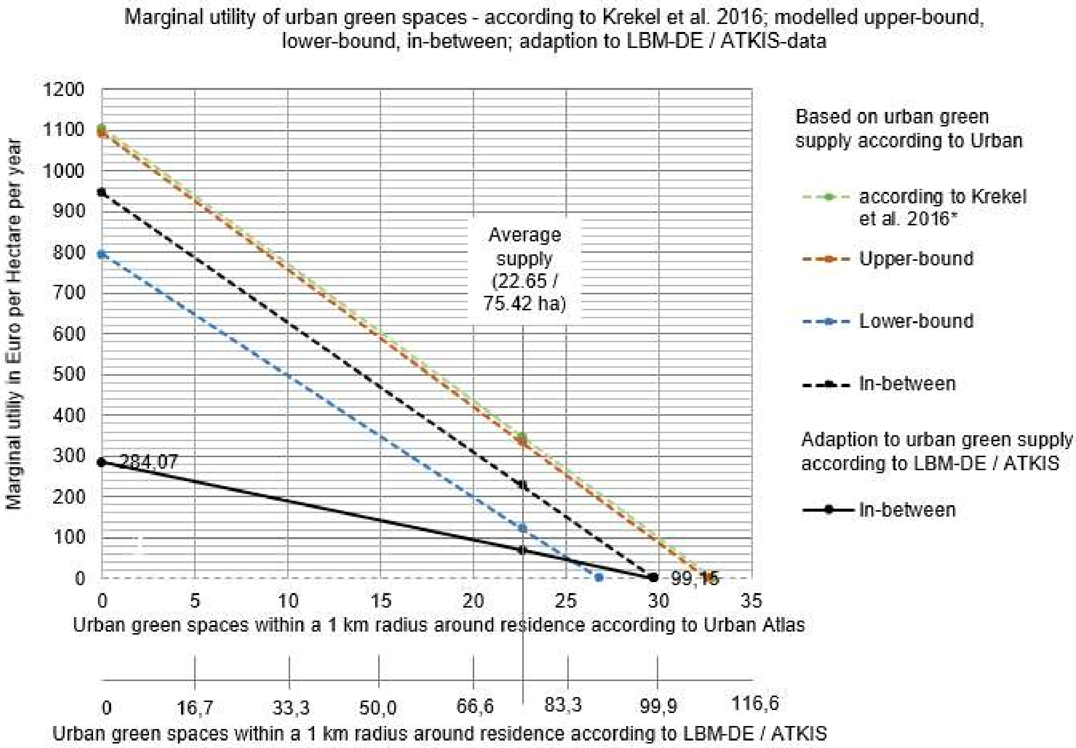
For hedonic pricing, the purchase prices of houses (and apartments) were analysed, again via multiple regression, with the coverage of urban green within the 1 km circle as one of the explanatory variables. Here the share of the house price explained by urban green was seen as the willingness of households to pay for green spaces. Although both methods were based on similar data, the estimated values differ considerably. The reason for this is that these figures are in fact complementary rather than substitutes. For a theoretical explanation see Welsch et al. (2014); an empirical analysis is provided by Krekel & Zerrahn (2017).

A recent study by Kolbe et al. (2019) showed how estimates of the value of urban green based on life satisfaction are biased in that residents choose their place of living according to their preference for urban green, whereas hedonic pricing only reflects the full value of urban green when there are no market frictions. They calibrated a market simulation model with market frictions and heterogeneous preferences using empirical data from complementary studies by Kolbe & Wüstemann (2015) and Krekel et al. (2016) to determine the upper and lower boundaries of the true full marginal utility of urban green, which lie between the results of the original studies.

For this study, we adopted the “in-between” marginal utility function from Kolbe et al. (2019), situated between the upper-level and the lower-level function (Fig. 5.2)[4].

(4) The empirical studies of Kolbe & Wüstemann (2015) and Krekel et al. (2016) both took the EEA’s Urban Atlas as their base geodataset, whereas the analysis presented here uses the ATKIS-Basis-DLM (hereinafter called LBM-DE / ATKIS; cf. Sect. 5.2.1).

Figure 5.2 Relationship between urban green spaces and marginal utility.



* Both household income and personal income were considered as explanatory variables. Therefore, unlike the authors, personal income was also taken into account here in determining the marginal utility function. The marginal utility function presented here is therefore slightly above the function published by the authors.

The local population distribution was modelled using data from the 2011 census. The census database records the population for each 100 m x 100 m grid cell. Around the centre of each of these cells, the extent of the public green areas identified in the ATKIS-Basis-DLM as suitable for recreational purposes was determined within a distance of 1 km. The marginal utility function shown above was then used to determine the willingness of every household living in the grid cell to pay for an additional hectare of green space. This figure is the simulated price that one could charge for permission to use the ES of one hectare of green space provided it would be possible to exclude residents from these services. It is the price that would apply if there were full competition between the different hectares of green space, and refers to all ES of urban green that have a positive effect on the life satisfaction of local residents. Therefore, the price not only reflects active use as a recreational area but also, for example, the aesthetic value of the area as well as the beneficial impact on air pollution and the local climate. The comprehensive significance of this price can be seen as an advantage of the method used. At the same time, however, it also means that an additional, specially calculated service, such as the improvement in air quality, cannot be simply added to the value until it has been checked whether and to what extent it is already included in the life satisfaction approach.

Table 5.1 gives the results for different sizes of settlement. The geographical area comprises all German cities with more than 50,000 residents, including smaller communities within the metropolitan areas (96 "Functional Urban Areas" according to Urban Atlas). The average supply of urban green in areas with more than one million inhabitants is 58 ha per resident within the 1 km radius. For small settlements of less than 50,000 residents, the corresponding value is 104 ha. The average willingness of households to pay for an additional hectare of green space within the 1 km-radius (= simulated price per ha) is €160.33 per year for the largest cities and €52.25 for the smallest settlements.

The largest share of the willingness to pay remains as a benefit to residents. A smaller share of the benefits accrues to the homeowner through the price. To estimate this share, we drew on the calculation of Kolbe et al. (2019), who found that the value of urban green captured by the experience-preference method is 38 to 124 times the value captured by hedonic-pricing. Furthermore, we consider that the corrected "in-between" marginal utility function referred to here shows values that are only about 80% of the original estimates (s.

Fig. 5.2). Combining these numbers, we can roughly estimate the share of benefits accruing to owners via the price at around 1.5 % of overall benefits. Taken as a present value of an infinite annuity at a discount rate of 3 %, the total amount flowing to owners through the price would be €119 billion compared to €7,616 billion of present value remaining as additional benefits with the residents.

Summing the values of urban green (for residents and owners) per hectare and household (column seven of Tab. 5.1) across all households, we determine an average figure of €2,204,385 for one hectare per year for the largest settlements and €189,003 for the smallest. These figures can be compared with the market value for an alternative use of the corresponding land, e.g. for housing. In 2012, the average price of residential land in cities with more than 500,000 inhabitants was €499.98 per m². In small settlements with 5,000 to 10,000 residents, the average price was €86.35 per m² (Destatis 2020d). The corresponding present (cash) values of 1 m² of green urban area, as shown in column eight of Tab. 5.1, is €7,348 in larger cities and €630 in smaller ones. This is 14 resp. 7 times the value of residential land, representing the current opportunity costs for green urban areas; residential, office and industrial buildings are the most prominent uses competing with utilization as urban green space.

Table 5.1 Value of green spaces in cities and metropolitan regions in the territorial setting of the Urban Atlas [1) 2)]

Settlement sizes [3)]	Number of settlements	Average no. of residents	Population density	Green space within a 1 km radius of each household [4)]	Value of an additional hectare within 1 km for each household	Average value per hectare (for all inhabitants)	Value per m² calculated as discounted value [5)]	Total value of green space within 1 km radius, all green spaces divided by the number of households
inhabitants (thousands)			Population per ha	ha per household	€ / ha / year / household	€ / ha / year	€ per m²	€ / year / household
< 50	4821	5,990	18.52	103.90	52.25	189,003	630	5,434
50-100	83	69,249	40.57	80.83	99.33	660,158	2,201	8,046
100-500	64	190,142	50.77	75.32	110.94	971,944	3,240	8,321
500-1000	9	560,388	65.38	65.92	134.74	1,491,032	4,970	8,893
> 1000	4	1,838,372	76.79	57.73	160.33	2,204,385	7,348	9,299

Total inhabitants: 59,191,525

Discounted value of all green spaces (€, PV): 7,734,232,661,677
Value per year (€): 232.026.979.805

1) Preliminary results
2) The values in columns two to six are all mean values
3) Data from the 2011 census
4) Average household size: 1.8 persons
5) Calculated as the present value (PV) of an infinite annuity with a discount rate of 3 %

Of course, there is no perfect market for urban space. The supply of construction land is constricted by urban planning and, ultimately, political processes – whereas the willingness to pay for green areas as discussed above has no opportunity to materialize itself on a competitive market for urban areas. The values derived from our calculations should be understood as relevant information about the strong preferences of the urban population that must be taken into account in urban planning and political decision-making processes. The currently very high overall value of urban green space of about €230 Bio. per year, compared with a gross value added of the real estate sector of about €273 Bio. in 2012 is a challenge for an accounting system which (still) primarily reflects activities (labor and capital) and not services of nature which are free. Further, if politicians and planner would do as pointed out above, even small increases in supply would change the figures fundamentally; for the average supply is rather near to the saturation point where the simulated prices would tend to zero (Fig. 5.2).

A pragmatic solution for an integration into the accounts could be fixing the current value of urban green on the opportunity cost level, which is 7 to 14 times smaller than the simulated price, and then calculate the future changes with the help of the simulated prices that are derived from the experienced preference method used here. This would have the advantage to start with values that are nearer to the current accounting concepts and add the future changes in a way that is compatible with the (potential and desirable) function of real net income to represent welfare changes (if all external effects and public goods are internalized) (Weitzman 1976, Schweppe-Kraft & Ekinci 2019). Last but not least, it should be noted here that falling values when supply is rising may become a communication problem. The values in the last column of Table 5.1 show this phenomenon quite clearly: They fall as the level of supply increases and rise as we move from well-served small towns to poorly-served large cities. This poses a particular challenge to communicating the value of public green spaces. Schweppe-Kraft & Ekinci (2019) show that it is possible to convert the nominal reduction in value triggered by an increase in supply into a positive contribution to the real national product. Such conversions can significantly boost communication about the high value of additional green spaces.

5.2.4 ES for biodiversity conservation

The Common International Classification of Ecosystem Services (CICES) 5.1 (EEA 2020) defines the cultural ecosystem service 3.2.2.1. belonging to "non-use values" as "Characteristics or features of living systems that have an existence value". The "simple descriptor" for this service states: "The things in nature that we think should be conserved". In a similar way, service 3.2.2.2 is defined for features that have a "bequest value" and should be conserved for the use or enjoyment of future generations. Example services of 3.2.2.1 and 3.2.2.2 are "Areas designated as wilderness" and "Endangered species or habitat".

We have used the so-called "biotope points" as the basis for our calculations. Biotope points take into account characteristics such as naturalness, age, the occurrence of endangered species or the degree of threat to the ecosystem itself. They are widely employed in Germany to determine the no-net loss under nature conservation law when impacts on biological diversity need to be offset by the upgrading or development of new habitats (OECD 2016). Biotope points can thus be regarded as physical exchange values for ecosystems. We have adopted the current federal list (Mengel et al. 2018), which defines average biotope points for about 500 different ecosystem types. The assessments range from 0 (pavements) to 24 (healthy bogs, old (semi-) natural forests). The listed points are considered to be average values that can be increased or decreased by a maximum of three points to reflect specific conditions. A new list, to be published shortly, will be even more differentiated, especially with regard to the sea and coastal ecosystems.

To monitor the extent and current state of the ecosystems, data from various sources has been integrated into a coherent system for long-term analysis (cf. Sect. 5.2.1):

- the German land cover model LBM-DE (BKG 2020), which is compatible with the Corine Land Cover data (Sect. 5.2.1),
- data on land use and on different kinds of agricultural land use from the Federal Statistical Office (Destatis 2020 a, b),
- the Federal Forest Inventory (BMEL 2020),
- data from the reporting on the Habitats Directives (BfN 2020a) and the Water Framework Directive (UBA 2020b),
- Monitoring of High-Nature-Value farmland (BfN 2020b).

With the help of these sources, areas were defined for about 300 different ecosystem types/condition classes, covering the entire territory of Germany.

A certain biotope point value per hectare could be assigned to each of these types. Between 2012 and 2018, the biological diversity in Germany determined by means of biotope points first fell from 420.1 Mio. points in 2012 to 415.6 Mio. points in 2015 and then increased again slightly to 415.7 Mio. points in 2018. The change from 2012 to 2015 can be caused through methodological changes in the data base. The increase from 2015 to 2018 is too small to derive a positive trend. In 2018, Annex I habitats of the Habitats Directive and High-Nature-Value farmland accounted for 18.2 % of Germany's land area as against 31.2 % of total biotope points.

The monetary value of the stock of biodiversity was calculated as the average cost of "producing" a biotope point. Average costs per biotope point were estimated by considering the ecosystem development measures that will be required in the coming years to meet the obligations of the EU Habitat Directives (LANA 2016). The applied calculation combines accounting methods to estimate values for real estate on the basis of construction cost (ImmoWertV 2019, Art. 22) with elements from Habitat Equivalence Analysis (NOAA 2020), which is used to determine compensation for ecological damage. The method takes into account the time needed for each ecosystem to reach the targeted condition (Schweppe-Kraft 2009). A discount rate of 3 % was applied.

The calculated value of the stock of biodiversity using this method was €1,713 billion. This is more than the value of Germany's productive capital (excluding buildings) in 2018, estimated at €1,395 billion (Destatis 2020c). The value of the annual service, calculated as an infinite annuity of the stock value with the above-mentioned interest rate of 3 %, is €1,242 per household and year.

Assessments based on two contingent-valuation studies (Meyerhoff et al. 2012, Hampicke et al. 1991) on the willingness to pay for nationwide nature conservation programmes show values per biotope point that are about twice as high as the values calculated using the cost approach.

5.3 Lessons learned

The project identified four key components of a system of ecosystem accounting in Germany:

1. An ecosystem extent account based on a highly disaggregated (1 ha) land cover dataset (LBM-DE), of 37 CLC classes updated every three years. The account is available in the form of tables, which can be used to devise a land cover change matrix as well as to generate maps.

2. An ecosystem account of agricultural soils based on the above extent account (covering cropland, grassland and land for fruit- and vegetable-growing) and its monetary valuation by considering annual lease prices, differentiated between eastern and western Germany.

3. An ecosystem account of urban green (for cities >100,000 inhabitants) with green based on the above land cover dataset. Its monetary valuation is based on the amenity concept along with the life satisfaction approach. The green amenities are valued with a simulated, spatially disaggregated function of willingness to pay as an ecosystem and as an ecosystem service.

4. The development of a biotope account to measure the conservation value of the ecosystems, differentiated by the conservation status of the various EU regulations (in particular the Habitat Directive; see Sect. 5.2.5). This is supplemented by a federal table of offset ratios according to the German landscape planning law to generate an account of ecosystems and their current conservation value expressed in the points system of the offsetting ratios. The conservation value is monetized by applying estimates of restoration costs on the basis of the net present value.

The project thus accomplished first important steps to advance natural capital accounting from an ecosystem extent account to ES accounts, including substantial elements of a condition account, testing its applicability to different ecosystem types and services. The heterogeneity of ecosystems is reflected in the level of differentiation and spatial disaggregation of the extent account, enabling us to upscale for different conservation topics. With its application to three ES we show that this system is an important step to permit comparisons across ecosystems and services upon a consistent spatial basis.

For many current and emerging issues around ecosystem assessment and accounting, it is vital that we have a clear and reliable delineation of ecosystem types. As discussed and confirmed in the SEEA revision process (UN 2020), the delineation of ecosystem assets should focus on classifying ecosystems from an ecological perspective. In so doing we analysed the German LBM-DE model by considered the CLC classes while introducing additional characteristics to land cover (Grunewald et al. 2020). These datasets can form the basis for the regular reporting on the extent, condition and services provided by Germany's ecosystems at national level. This approach to ecosystem accounting is in line with SEEA-EEA requirements (UN 2020) and the recently published IUCN Global Ecosystem Typology (Keith et al. 2020).

Some challenges to the valuation of ES are as follows (for a more comprehensive discussion, please refer to the project report to be published in 2020):

As with all provisioning services, today a number of (perhaps all?) physical indicators for the supply of ES are highly dependent on anthropogenic influences. In the case of cropland, for example, the potential and the actual harvest depend not only on the natural ecosystem conditions and processes (which will probably have been greatly modified) but also on other factors in the production process, whose contribution might be difficult to disentangle (Sect. 5.2.2).

A similar challenge exists in regard to monetary valuation. By common agreement, economic rent is here taken as the valuation basis; yet this may be difficult to calculate, as the underlying data for the empirical estimate of rents is generally lacking (particularly on a regionally disaggregated scale). While market prices (sales prices and lease prices) can serve as appropriate substitute indicators for the economic rent of the productivity of the soil, they tend to overestimate the value. Since the lease and sale prices are influenced by factors outside the contribution of natural capital (competitive situation, intensity of use of other production factors and their substitution possibilities), it is highly desirable to estimate the contribution of the soil quality rating (SQR) to market prices. The current research interest in land markets has not dealt with the topic in a way compatible with the System of National Accounts (SNA).

When defining and measuring the ES of urban green, this is usually understood as recreation, i.e. a cultural service (Sect. 5.2.3). It is something of a challenge to define this ES, which hitherto has not been addressed in depth. Here urban green is basically regarded as an amenity, without discussing in detail the causal mechanism of how it affects human wellbeing. The methods of hedonic pricing and the life satisfaction approach determine the cause as the proximity of urban green (usually publicly accessible parks) to homeowners within a limited radius around the residence. While this is an important indicator within internationally-agreed sustainability reporting, it only covers one of the benefits of urban green. Private gardens, allotment gardens and the green space around housing also provide previously hidden benefits, which will be similar to the amenity value of parks. Another benefit ignored in the above approach is the activity-based recreational opportunities offered by urban green to residents from outside the neighbourhood. To cover these benefits, another approach has been suggested: To survey the frequency and duration of visits and visitors as well as to value their benefits in terms of travel costs or willingness-to-pay. In Germany this approach has generally been established to determine the use of urban green at individual sites showing above average values rather than on a national scale.

By means of the case study "Ecosystem Services for the Conservation of Biological Diversity" (Sect. 5.2.4), it could be shown how to use ecosystem accounting to integrate large nationwide representative surveys that are exclusively or partially dedicated to nature conservation issues. Based on this, it was possible to assign values to ecosystems throughout Germany for the conservation of biological diversity. This made it possible to define a sufficiently highly aggregated figure for environmental accounting, which can be meaningfully linked with other economically relevant figures from the SEEA and national accounting.

Particularly in the case of common biotopes such as intensively-used grassland and arable land, information gaps can still be identified with regard to their condition and thus their contribution to the conservation of biodiversity. These gaps could be closed by implementing the planned ecosystem monitoring. In addition to the proposed aggregations and interlinked information, there is a need to examine which additional data sources could be usefully integrated into the system to further improve accuracy. Some possibilities include bird monitoring or other indicators from the Federal Forest Inventory such as the proportion of deadwood. Here it is important to ensure that there is no "double counting" of individual aspects of biological diversity.

The basic assumption in the developed methodology is that the relative contribution of diverse ecosystems to biodiversity can be expressed by a single measure. Here we employed the so-called biotope value points, which in Germany have been used for decades to assess compensation measures as demanded by nature conservation law. The ordering of the biotopes within the value scale that is applied in the regulation of compensation measures is very similar to the ordering of biotopes resulting from the application of scientific concepts of human influence (hemeroby) or so-called degrees of naturalness. Furthermore, even in countries where compensation for impairments to nature and landscape is not prescribed, there exist procedures for the comparative assessment of different biotopes, e.g. when optimizing sites or transport networks. It can therefore be assumed that a standard comparative assessment of different ecosystems could be agreed at the international level.

The approach presented here to physically measure the contribution of ecosystems and services to the conservation of biological diversity by means of biotope points can be linked to the economic valuation of these services, both in terms of "subjective" prices and "objective" provision costs. The latter costs should not be confused with the so-called "restoration cost approach", which is viewed rather critically in the context of SEEA-EEA. Rather, they are rooted in exchange values estimated with cost-based methods, which are also used for the valuation of real estate, and in methodological building blocks from the US Department of Commerce's so-called habitat equivalency analysis to quantify ecological damage in monetary terms for some kind of off-setting, which can be seen as a special kind of exchange.

5.4 Conclusions for environmental-economic policy

Our pilot study analysed various international factors as well as actors in order to construct a contextual framework for a new natural capital and ES accounting. Furthermore, the study reviewed theories on the problem of "external costs" of economic reporting systems, a new vision of "nature protection" including the vital economic contribution of natural capital and related ecosystems as well as international activities to stop the loss of biodiversity such as the IPBES and the CBD.

The study succeeded in presenting methodological principles for the definition and empirical identification of ecosystem extent accounting in Germany as well as discussing three important aspects of ES accounting in both physical and monetary terms (Sect. 5.2). A detailed description of the methodological challenges would be a specific German contribution to the international discussion, for example in comparison to some Dutch and British approaches. The final project report will also include a roadmap for a comprehensive reporting system of ecosystems and their services that is fully integrated/linked to the central accounting framework. This will serve to inform policymakers about the full ecological and economic impact of their decisions.

Nevertheless, numerous methodological principles for the consideration of ecosystems and their services in the German SEEA still need to be clarified at the interface of interdisciplinary science and international statistical standards. The results of the current project constitute a building block towards this and, in coordination with the Federal Statistical Office for the further development of the SEEA-EEA, should also contribute to an international standard.

One recommendation that can be formulated here is to orient the practical accounting work towards selected issues that are of high political relevance and closely related to biodiversity conservation targets in urban and rural areas (e.g. land conversion, green urban areas, biodiversity accounting).

While in Germany the Federal Environment Ministry (BMU) and the Federal Nature Conservation Agency (BfN) as well as the scientific community now appreciate the importance of ecosystem accounting, this awareness has not yet seeped into the public consciousness. In this respect, the research project has not merely aimed to advance the physical and monetary recording of exemplary ES but also to help lay the groundwork for this still new agenda. One previous policy paper issued within the project on the "overlooked values of nature" (Zieschank et al. 2018) led to a minor inquiry in the German Bundestag (Deutscher Bundestag 2019). Furthermore, a publication in the nature conservation journal "Natur und Landschaft" proposed a "First National Workshop for a Future Ecosystem Accounting in Germany", in cooperation with the EU Horizon 2020 Project MAIA. This will help to establish a relevant network involving different federal agencies and scientific institutions as well as the Federal Statistical Office.

Such forms of agenda setting and communication about the possibilities of a new ecosystem accounting are opportunities to further enhance SEEA-EEA work. Certainly, the creation of a reliable data basis for the identification of ES is a challenge both for the research landscape as well as for the various involved ministries (and indeed their respective perception of administrative responsibilities). If the relevant ministries act in accordance with the national government's clear statement that the values of biodiversity, ecosystems and their services must be better recorded, evaluated and also integrated into national accounting systems (German Bundestag 2019), great strides could be taken in the coming years. In the field of biodiversity research, there are already promising signs of closer cooperation between the BMU and the Federal Ministry of Education and Research (BMBF).

Finally, an important factor in coming years will be to ensure an institutional interface between science or research and politics, so that the results on the significance of ES can be more easily incorporated into political decision-making processes (see Daily et al. 2011 and Saarikoski et al. 2018). This is underlined by EU guidance on the "Integration of Ecosystem Services in Decision-making". The considerable effort required to further develop SEEA and to provide information for other reporting systems also implies – particularly in our information age – the setting of new priorities within political decision-making.

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6 Integrated Accounting for Wildlife Watching Tourism in Uganda

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This work is funded by the UK Government's Darwin Initiative.

6.1 Introduction

Biodiversity is an essential part of Uganda's 'natural capital'; the interactions of ecosystems and species underpin the delivery of many services and benefits that support economic activity and the well-being of its people. However, the value of biodiversity is often neglected in traditional assessments of economic progress and development planning. This encourages inefficient, inequitable and unsustainable growth. These challenges are recognized in the Uganda Green Growth Development Strategy (UGGDS), as well as the National Development Plan (NDP II) and National Biodiversity Strategy and Action Plan (NBSAP). Collectively, these plans describe the need to manage natural capital to deliver economic development, wealth creation and poverty alleviation. The plans also identify natural capital accounting as a strategic tool towards improved management.

In order to extend Uganda's current national accounting system to better consider biodiversity-related natural capital, the National Environmental Management Authority (NEMA), the National Planning Authority (NPA) and Uganda Bureau of Statistics (UBoS), with support from the United Nations Environment Programme World Conservation Monitoring Centre (UNEP-WCMC), International Institute for Environment and Development (IIED) and Institute for the Development of Environmental-Economic Accounting (IDEEA Group) are implementing the project: Integrating Natural Capital into Sustainable Development Decision-Making in Uganda. The project was initiated in July 2018 and will run until September 2021. This ongoing project is being funded by the UK Darwin Initiative. A dedicated webpage for the project is available at: https://www.unep-wcmc.org/featured-projects/nca-in-uganda

A key objective of the project is to support the delivery of Uganda Green Growth Development Strategy (UGGDS) by contributing to poverty alleviation, wealth creation and meeting biodiversity goals (e.g. Aichi Target 2). The project is also designed to help deliver Uganda's National Plan for Advancing Environmental-Economic Accounting (NP-AEEA), developed as part of a coordinated effort between UBOS, United Nations Statistics Division (UNSD), NPA, NEMA and other Ministries, Departments and Agencies. The project complements existing initiatives of the NP-AEEA by ensuring biodiversity elements become a concrete component of Uganda's regular environmental accounting process. The proposed biodiversity-related natural capital accounts to be compiled, comprise: Fisheries accounts; Land and soil improvement accounts; and, Integrated tourism and biodiversity accounts.

The project is structured on four sets of activities:

- Building awareness of biodiversity-related natural capital via regular communications.
- Developing and testing accounting approaches, including user needs assessment and developing a credible, legitimate approach via regular stakeholder workshops and meetings.
- Building communities of practice via capacity building workshops and training materials.
- Institutionalizing the accounts by working with sectors to apply them in development planning.

This chapter focuses on the development of an initial, indicative set of integrated tourism and biodiversity accounts. The accounting structures presented have been developed in response to identified user needs. They are currently populated using readily available information and work is ongoing in Uganda to update the accounts with improved, quality assured data. Work on fisheries and land and soil improvement accounts is also ongoing. All outputs will be posted on the project website in due course.

6.2 Indicative integrated tourism and biodiversity accounts

The tourism sector is the highest foreign exchange earner in Uganda, contributing US$ 1.9 billion to Uganda's GDP (7.3%) and employing 6% of her labour force (2017/18). A key motivation for tourists visiting Uganda is to observe iconic species and habitat, such as gorillas, chimpanzees, lions, elephants, lakes and forests. Consequently, the tourism sector in Uganda relies heavily on a healthy stock of ecosystems and species to supply tourism related goods and services to different consumers. However, Ecosystem Accounts for Uganda published in 2017 reveal significant reductions in the extent of suitable habitat for Elephants (-103,735 ha) and Chimpanzees (-72,326 ha) between 2005 and 2015 (UNEP-WCMC & IDEEA, 2017).

To better understand the link between ecosystems and tourism, the accounts presented in this section are structured to organise information on the 'Stock' of ecosystems and species that use them and on the 'Flows' of ecosystem services (ES) (i.e., enabling tourism and recreation) they provide to the tourism sector and associated expenditure by tourists. The flow of this ecosystem service from an ecosystem to an economic unit essentially represents a transaction involving supply and use. However, there is not a transfer of funds between the ecosystem and the economic unit. To realise the monetary value of the ecosystem service, the economic unit provides access, accommodation and other services to tourists. Figure 6.1 sets out this sequence of transactions and the associated agents.

Figure 6.1. Transactions between ecosystems, economic units and consumers, adapted from Eigenraam and Obst, (2018).

With reference to Figure 6.1, the accounts presented relate to the following:

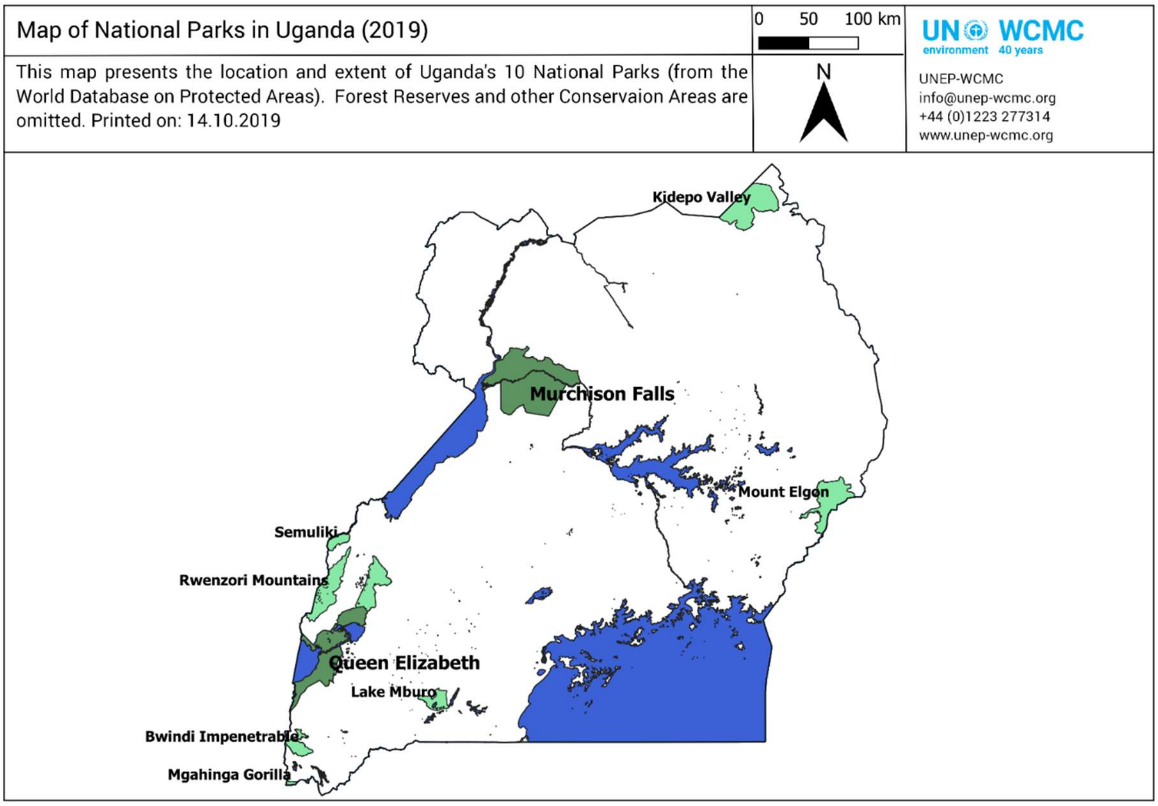
- Ecosystem extent accounts: Provide information on the 'Stocks' of natural ecosystems;
- Species (thematic biodiversity) accounts: Provide information on the 'Stocks' of iconic species relevant to wildlife watching tourism.
- Ecosystem service accounts (physical and monetary): Provide information on the 'Flows' of 'enabling tourism and recreation' services provided to the tourism sector (e.g., visits to National Parks operated by the Uganda Wildlife Authority).
- SNA supply and use accounts: This novel extension to the SEEA EEA is a combined presentation of tourist expenditure on SNA goods and services, integrated with information from the ecosystem service accounts.

It is highlighted that the accounts presented are indicative. Their structures have been populated using readily available information from the statistical and other sources cited. As part of the ongoing project, work is ongoing in Uganda, under the direction of UBoS, for further data collation, harmonisation and quality assurance to make accounts fit for national planning purposes.

6.2.1 Ecosystem Accounting Areas

As a first compilation step, indicative integrated tourism and biodiversity accounts for Uganda have been compiled for the network of National Parks (see Figure 6.2). Where possible, these accounts are further disaggregated for Murchison Falls and Queen Elizabeth National Parks to illustrate the approach (dark green in Figure 6.2). The ambition is to improve the data foundation for these areas and expand the accounts to also include forest reserves, RAMSAR or other wetland sites over the lifetime of the project.

Figure 6.2 Map of National Parks in Uganda.



6.2.2 Ecosystem Extent Accounts

As proposed in para. 3.18 of the SEEA Technical Recommendations, land cover can be used as a proxy to delineate the extent of different ecosystem assets as a starting point (UN et al., 2017). The National Biomass Study (NBS) (Diisi, 2009) provides land cover maps for 1990, 2005, 2010 and 2015 and a starting point for delineating ecosystem types in a fashion that will be recognizable to national decision makers.

Ecosystem extent accounts for Murchison Falls and Queen Elizabeth National Park are presented in Table 6.1. Table 6.1 follows the typical asset structure for environmental accounts, with the opening stock in hectares for each land cover class set out in the top row and closing stock in the bottom row. Gross and net changes are recorded in the middle rows. These accounts draw on the NBS land cover data and information on protected area extent from the world database of protected areas. In Table 6.1 all natural land cover classes have been aggregated to a single category. As Table 6.1 reveals, natural ecosystem extent has decreased slightly in Murchison Falls between 1990 and 2015 (-3,126 ha) and increased slightly in Queen Elizabeth (+1,164 ha). The overall picture is one of general stability over this period.

As the projects progresses, these ecosystem extent accounts will be expanded to include other accounting areas discussed in Section 6.2.1 and aligned with the official national land accounts.

Table 6.1 Ecosystem Extent Accounts, Murchison Falls and Queen Elizabeth National Parks.

Murchison Falls NP Classifications >>	Built up area	Farmland and plantations	Natural	Open Water	Other	TOTALS
Opening Stock (1990)	-	1,351	380,957	5,342	-	387,650
Additions to stock						-
Total additions to stock	130	5,330	3,148	422	405	9,435
Reductions in stock						-
Total reductions in stock	-	927	6,274	2,234	-	9,435
Net change in stock	130	4,403	(3,126)	(1,812)	405	-
Closing stock (2015)	130	5,754	377,831	3,530	405	387,650

Queen Elizabeth NP Classifications >>	Built up area	Farmland and plantations	Natural	Open Water	Other	TOTALS
Opening Stock (1990)	221	1,578	200,108	6,335	939	209,181
Additions to stock						-
Total additions to stock	109	674	2,797	845	105	4,530
Reductions in stock						-
Total reductions in stock	193	1,275	1,633	498	931	4,530
Net change in stock	(84)	(601)	1,164	347	(826)	-
Closing stock (2015)	137	977	201,272	6,682	113	209,181

6.2.3 Species (thematic biodiversity) accounts

Observing iconic species will be a prime motivation of many tourists visiting Uganda. The extent of natural habitat provides useful (proxy) information on the suitability of ecosystems to support species. However, information on the actual stocks of iconic species provides tangible links to the condition of ecosystems that enable tourism and recreation, and associated wildlife watching tourism opportunities.

Species Accounts can be considered a thematic biodiversity account, as described by the SEEA EEA. It is proposed to develop these accounts using species census data for the species that are of particular interest to tourists. These accounts need to organise species census data for the same ecosystem accounting areas as the other accounts, if an integrated set of accounts is to emerge. Table 6.2 provides a Species Account structure for Uganda. The final set(s) of species to include in the account and the collation of data to compile the account is ongoing.

Table 6.2 Proposed Species Account for Protected Areas.

Classifications >>	Species Account (Protected Areas)				
	Chimpanzees	Gorilla	Lions	Elephant	Buffalo
Opening Stock (2010)					
Additions to stock					
Total additions to stock					
Reductions in stock					
Total reductions in stock					
Net change in stock					
Closing stock (2015)					

6.2.4 Monetary Ecosystem Service Supply and Use Accounts & SNA Goods and Services Accounts

The structure of the ecosystem service supply and use accounts is presented as Table 5.1 in the SEEA EEA Technical Recommendations (UN et al., 2017). The same structure can be used for both physical and monetary accounts. Table 6.3 applies this structure to provide a monetary Supply and Use Table (SUT) for the 'enabling tourism and recreation' ecosystem service in Uganda, for the 2017/18 financial year. The specific protected areas supplying the 'enabling tourism and recreation' ecosystem service are listed in the right hand columns of Table 6.3. The different types of economic units using the 'enabling tourism and recreation' ecosystem service are set out in the left-hand columns.

The top section of Table 6.3 presents expenditure by tourists on park entrance fees to Queen Elizabeth (USD 1,446,537), Murchison Falls (USD 1,994,709) and the other eight national parks (USD 2,944,685) and also guiding fees expenditure (USD 9,355,603, in aggregate) for the 2017/18 financial year. The information on park fees was obtained from park visitor counts reported in Uganda Wildlife Authority's Corporate Annual Report 2017/18 (UWA, 2018) and the UWA tariffs for 2018 to 2020.[5] Guiding fees were estimated for the national park network as a whole from park entry and recreation activities revenues reported in the annual tourism sector performance report 2016/17 (MTWA, 2017). These are considered suitable proxies for valuing the supply of the 'enabling tourism and recreation' ecosystem service.

The bottom of Table 6.3 presents these values disaggregated by the type of economic unit that uses the 'enabling tourism and recreation' ecosystem service as a basis for a subsequent transaction with a consumer (i.e., the tourist). As the national parks are run by the government, this is the economic unit using the ecosystem service (with an aggregate proxy value of USD 15,741,534 collected by UWA).

With reference to Figure 6.1, Table 6.3 provides the information on the transaction between the ecosystem and the supplying economic unit. As such the middle columns relevant to consumers are blanked out. Table 6.4 provides the information on the subsequent transactions between economic unit and the ultimate consumers of the 'enabling tourism and recreation' ecosystem service, the tourists (the right part of Figure 6.1).

The top of Table 6.4 provides information on the value of SNA products and services associated with wildlife watching tourism that accrue to different economic units. It includes the value of the park entrance and guiding fees that accrue to the government. It also includes additional services, such as accommodation, meals and transport, revenue from which may accrue to other economic units. These values were estimated using an economic and statistical analysis of tourism in Uganda (World Bank Group, 2013).

The bottom section of Table 6.4 presents the value of the expenditure on these products and services associated wildlife watching tourism by type of tourist (this is final consumption by household). This comprises information on whether the tourist is an international visitor, a regional / East African Community

[5] https://www.ugandawildlife.org/conservation-tariff-fees

(EAC) visitor or a domestic tourist (although some effort is still required to disaggregate Ugandan visitors from non-Ugandan EAC visitors).

Table 6.4 is important because it provides information on all the economic activity supported by the 'enabling tourism and recreation' ecosystem service. Table 6.4 reveals that this is USD 75,051,378, five times the revenue accruing to the government in park entrance and guiding fees. It also provides useful information on which consumers participate the most in these transactions, where they participate in these transactions and their trends over time. For example, Table 6.4 reveals that well over half the economic activity associated with wildlife watching tourism is derived from international tourists from outside the EAC (USD 40,358,285).

6.2.5 Limitations

It is highlighted that the accounts presented are indicative and have been rapidly compiled using readily available data. They should not be used for decision making purposes at this stage and remain under development. Nonetheless, a couple of clear measurement limitations are highlighted:

- Further work is required to isolate the contribution of ecosystems to the value of experience the consumer enjoys. Following, Remme et al., (2015) the resource rent approach can be used, where the contribution of the ecosystem service to the overall value of the experience the consumer enjoys is estimated by subtracting all costs for capital and labour from the park visitor and guiding fees. However, this may not be wholly reasonable or straight forward, as there are multiple objectives for capital investment in national parks.

The core SEEA EEA accounting model aims to organize information on the supply of ES by ecosystem type. However, tourists will be motivated to visit national parks to see a range of natural features (e.g., waterfalls, forests, savannahs) and different species using these different ecosystems. As such, treating national parks as ecosystem accounting areas providing the overall 'enabling tourism and recreation' ecosystem service is considered appropriate at this stage.

Table 6.3 Monetary Supply and Use Tables for enabling tourism and recreation ecosystem services.

	Ecosystem Service Users				Consumers				Ecosystem Service Suppliers				
	Type of Economic Unit				Type of Consumer				Protected Areas				
Classifications >>	Government (UWA run National Parks)	Businesses (Private tourist operators)	Households (inc. cultural cooperatives)	TOTAL USED	Households (International visitors FNR)	Households (EAC visitors)	Households (FR & Student visitors)	TOTAL CONSUMED	Queen Elizabeth	Murchison Falls	Other NPs	NFA Forest Reserves	TOTAL SUPPLIED (Protected areas)
Monetary Supply Ecosystem Service Supply (2017/18)													
Enabling tourism and recreation (Park entrance fees)									1,446,537	1,994,709	2,944,685	ND	6,385,931
Enabling tourism and recreation (Guiding services)									ND	ND	ND	ND	9,355,603
TOTAL									**1,446,537**	**1,994,709**	**2,944,685**	**ND**	**15,741,534**
Monetary Use Ecosystem Service (2017/18)													
Enabling tourism and recreation (Park entrance fees)	6,385,931	ND	ND	6,385,931							Intermediate services		
Enabling tourism and recreation (Guiding services)	9,355,603	ND	ND	9,355,603							(dependencies between ecosystems)		
TOTAL	**15,741,534**	**-**	**-**	**15,741,534**									

Work is ongoing to establish values for this table and undertake necessary data quality assessments. "ND" Means No data available

Table 6.4 Monetary Supply and Use Tables for SNA Products and Service associated with wildlife watching tourism and recreation.

	Producers				Consumers				Ecosystem Service Suppliers				
	Type of Economic Unit				Type of Consumer				Protected Areas				
Classifications >>	Government (UWA run National Parks)	Businesses (Private tourist operators)	Households (inc. cultural cooperatives)	TOTAL USED	Households (International visitors FNR)	Households (Regional / EAC visitors)	Households (FR & Student visitors)	TOTAL CONSUMED	Queen Elizabeth	Murchison Falls	Mount Elgon	NFA Forest Reserves	TOTAL SUPPLIED (Protected areas)
SNA Supply Products & Services (2015)													
Park entrance	6,385,931	ND	ND	6,385,931									
Expenditure on Hotels, bars, restaurants *		39,296,097	ND	39,296,097									
Guiding services	9,355,603	ND	ND	9,355,603									
Expediture on retail items*	ND	8,244,866	ND	8,244,866									
Expenditure on passenger road transport*	ND	8,843,284	ND	8,843,284									
Expenditure on other services	ND	2,925,598	ND	2,925,598									
TOTAL	**15,741,534**	**59,309,845**	**-**	**75,051,378**									
SNA Use Products & Services (2015)													
Park entrance					5,463,245	437,870	484,816	6,385,931					
Expenditure on Hotels, bars, restaurants*					23,119,920	13,713,226	2,462,950	39,296,097					
Guiding services (Days)					ND	ND	ND	9,355,603					
Expediture on retail items*					4,850,880	2,877,225	516,761	8,244,866					
Expenditure on passenger road transport*					5,202,960	3,086,056	554,268	8,843,284					
Expenditure on other services*					1,721,280	1,020,951	183,367	2,925,598					
TOTAL					**40,358,285**	**21,135,328**	**4,202,162**	**75,051,378**					

Work is ongoing to establish values for this table and undertake necessary data quality assessments "ND" Means No data available. *Considers 'Foreign Residents Only' (Students excluded)

6.3 Policy use

The UGGDS acknowledges the risk decline in natural capital (including ecosystems) pose to tourism and other sectors. In response, it targets natural capital management as a catalytic investment area. The Tourism and Wildlife Sector is one of four natural capital sectors targeted, with an ambition to quadruple the value of foreign tourism, create jobs and enhance natural capital protection by 2030. The Integrated tourism and species / biodiversity accounts presented in Section 6.2 will help support the implementation of the UGGDS by:

- Revealing expenditure associated with the wildlife tourism sector (identifying highest multipliers for green growth)
- Revealing trends in the natural ecosystem and species loss by location and identifying where these are a risk to tourism revenues (informing the protection of biodiversity related natural capital)
- Identifying opportunities for developing wildlife watching packages for different tourists (increase export revenue)
- Linking wildlife tourism development to job creation and poverty alleviation opportunities (via integration with local employment and poverty statistics)
- Informing macroeconomic analysis for Green Economy policy planning (by linking ES to standard economic units).

6.4 Lessons learned and conclusions

This project benefited from a context report that initially identified these entry points and relevant stakeholders (UNEP-WCMC et al., 2019). This helped identify clear policy entry-points, which was essential to inform the structuring of the accounts around a meaningful set of relevant analyses.

A key outcome from the project is now to deliver a set of SEEA EEA based accounts that remain relevant and also credible and legitimate. This requires broad institutional support, to allow stakeholders to shape the development of the accounts to meet user needs, establish the relevant data foundation and to foster ownership in the regular production and use of the accounts. This all requires time and resources to achieve. It should also be appreciated that both account producer and user groups will need to have their capacity built if the accounts are to build demand for such regular production. A clear communication strategy should also be implemented to build this demand.

In order for the accounts to be institutionalized and regularly contribute to national planning, it was essential that the National Statistical Office was involved at the outset. For Uganda, it clearly helped to have an overarching national plan for advancing the implemention of the SEEA to guide the compilation process.

In terms of the production of the indicative biodiversity and tourism accounts, this paper identifies that once suitable accounting structures and data items are agreed initial accounts can be compiled for demonstration rapidly. This highlights that useful outcomes can be, relatively, easily achieved using existing information.

A key objective of environmental accounting is the integration with wider statistics on economic activity and society. As shown in this paper, whilst information on the goods and services associated with wildlife watching tourism be recorded elsewhere in the SNA, it is not aligned or integrated with information on the 'Stock' of ecosystem assets that support their provision (e.g., Protected Areas and the Species they support). Addressing this disconnect using the types of integrated environmental-economic accounting approach presented is vital to informing the relationship between Uganda's environment and its economy, highlighting the importance of sustainably managing ecosystem assets and identifying economic opportunities for development based on their sustainable exploitation.

Going forward, of interest will be linking the accounts to tourism satellite accounts (UN, 2010). This could deliver a more integrated information set on employment data and the wider value chain related to wildlife watching tourism. Work on linking the environment and the economy in the context of tourism is also occurring within the UN World Tourism Organization's project on Measuring the Sustainability of Tourism (MST).[6] It will also be interesting to link information on environmental expenditure associated with

(6) https://www.unwto.org/Measuring-Sustainability-Tourism

conservation activities and protected areas, in particular to the information organised via the BioFin initiative in Uganda[7]

Based on the experience to date in implementing the Integrating Natural Capital into Sustainable Development Decision-Making in Uganda project, key elements to consider when compiling SEEA EEA accounts are:

- Compilation should be guided by identifying clear policy entry-points and analytical objectives (e.g., integration with other economic and social statistics to guide development planning).
- National statistical offices should be involved at the outset and throughout.
- All stakeholders should be identified and engaged to foster ownership and ensure relevant, credible and legitimate accounts are delivered. This takes time and resources.
- Use readily available data to compile the priority accounting modules quickly and demonstrate the potential of accounts and build from there.
- The data collection process for accounts compilation is a social, as well as technical, process. It should aim to build the institution relationships to support regular accounts compilation.
- Allow for communication and capacity building for accounts producers and users to build demand for regular production and use.

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(7) More general work on linking the SEEA and BioFin is ongoing, see: https://unstats.un.org/unsd/envaccounting/ceea/meetings/twelfth_meeting/Methodological%20alignment-biodiversity%20accounting%20Final.pdf

7 Modelling flood regulation ecosystem services in support of ecosystem accounting in Bulgaria

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7.1 Introduction

The EU Biodiversity Strategy 2020 provided an important push to the implementation of ecosystem services (ES) concept by the initiative for mapping and assessment of ecosystems and their services (MAES) which developed a conceptual framework and guided the countries in their efforts to fulfil the requirements of the strategy (Maes et al., 2018). The MAES process in Bulgaria started in 2014 with the preliminary mapping of ecosystems and the next stage was the development of a methodological framework and its implementation through nine mapping projects corresponding to the main ecosystem types in MAES typology (Nedkov et al. 2017). The work on these projects led to the development of knowledge and data which can be used for the next step of the implementation of the strategy i.e. to promote the integration of ecosystem values into accounting and reporting systems at the national level.

The National Institute of Geophysics Geodesy and Geography (NIGGG) is a research unit within the frame of Bulgarian Academy of Sciences which carries out fundamental and applied studies in the field of geophysics, seismology, earthquake engineering, geodesy, and geography in order to facilitate the sustainable development of the Republic of Bulgaria. A research group in the department of geography works in the field of ES mapping and assessment during the last 15 years. The first study has been initiated within the frame of flood risk assessment project implemented in 2006-2007 by application of GIS-based hydrologic modelling tools (Nikolova et al., 2009). This work has been developed for flood regulation ES mapping and assessment at a local level (Nedkov and Burkhard, 2012). The methodology from this work has been further developed and implemented for water-related ES within the frame of EU FP 7 project SWAN (Sustainable Water Action). The mapping of flood regulation has been implemented through the application of the SWAT (Soil and Water Assessment Tool) model at different watersheds (Boyanova et al., 2014; Nedkov et al., 2015. The SWAT modelling results have been further developed for quantification and mapping of water supply and water purification (Boyanova et al., 2016a; 201b). The mapping of flood regulation and water supply have also been implemented for the development of the methodology for mapping and assessment of ES for the needs of MAES in the ESMERALDA project (Nedkov et al. 2018).

The modelling of water regulation services is among the main aims of the NIGGG team as a part of the MAIA (Mapping and Assessment for Integrated ecosystem Accounting) project which aims to mainstream natural capital and ecosystem accounting in the EU Member States based on the SEEA-EEA framework. Water regulation is considered as one of the main regulating ES by SEEA-EEA. It includes water retention, storm and high water protection (including flood control) and it is also closely related to erosion and sedimentation control. Although there is some progress in the accounting of water-related regulating services, further development in this area is much needed (Vardon, 2014). The main objective of this work is to apply GIS-based modelling for one of these services (flood regulation) for the needs of ecosystem accounting which could provide the necessary information for different aspects of the water cycle that cannot be extracted through direct measurements. The methodological approach is based on process-based biophysical modelling with GIS-based hydrologic tool AGWA.

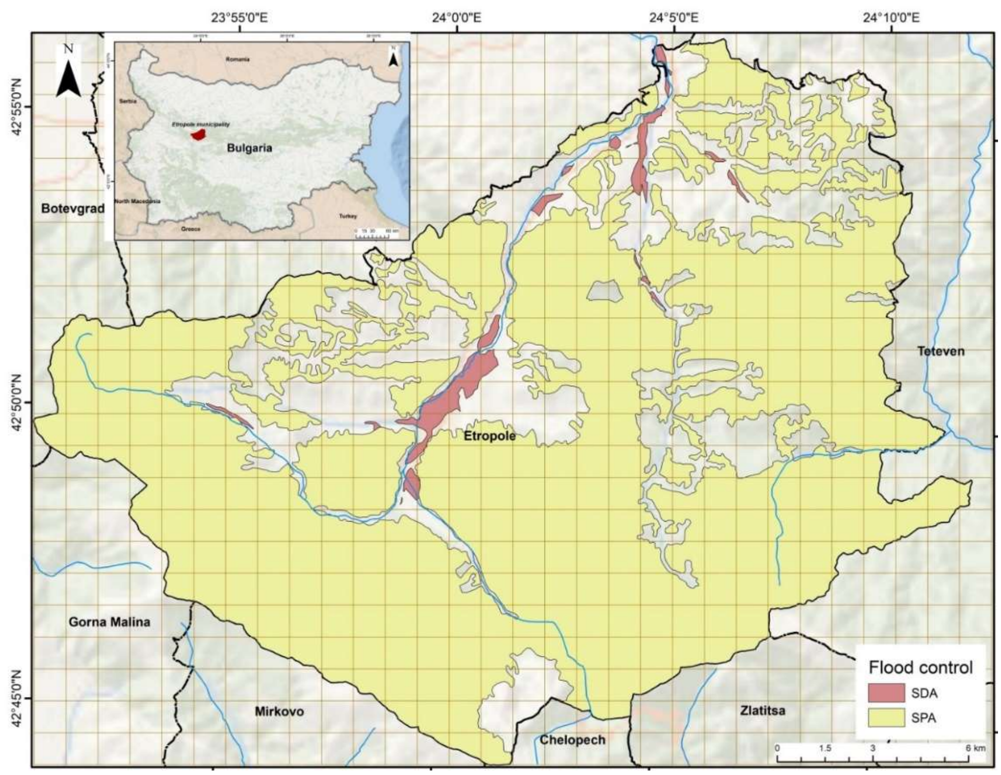
In this chapter we address mainly the physical component of the accounting, namely service supply and service use accounts for the flood regulation based on biophysical modelling.

7.2 The accounts

The accounting of flood regulation is based on the assumption that specific ecosystems can reduce the extent and intensity of floods, thus reducing the risk of damage to build environments (UN et al., 2014). In the case of river floods, the regulation function can be preventing or mitigating. The preventing function occurs when the ecosystems (i.e. forests) redirect or absorb parts of the incoming water (from rainfall), reducing in such a way the surface runoff and consequently the amount of rivers swelling discharge. The flood mitigation function comes into effect when the flood is already formed and the ecosystems (i.e. flood plains and wetlands) provide retention space for the water surplus to spill, thus reducing the flood's destructive power. In both cases, the ecosystems which provide the service are located at a particular distance from the demand areas. The spatial relationship between them can be represented by the so-called Service Providing Areas (SPA) and the Service Demanding Areas (SDA) (Syrbe et al., 2017). For accounting purposes, the SPA corresponds to the service supply, while the SDA to the service use. In many studies the ES supply is separated into potential and actual flow, thus taking into account the difference between the whole amount of the service provision and its actual use. Sturck et al. (2014) state that the benefits of flood regulation ecosystem service supply can only be assessed when demand and supply, as well as their spatial interactions, are considered. This spatial interaction can be represented by the actual flow of the flood regulation. For the needs of flood control accounting, Vallecillo et al. (2019) define the actual flow as the "extend of the demand with upstream protection from the upstream ecosystems with high runoff retention potential". Therefore in this work, we focus on three modules of flood regulation ecosystem accounting, i.e. ES potential, ES demand, and ES actual flow.

The accounting is applied in the case study area of Etropole municipality (fig.7.1), which has already been an object of flood regulation mapping and assessment (Nedkov and Burkhard, 2012; Boyanova et al., 2016a). The assessment of ES supply is based on the results of biophysical modelling by the GIS-based AGWA tool which utilizes the KINEROS (Kinematic Runoff and Erosion model) hydrologic model. The results are in the form of flood regulation supply capacity map presented in six categories ranging from 0 (no relevant capacity) to 5 (very high relevant capacity) (Nedkov and Burkhard, 2012). In order to define the SPA, we select the upper three categories from the assessment scale (medium, high and very high capacity). The resulting SPA areas are presented in figure 7.1. The SDAs are defined in a similar way by selecting the areas with medium to very high demand from the map of ES demand for flood.

Figure 7.1 The Service Providing Areas (SPA) and the Service Demanding Areas (SDA) in Etropole municipality



The extent account of the SPA and SDA is performed using a 1x1 km grid (fig. 7.1). The grid is intersected with the SPA and SDA polygons and each cell of the grid is assigned to a particular category. Then, the grid is intersected with the CORINE land cover data (available for 2000, 2006, 2012 and 2018) and the results are distributed into ecosystem types following the MAES typology (Maes et al., 2013) and its implementation in the the mapping of ecosystems in Bulgaria (Nedkov et al., 2017). The results for SPA represent the ES potential for the case study area which are given in the accounting table, while the results for SDA represent the ES demand (table 1). The actual flow of flood regulation is calculated as a ratio between ES demand and ES potential and it represents the area of SPA which corresponds to the demand for flood regulation represented by SDA.

Table 7.1. Accounting table of flood regulation potential, demand and actual flow in Etropole municipality.

ES Flood regulation							
Components	Ecosystem types					Total [ha]; [€]	Years assessed
	Cropland	Grassland	Heathland and shrub	Urban	Woodland and forest		
ES Potential	76.35	1560.82	132.12	48.14	26316.60	28134.03	2000
	76.91	1560.71	132.15	74.10	26290.10	28133.97	2006
	190.40	1551.12	124.04	68.44	26200.00	28133.99	2012
	271.40	1812.11	0.00	146.97	25903.50	28133.98	2018
	153.76	1621.19	97.08	84.41	26177.55	28133.99	average
ES Demand	255.38	0.00	0.00	244.91	1.03		2000
	255.39	0.003	0.00	244.90	1.03		2006
	259.91	3.40	0.00	231.78	6.23		2012
	263.01	0.00	0.00	232.08	6.23		2018
	258.42	0.85	0.00	238.42	3.63	501.32	average
ES Actual flow	0.21	4.20	0.36	0.13	70.77		2000
	0.21	4.20	0.36	0.20	70.70		2006
	0.51	4.17	0.33	0.18	70.46		2012
	0.73	4.87	0.00	0.40	69.66		2018
	0.41	4.36	0.26	0.23	70.40	75.66	average

The figures presented in Table 7.1 should be considered as preliminary results of an accounting study which is still in its initial stage. The hydrological model used for this study is applicable for relatively small watersheds which is the main limitation of the approach. The utilization of other models such as ArcSWAT which have already been used in ES assessment (Boyanova et al., 2018; Nikolov and Nedkov, 2020) could contribute to overcoming this limitation. The identification of the SPA in this study is based on ES assessment results presented on a relative scale which is a source of uncertainty. This procedure also needs further development by finding more precise indicators and mapping techniques.

7.3 Policy use and lessons learned

The main policy drivers for flood regulation accounting are in relation to water management which is set out in the Bulgarian Water Act (WA). It is implemented mainly through two key planning instruments, the River Basin Management Plans (RBMPs) and Flood Risk Management Plans (FRMPs). They promote integrated water resources management at the national and transnational level and according to the WA should be reviewed and updated every six years after their initial publication. The main activities in the FPMSs were focused on the floodplain areas while the regulation of the ecosystems in the whole basin was more or less neglected. The identification of the SPAs and the accounts of their regulation function would be a valuable contribution to the next update of the FPMSs.

There is also a need to measure and communicate water regulation services within the local context of decision making and within the local landscape where the conflict between development and conservation is played out (Barbedo et al., 2014). From this point of view, the flood regulation accounting gives important evidence to strengthen the conservation policy position in the debates.

The main outcome of this work is that we manage to extract appropriate quantitative results suitable for the ecosystem accounting for the spatial distribution of one important regulation service which has been a big challenge so far. The approach is based on the reprocessing of modelling results from the assessment of the flood regulation supply. The results show that hydrological modelling can provide a good basis for accounting purposes. For the current work, we use data from flood regulation assessment which have already been classified according to the assessment categories and then reclassified into two classes for the needs of the accounting. For future work, this step could be avoided and the results of the hydrologic modelling can be used directly for the accounting needs.

One of the critical points of the approach is the identification of the SPA based on the hydrological modelling results. The main problem is how to determine the threshold value which outlines the SPA. In this study, we use the intervals for the flood regulation assessment which is defined through statistical quantile distribution. This distribution is specific for the watershed of the case study area and in another watershed it will be different. The development of a precise procedure to define the threshold value is one of the main challenges for future work.

Another critical point is the precision in the identification of SDA. These are the areas under threat of flood hazard and their delineation is a complicated procedure based on various data including long term hydrological dataset, precise topography of the floodplain, soil and land cover data in combination with hydraulic modelling.

7.4 Conclusions

The quantification of flood regulation function of the ecosystems is crucial for both ES assessment as well as accounting. The biophysical modelling can provide the much needed quantitative data for the important hydrological parameters such as surface runoff and infiltration of the ecosystems throughout the watershed which are not available through direct or indirect measurements. In this work, we demonstrate how the results from flood regulation assessment can be used for accounting of ES potential and ES Demand on a large scale at the municipality level. Their spatial distribution is a basis for the calculation of the actual flow. The preliminary results are encouraging but the approach needs further development for more precise identification of SPA and the calculation of ES value. The main challenge for the near future is to develop the approach for application and effective integration into accounting and reporting systems at the national level.

Acknowledgment

This study is carried out under the project “Mapping and Assessment for Integrated ecosystem Accounting (MAIA)”, funded from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 817527.

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Sub-national accounts

8 Ecosystem services accounting: Application to holm oak open woodlands in Andalusia-Spain

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8.1 Introduction

8.1.1 Brief background to publications by the authors on ecosystem accounting

The authors have extensive experience in the application of physical accounts (including unit energy metrics) and integration of ecosystem economics in national accounting of forest, silvopastoral and agroforestry landscapes. In the early 1980's we published papers comparing the production accounts and energy use of agriculture in Spain for the years 1950 and 1977 (Naredo and Campos, 1980), of traditional and industrialized agricultural systems in large properties in Andalusia for the years 1951 and 1980 (Campos and Naredo, 1980), of small family owned properties in Asturias (Campos, 1982)and of a group of agroforestry farms in Extremadura for the years 1955 and 1975. Campos and Riera (1996) presented the first application of the Agroforestry Accounting System (AAS) incorporating private amenity auto-consumption by non-industrial landowners and public recreational services in a sample of silvopastoral farms in Spain (where they are termed dehesas) and Portugal (montados) for the year averaged period of 1991-1993. In Caparrós et al. (2003) the simulated exchange value is applied to the valuation of public recreational services in Scots pine forests of the Guadarrama mountain range in Madrid. In Campos et al. (2009) we estimate the value of landowner's amenity auto-consumption in private silvopastoral farms in areas with a Mediterranean climate in Spain, Portugal and California (USA). In Campos et al. (2016) we estimate the ecosystem services (ES) of natural grazing in silvopastoral areas of Andalusia. Ovando et al. (2016) estimate the environmental income of private silvopastoral farms (dehesas) and public forests farms in Andalusia. Martínez-Jauregui et al. (2016) apply an ad hoc method for estimating the environmental price of game species captures and their environmental assets in the forests and woodlands of Andalusia. Oviedo et al. (2017) estimate the ES of the private amenity and their contribution to the total private income of a group of silvopastoral farms in Andalusia and private ranches in California. Campos et al. (2019a) present the first regional scale application of the AAS methodology to the woodlands of Andalusia in which the ES, environmental income and social total income are measured at market prices, providing results at the scale of the land-use tiles of the Forest Map of Spain (FMS). Campos et al. (2019b) present the results, at social price, for the application of the AAS to a group of large private cork oak silvopastoral farms. In Campos et al. (2020a),ecosystem accounting methods aimed at estimating the environmental income using the refined System of National Accounts (rSNA), the refined System of Environmental Economic Accounting - Experimental Ecosystem Accounting (rSEEA-EEA) and the simplified Agroforestry Accounting System (sAAS) which are applied to areas of holm oak open woodlands (HOW) in Andalusia. In Campos et al. (2020b) we compare the concepts and measurements of the environmental incomes, under our rSNA and the rSEEA-EEA approaches with our AAS in a case study of large holm oak farms in Andalusia. Campos et al. (2020c) develops the novel concept of an economic ecosystem service sustainability index and compares the results accrued from applying the rSNA and the authors' AAS applied to a case study of sixteen large, non-industrial, privately-owned holm oak dehesas in Andalusia. In Campos et al. (2020d) we conceptualize and compare the ecosystem services and environmental incomes of individual activities using the AAS and rSNA, wich are applied to areas of cork oak open woodlands (COW), which cover 248,015 hectares in Andalusia.

8.1.2 Production and income generation accounts

In our communication in the ESP10 (2019) in Hannover (Germany) we briefly summarized the main concepts of the ecosystem accounting and we described the environmental incomes of the individual activities estimated in its application to the holm oak open woodlands (HOW) of Andalusia, Spain. Here, the objective of this chapter is to present a brief description of the development of the ecosystem service accounting based on the refined versions of the production and income generation accounts of the rSNA, rSEEA-EEA and sAAS methodologies applied to the HOW of Andalusia.

8.1.3 Institutional setting of scientific Research in CSIC

The Spanish National Research Council (CSIC) is one of the largest public scientific research institutions in the European Union. Our research is based on our own field-issue preferences with no mandatory specific scientific commitments from the CSIC. Our research is funded through competitive applications developed by our researchers as part of public research calls and contracts with public institutions and private corporations. Our institutional setting as civil servants with research freedom allows for fully independent scientific research.

8.2 Ecosystem service accounting frameworks

Campos et al. (2019a) provide a detailed description of the methodological concepts of ecosystem accounting in the context of the AAS. The aim is to measure the environmental income, the ecosystem service and the change in environmental net worth within the framework of measuring the social total income at market prices, derived from the production and capital accounts for the HOW 15 individual activities valued.

The concepts and valuation methods used in the ecosystem service accounting (ESA) frameworks applied to the HOW of Andalusia, i.e. rSNA, rSEEA-EEA and sAAS. The three methodologies compared are defined in Campos et al. (2020e). Our refinement of the standard System of National Accounts (rSNA) consists of incorporating the activities of the government general institutional sector which we have estimated to take place in the holm oak woodlands of Andalusia. Our refinement of the SEEA Experimental Ecosystem Accounting (rSEEA-EEA) involves changes to the designation of the products, the intermediate consumptions and the incomes, such as the concept of ecosystem output, which we replace with the product, among other changes. The simplified Agroforestry Accounting System (sAAS) excludes the results for the total product as they are unnecessary to estimate ES (Campos et al., 2019a, 2019b, 2020a; Caparrós et al., 2017; Martínez-Jauregui et al., 2016); Ovando et al., 2016; Oviedo et al., 2017). The objective of the three ESAs are to estimate the ES embedded in the environmental and total social incomes of the total products consumed (TPc) of the individual activities of an ecosystem type and/or spatial economic unit. Estimating the ES implies complete registering of production and income generation accounts referring exclusively to the total product consumed in the accounting type and/or unit.

8.2.1 The production and income generation accounts applied to total product consumption of holm oak open woodlands in Andalusia-Spain

In the application of the rSNA, rSEEA-EAA and sAAS methodologies to the holm oak open woodlands (HOW) in Andalusia, Spain, we modify the organization of the production and income generation accounts, the preliminary development of which had been carried out by van de Ven et al.(2019: Table 2, [SEEA-EEA] Model C, p. 10). In the following paragraphs we describe the refinements effected in the three ESA methodologies referred to above, and which are used to estimate and make visible the aggregate ES of the farmers, government, ecosystem and the total for the activities of the HOW.

In our application the rSNA includes the government institutional sector (public activities) among the activities of a given agroforestry system. It shows, in a visible way, the intermediate products and the environmental production factors that make up the value of the ES (work in progress used e.g. timber, cork, firewood, consumption of environmental fixed assets e.g., forest carbon emission and surplus/ordinary environmental net operating margin).

The rSEEA-EEA Model C incorporates the ecosystem institutional sector as the “collective owner” of the HOW public activities. The ecosystem omits the government ordinary manufactured total cost and implies that the total product consumed coincides with the sum of the consumption of environmental fixed asset and the ecosystem service.

The sAAS substitutes the ecosystem institutional sector of the rSEEA-EEA Model C for the government institutional sector. This implies that the only difference between the rSEEA-EEA Model C and the sAAS is the inclusion of the government ordinary manufactured total cost.

The rSEEA-EEA and sAAS methodologies substitute the valuations of the total products without market price consumed, valued at simulated exchange prices derived from the willingness to pay, either revealed or declared by personal consumers and the institutions which either consume or appropriate them.

In the following sub-sections, we describe the results for the total products consumed (TPc) and the values of their production factors according to the three ESA methodologies applied in the HOW of Andalusia region-Spain (Table 8.1).

8.2.2 Ecosystem services measurement

The rSEEA-EEA and sAAS methodologies take into account 15 economic activities whereas the rSNA values 14 (it omits the public activity of forest carbon global warming mitigation). The activities valued are divided into eight farmer-attributed activities (timber, cork, firewood, nuts, grazing by game species and livestock, residential, conservation forestry and private amenity) and seven attributed to the government institutional sector (fire services, water supply, mushrooms, carbon, free access recreation, landscape conservation and threatened wild biodiversity preservation). Ecosystem services, by convention, are not incorporated in the intermediate products of the residential, conservation forestry and fire service activities. The 22,281 land use tiles in which HOW predominate make up 1,408,170hectares. The rSNA methodology estimates seven ES for products consumed with market price, divided into five farmer and two government (mushrooms and water) services. On this same mosaic of the HOW areas, the rSEEA-EEA and sAAS methodologies value up to 12 types of ecosystem services, divided equally between the institutional sectors of the farmer (adding the amenity ES with respect to the rSNA) and the government (incorporating the ES of public carbon, public recreation, landscape and wild biodiversity).Only the HOW ES with higher economic value were valued. The 15 total products consumed incorporate all the production factors, except the possible ordinary consumption of environmental fixed asset (CFCeo). The rSNA also omit, by convention, the intermediate consumption of environmental work in progress used (WPeu), which is why we retain the term ordinary net operating surplus (NOSo) and we substitute it for the ordinary net operating margin (NOMo) in the rSEEA-EEA and sAAS methodologies.

The intermediate consumptions of the private amenity and landscape activities incorporate ordinary own non-commercial intermediate consumption of services (SSncooc/a/d). These derive from the non-commercial intermediate production of services compensated (ISSncc), auto-consumed (ISSnca) and donated (ISSncd) of the hunting and livestock activities of the HOW, which have not been included among the activities valued in this study of the HOW. As these activities have been omitted in this study, their ISSncc/a/d has not been taken into account among the HOW intermediate products of services estimated.

Similarly, the intermediate raw material of grazing (IRMg) is not recorded among the ordinary own commercial intermediate consumptions of raw material (SScoog) as it is not consumed by the HOW activities valued. The consequence of the intermediate products and own intermediate consumption of the HOW activities valued not coinciding is that the values for the surpluses/net margins at producer (market), basic and social prices do not coincide when aggregated for the 15 activities valued.

We define producer price (pp) (or market price) of an individual product as the transaction price received by the farmer in the observed or simulated exchange of the product consumed. The producer price does not incorporate the non-commercial intermediate product of services (ISSnc) or the ordinary own non-commercial intermediate consumption of services (SSncoo). The basic price (bp) is estimated by adding to the producer price the compensations (ISSncc) for the intermediate products of the activities which produce them, then adding the intermediate consumption of ordinary own services compensated (SSncooc) to the intermediate consumption of the activities which use them. The social price (sp) is estimated by adding the ISSnca/d to the basic price and subtracting the SSncoa/d which affects the value of the product consumed of the activities involved.

In the application to the HOW, the SSncooa/d are only used by the amenity and landscape activities. Thus, as the social price is not admitted by the rSNA, the valuations in Table 8.1 are at producer prices for all the activities referred to in the rSNA and rSEEA-EEA and sAAS records, except for the private amenity and landscape activities which are valued at social price as they include own non-commercial intermediate consumption of amenity services (SSncooa) in the case of the amenity activity, and compensations (SSncooc) and donations (SSncood) in the case of the landscape activity.

8.2.2.1 Total product consumption

In the HOW we explicitly record the intermediate production of grazing and services of the residential (ISScrs), conservation forestry (ISSccf) and fire service activities (ISScfs) which are omitted in the ecosystem institutional sector.

The rSNA final product consumed values the private amenity at production cost, while the rSEEA-EEA and the sAAS estimate them according to the exchange value declared by the private landowners. Public landowners do not consume private amenity services. We assume that public landowners have the option of sale the farms and therefore, they could benefit from private amenity environmental asset gain.

The ESAs applied to the HOW record the final products consumed of mushrooms and regulated forest water in public reservoirs at market price, except for the 15% of physical water consumed by non-agricultural economic sectors and households which, because it is valued at production cost (including a normal manufactured margin), has a value of zero (we have not estimated manufactured costs of the forest water supply as these were not identified in the forest land) (Campos et al., 2019a).

The TPc of the ESAs hardly differ between the rSEEA-EEA and sAAS, and are 2.4 and 2.5times greater, respectively, than those of the rSNA. Table 8.1 shows that the differences with respect to the rSNA are due both to the farmer activities and those of the government. These differences are due to valuations at production prices and the absence of valuation of the carbon activity in the rSNA. The difference in the TPc of the ecosystem and government institutional sectors in the rSEEA-EEA and sAAS is explained by the omission in the ecosystem institutional sector of the fire services activity in the rSEEA-EAA.

8.2.2.2 Ordinary intermediate consumption

The ordinary intermediate consumptions (ICo) originate in the commercial ($ICco_{SNA}$) and the non-commercial ($ICnco_{non\text{-}SNA}$). The latter are due, on the one hand, to the voluntary opportunity costs incurred by the farmers in the hunting and livestock activities generating the $ISSncc/a/d_{non\text{-}SNA}$, and which are employed as inputs of ordinary own manufactured non-commercial services ($SSncoc/a/d_{non\text{-}SNA}$) of compensations, amenity and donation for the private amenity (SSncoa) and landscape ($SSncoc/d_{non\text{-}SNA}$) activities respectively. The $ICono_{n\text{-}SNA}$, on the other hand, contain environmental work in progress used ($WPeu_{non\text{-}SNA}$) in the case of the rSEEA-EEA and sAAS, the rSNA omits the lsoWPwu in the $ICnco_{non\text{-}SNA}$. In the holm oak woodlands (HOW), the WPeu is contributed by the timber, cork and firewood activities.

Table 8.1 shows notable differences in ICo between the rSEEA-EEA and sAAS in the ecosystem and government institutional sectors, whereas they coincide in the case of the farmer institutional sector. The absence, by convention, of the manufactured production factors in the ecosystems is once again the reason for the divergence between them. In the case of the rSNA, the differences with respect to the rSEEA-EEA and sAAS can be attributed to the omission of the ICnca/dnon-SNA in the farmer.

8.2.2.3 Ordinary gross value added

Ordinary gross value added (GVAo) is the gross operating income of the HOW which may be destined, on the one hand, to the replacement of manufactured consumption of fixed capital (CFCmo) and consumption of environmental fixed asset (CFCeo). In table 8.1 it can be seen that the CFCmo recorded coincide in the three ESAs, and that we have omitted recording possible CFCeo embedded in the TPc. On the other hand, the difference between the GVAo and the ordinary consumption of fixed capital (CFCo) represents the ordinary net value added (NVAo) which remunerates the production factors of ordinary labour (LCo) and capital investment represented by the ordinary net operating surplus/margin (NOSo/NOMo). Ordinary self-employed labour compensations (LCseo) are not registered in this HOW regional case studies. The values for ordinary employee labour cost (LCeo) in the rSNA and sAAS coincide, and they differ from the rSEEA-EEA in that the latter omits the manufactured costs of the public activities of the ecosystem institutional sector.

The differences in the GVAo and NVAo values among the ESAs applied are due to the dissimilitude in the valuations and omissions of the TPc and ICo described above.

It is necessary to redistribute the NOSo/NOMo among the ordinary net operating margins (NOMmo) of the manufactured fixed capitals and environmental assets (WPeu and NOMeo). The rSNA incorporate the WPeu in the ordinary net operating surplus (NOSo), and also incorporate the NOMo. Since the WPeu is an environmental intermediate consumption, it gives rise to the NOMmo as a pure operating capital income, unlike the NOSo, which is not, because it implicitly includes the WPeu omitted by the rSNA in the ICo.

Finally, the separation of the NOMo into NOMmo and NOMeo allow the ecosystem components to be visible in the production and income generation accounts of the three ESAs compared.

8.2.2.4 Ecosystem services

In the HOW activities valued, three have WPeu (timber, cork and firewood) and nine have NOMeo (nuts, grazing, private amenity, water supply, mushrooms, carbon, free access recreation, landscape and threatened wild biodiversity preservation). None of the activities have both components at the same time, although, by convention, it could occur in the case of a single product consumed, a part of which does not form part of the inventory of environmental asset work in progress (e.g., migrant wild animal captures) at the opening of the period.

Table 8.1 shows the values we have estimated for the WPeu and NOMeo implicit in the TPc and in the NOSo of the rSNA. Thus, the estimates of the HOW values added in the SNA and the rSNA added to the farmer and government institutional sector activities coincide.

The comparisons of the HOW ES reveal that the aggregate values for the rSEEA-EEA are 21% higher than those for the sAAS. The difference is significantly greater in the ecosystem and government institutional sectors, the ES of the rSEEA-EEA being 45% greater than those of the sAAS (Table 1). The ES of the rSEEA-EEA and rAAS are 4.3 and 3.6 times greater, respectively, than those of the rSNA.

8.2.3 Discussion of ecosystem services accounting issues

8.2.3.1 The extended concept of economic activity

Unlike the rSNA, we assume that the rSEEA-EEA and sAAS methodologies admit all consumption for which the economic ownership is attributed to the farmer or the government (in delegation by the collective owners) as total product consumed. By convention, it is accepted that economic ownership implies the existence of formal or implicit regulation, therefore the extended economic activities of the rSEEA-EEA and sAAS do not necessarily require the existence of remunerated manufactured production factors (water and carbon in the case of the HOW).

8.2.3.2 Measuring environmental fixed asset degradation

We have not measured the possible use of CFCeo as the part of the total economic degradation of the environmental fixed assets embedded in the individual TPc has not been identified. The absence of a valuation for the ordinary manufactured consumption of biological fixed capital (CFCmbo)is not in SNA practice as regards livestock activity. This absence of a measurement of CFCeo in the ESAs applied to the HOW means that we cannot derive any direct significance from the value of the ES as an indicator of the degree of economic sustainability of environmental fixed asset management.

It may be that the environmental degradation is not a component of the TPc value in the period. In this case, the degradation (consumption) of the environmental fixed (CFCei) could be a component to be deducted from the natural growth (NG), giving rise to the environmental net operating margin of investment (NOMei) in the production account. Environmental degradation can also be external to the production account and be a component of the environmental asset gain (EAg), which implicitly incorporates the environmental degradation in the closing environmental asset (EAc). In these cases, the sum of the ordinary environmental net operating margin and the change in environmental net worth (CNWe) give the environmental income (EI).Depending on the type of adjustment of the NOMeo residual variable in the rSEEA-EEA Model C, the result tends to be a measure of environmental income (van de Ven et al., 2019: Table 2, p. 10).This result means that the problem of measuring the CFCeo embedded in the TPc becomes a question of dividing the environmental income between the NOMeo and the CNWe, since the EI of the environmental asset for the period does not vary according to the type of registers chosen. If the CFCeo is included among the production factors of the TPc, and since it is inevitably entered at the same time in the final asset at the closing of the period, an adjustment of the EAg is necessary to avoid double counting of the CFCeo in the TPc and in the EAc.

The main strength of the sAAS ecosystem accounting framework (Campos et al., 2020a) is that it allows us to estimate the ecosystem service as part of a consistent measurement with the environmental and total social income of the TPc by adjusting the change in environmental net worth (CNWead) according to the WPeu, leading to the accounting identity which estimates the environmental income (EI) as the sum of the ES and the CNWead (Campos et al., 2019a).However, the possible measurement of the proposed NOMeo adjustment (which is equivalent to the NOSo/NOMo adjustment) by the CFCeo proposed in the rSEEA-EEA, is not rooted in measurement consistent with environmental and total social income of the TPc.

8.2.3.3 Regarding the impossibility of a negative ecosystem service value

The government, owners and employees, who expend their time and invest economic resources in the economic activities, expect in return to receive income from labour, manufactured capital and, as a residual expectation value, from the environmental asset. The rationale prioritizing the remunerations follows this same order. We assume that the productivity of self-employed labour does not exceed 80% of the corresponding paid labour for the same task and that it may have a residual remuneration of zero, leading to a zero or negative ordinary net operating margin (Ovando et al., 2016; Oviedo et al., 2017).Having remunerated the labour, if the ordinary net value added of the activity exceeds the former, the ordinary net operating margin will be greater than zero. We simulate a normal remuneration of normal manufactured operating investment and it is measured by a normal manufactured ordinary net operating margin (NOMmon). If the latter is equal to or greater than the residual ordinary net operating margin (NOMo), then the component of ordinary environmental net operating margin (NOMeo) will be zero and the ordinary manufactured net operating margin (NOMmo) will coincide with the NOMo. However, if the NOMmon < NOMo, then the NOMeo > 0. In other words, if after remunerating the labour and the operating manufactured capital employed in producing the total product consumed there is a positive residual, this corresponds to the NOMeo gifted by the ecosystem nature. In other words, we obtain an ecosystem service which, by convention, is always > 0.

The environmental intermediate consumption component (WPeu) of the ES is also positive by convention, being the result of multiplying the physical amount of the product consumed by its environmental price (unit resource rent).

8.2.3.4 Meaning of conditioned economic sustainability of the ecosystem services

The economic concept of ecosystem service may not correspond to a natural operating income. It may lack a direct relationship with the future evolution of the biological productivity which is expected to be consumed in the future of the environmental asset. The latter generates the total product consumed in which the ES are embedded.

However, ES can provide a limited indication of the economic sustainability of the TPc if linked to the measurement of the environmental income. Even so, this relationship is insufficient unless subject to the availability of biological information on whether the amount of the biological asset exceeds the threshold that signals its proximity to a physical stock which available scientific knowledge recognises as the safe minimum standard (SMS) at the closing of the period. The robustness of the possible employment of ecosystem service estimates is conditioned in its concept of economic sustainability by the information given by the distance of the physical stock from the SMS, at the closing of the period. This allows the flexibility of accepting the concurrence of economic and biological sustainability in contexts beyond the SMS, in which the environmental income decreases and the total social income from the product consumed increases, with respect to the previous period.

Table 8.1 ES accounting: refined SNA, refined SEEA-EEA and simplified AAS production and generation of income accounts applied to holm oak open woodlands in Andalusia, Spain (2010: thousands of euros).

Class	Refined SNA			Refined SEEA-EEA			Simplified AAS		
	Farmer	Government	Woodlands	Farmer	Ecosystems	Woodlands	Farmer	Government	Woodlands
1. Total product consumption (TPc)	96,519	312,620	409,139	558,480	424,887	983,367	558,480	478,568	1,037,049
1.1 Intermediate products (IP)	72,265	53,682	125,947	72,265		72,265	72,265	53,682	125,947
1.1.1 Intermediate product SNA (IP$_{rSNA}$)	72,265	53,682	125,947	72,265		72,265	72,265	53,682	125,947
1.1.2 Intermediate product non-SNA (IP$_{non-rSNA}$)									
1.2 Final product consumption (FPc)	24,254	258,939	283,192	486,215	424,887	911,102	486,215	424,887	911,102
1.2.1 Final product consumption SNA (FPc$_{rSNA}$	24,254	258,939	283,192	24,254	132,621	156,875	24,254	258,939	283,192
1.2.2 Final product consumption non SNA (FPc$_{non-rSNA}$)				461,961	292,265	754,226	461,961	165,948	627,909
2. Ordinary intermediate consumption (ICo)	24,965	123,822	148,788	199,942		199,942	199,942	126,789	326,730
1.1 Ordinary intermediate consumption SNA (ICc$_{SNA}$)	24,965	123,822	148,788	24,965		24,965	24,965	123,822	148,788
1.2 Ordinary intermediate consumption non-SNA (ICo$_{non-SNA}$)				174,976		174,976	174,976	2,966	177,943
1.2.1 Own manufactured non-commercial (SSncoa/d$_{non-SNA}$)				173,573		173,573	173,573	2,966	176,539
1.2.2 Environmental work in progress used (WPeu$_{non-SNA}$)	na	na	na	1,404		1,404	1,404		1,404
3. Ordinary gross value added (GVAo)	71,554	188,798	260,352	358,538	424,887	783,425	358,538	351,780	710,318
3.1. Ordinary consumption of fixed capital (CFCo)	9,639	8,070	17,709	9,639		9,639	9,639	8,070	17,709
3.1.1 Manufactured consumption of fixed capital SNA (CFCmo$_{SNA}$)	9,639	8,070	17,709	9,639		9,639	9,639	8,070	17,709
3.1.2 Ecosystem degradation non-SNA (CFCeo$_{non-SNA}$)	?	?	?	?	?	?	?	?	?
3.2. Ordinary net value added (NVAo)	61,915	180,728	242,643	348,899	424,887	773,786	348,899	343,710	692,609
3.2.1 Ordinary labor cost (LCo)	16,906	48,223	65,128	16,906		16,906	16,906	48,223	65,128
3.2.1.1 Compensation of employees SNA (LCoe$_{SNA}$)	16,906	48,223	65,128	16,906		16,906	16,906	48,223	65,128
3.2.1.2 Compensation of self-employed non-SNA (LCose$_{non-SNA}$)									
3.2.2 Ordinary net operating surplus/margin (NOSo/NOMo)	45,009	132,506	177,515	331,994	424,887	756,880	331,994	295,487	627,481
3.2.2.1 Environmental work in progress used (WPeunon-SNA)	1,404		1,404	na	na	na	na	na	na
3.2.2.2 Manufactured net operating margin (NOMmo)	3,781	120	3,901	3,781		3,781	3,781	2,421	6,202
3.2.2.3 Environmental net operating surplus/margin (NOMeo)	39,824	132,385	172,210	328,213	424,887	753,099	328,213	293,067	621,279
4. Ecosystem services (ES)	41,228	132,385	173,613	329,616	424,887	754,503	329,616	293,067	622,683

na is not applicable, ? is unknown.

Source: Own elaboration from RECAMAN project primary data and Campos et al. (2020a: Table 1, p. 19). Andalusian holm oak woodlands area: 1,408,170 hectares.

8.3 Policy implications and ecosystem accounting use

8.3.1 From standard national accounts to ecosystem accounting

The results for the comparisons of the three ecosystem accounting methodologies (ESAs) applied to the holm oak open woodlands of Andalusia evidence the fact that the SNA does not allow the ES of the individual activities of the ecosystem type to be measured directly. On the one hand, the rSNA are necessary in order to make visible the entries of the WPeu and NOMeo of the ES components embedded in the total products consumed of the activities with market prices and, on the other, to both extend the concept of economic activity and to substitute the production cost valuations of products without market price for simulated exchange values. The rSEEA-EEA and sAAS methodologies show that by applying the principles which allow the measurement of the gross value added (gross domestic product), it is possible to extend the SNA in order to make visible the economic contribution of the ecosystem types within the national territory to the total products consumed in the period.

8.3.2 Application of the Agroforestry Accounting System to the Andalusian forest land

Our scientific research on ecosystem accounting integrates the refined SNA. We have applied the Agroforestry Accounting System (AAS) in the RECAMAN project to the woodlands, other forest land and natural grazing land in Andalusia-Spain (these areas as a whole are referred to in Spanish as montes) (Campos et al., 2019a). The objectives of the RECAMAN project are to measure the total income, its factorial distribution among the labour income, manufactured capital income and environmental income, and the total capital divided into manufactured capital (Cm) and environmental assets (EA) of the Andalusian montes, which cover an area of 4.4 million hectares (Campos et al., 2019a). The government of Andalusia, which financed most of the RECAMAN project, has not updated the results from 2010 and there is no certainty of future updates. In 2018, the CSIC and the government of Andalusia agreed to transfer the AAS geo-referenced map and tables viewer (VICAF in Spanish) to the official web of the Andalusian government (the VICAF can be accessed free on line: http://vicaf.cchs.csic.es (access username: guest1, and password: Hal024Euc61Pi23f). The government of Andalusia uses the RECAMAN information in the ongoing updating of the Andalusian forest plan and other sectorial forest plans (e.g. cork oak forest plan 2017). Other regional governments in the western part of Spain also use the RECAMAN results for forestry technical assistance by public environmental administrations (e.g., the region of Castile-León).

8.4 Lessons learned and conclusions

The economic concept of ES tells us its contribution to the total value of the total product consumed (TPc). ES do not tell us the non-economic contribution (free service) when the economic value of the ES is zero. It should not be interpreted from an ecosystem service value of zero that the free services (non-economic) lack economic relevance for the generation of the product consumed. In this situation, the free environmental service of nature is the necessary condition in order to obtain a greater net value added from the ecosystem, mainly made up of the residual remuneration for self-employed labour. If improvements in labour productivity were to occur through new manufactured investment, it is likely that the number of economic units and total income from labour would decrease, possibly leading to an appearance of a positive ecosystem service value (e.g., embraced by the land market). In other words, thanks to the fact that the ES provided by nature are zero values (free services) for most of the land uses on the Planet, it is possible to guarantee the supply of food and basic livehoods associated with the collection of wild biota and the practice of shepherding by the poorest communities on Earth.

In the presence of ordinary manufactured economic opportunity costs incurred voluntarily by owners of the land (including wild biota) and livestock, the measurement of ES is conditioned by the allocation of private amenity non-commercial intermediate services produced (ISSnca) and of donations (ISSncd) to the activities which generate them and simultaneously incorporate them as inputs of ordinary own non-commercial intermediate consumption (SSncooa/d) to the activities which consume them. This process of imputed internalization of the voluntary opportunity costs allows us to estimate the values at social price of the ES of the individual activities in a way that is consistent with the measurement of the factorial distribution of the total social income.

The concept of ES is in fact an environmental-economic service embedded in the total products consumed in the period. This is not the case for environmental work in progress accumulated (e.g., natural growth) in the period or for environmental asset gain, these being environmental services which are not consumed in the period in which the total social income of the total product consumption of an activity is measured. Moreover, in a situation where the values of the total product consumption and the ecosystem service in which it is embedded coincide, the term ecosystem service should be maintained, by convention, for the environmental production factors which compose its total value, and the term product for the value of the supply of the good or service consumed. The corollary of this convention of ecosystem accounting is that we consume products that contain the ES embedded in them, and we maintain the terminological convention even when the ES are the only production factor of the product consumed, in which case the environmental production factor (ecosystem service) and the value of the total product consumption coincide.

In this study applied to the holm oak open woodlands of Andalusia, we compare the results for total products consumption, production factors, values added, surpluses/operating margins and ES using the rSNa, rSEEA-EEA and sAAS approaches. We have shown how the sAAS production and income generation accounts make visible the ES of the total products consumed for an ecosystem type and/or spatial economic unit. The structure of the rSEEA-EEA and sAAS ecosystem service accounts are organised in consistence with the principle of transaction value applied to the economic activities grouped into the farmer, ecosystem and government institutional sectors. The results reveal that the rSNA undervalue the ES due to the joint effect of valuation at production cost of the products without market price consumed and the exclusions of both the forest carbon activity and the ordinary own non-commercial intermediate consumption of amenity and donation services (SSncooa/d). The rSEEA-EEA overvalue the ES since they record the ecosystem final products consumed without incorporating manufactured production costs and they also undervalue the total product of the ecosystem due to the exclusion of the intermediate production of the fire services activity. The sAAS is the only one of the three EAS methodologies compared which estimates the ES integrated consistently with the measurement of the total social income of total products consumption at social prices. The three EAS applied to the HOW do not include measurement of the possible ordinary environmental degradations (CFCeo) incorporated in the values for total products consumed (TPc). This limitation of the HOW ES valuation is mitigated in the sAAS by measuring the environmental income, which implicitly includes the environmental degradations in the valuation of environmental asset gains (EAg) for the period.

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9 Applying urban ecosystem accounting to municipal policy and planning in Oslo, Norway

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9.1 Introduction

The system of environmental and economic accounts (SEEA) is compiled by Statistics Norway (SSB). SSB has no regular statistics production related to ecosystem accounts. The URBAN EEA project has encouraged work on a production line for land cover accounts combining register data and remote sensing data. Since 2019, Norwegian Institute for Nature Research (NINA) and SSB participated in the EU H2020 MAIA project, aimed at demonstrating ecosystem accounting in the EU (and Norway). SSB predicts that regular production of land use accounts, including the detection of actual green cover in urban areas, will take place from 2021. At a national level, Norway is prioritizing the mapping of nature types and indicators for good ecological status. Mapping and accounting of ecosystem services (ES) is not prioritized by national environmental authorities.

The work of URBAN EEA has focused on extending a set of green cover accounts (NDVI) produced by Oslo Municipality for the period 2011-2017 using orthophotos. The URBAN EEA project has invested most of its time in ecosystem condition accounting of urban vegetation using alternative remote sensing, including Lidar and Sentinel-1 and -2. We have explored the accuracy of remote sensing alternatives for the purpose of urban greenspace management, modelling down to individual tree canopy level. In addition, URBAN EEA has focused on mapping and valuing priority topics for the municipality of urban biodiversity, pollinator habitat, storm water mitigation and recreation. In addition, we have modelled the regulating services of urban tree canopy specifically.

In this chapter we focus on urban ecosystem extent accounting, with a focus on classification error in an urban development context. We ask whether land cover classification error allows ecosystem accounts to fulfil one of its basic purposes – that of detecting significant trends in ecosystem extent as a basis for trends in ecosystem service supply. This is discussed in light of land cover change in Oslo.

9.2 The accounts

The extent accounts for Oslo's Urban EEA project were derived from satellite remote sensing (RS). RS land cover (LC) maps have been used extensively in ecosystem accounting, but many studies have relied on pre-classified LC products, such as MODIS MCD12Q1 land cover product, FAO Global land cover or CORINE land cover (CLC) (Burkhard et al. 2009, Ayanu et al. 2012, Burkhard et al. 2012, Andrew et al. 2014, Vargas et al. 2019). These standardized products are valuable for change detection at coarser scales, but do not adequately capture the LC at the fine scale needed for creating municipal accounts. This is especially true for complex urban environments where much of the green infrastructure is not captured by the spatial resolution of MODIS (500m) or CLC (25ha). Mapping land cover as part of the ecosystem accounting process gave us the advantage of being able to update the LC maps as frequently as required, the flexibility to custom select LC classes relevant to Oslo, and to map LC at a much finer spatial resolution (i.e. 10m).

The ecosystem accounting area (EEA) was Oslo municipality, an area of 480 km2, of which roughly one quarter is urban and the remainder is predominantly forest. We used a land use/land cover (LULC) map to delineate the ecosystem asset (EA) units. This LULC map enabled us to explore changes in specific economic sectors. The basic spatial units (BSU) was the 10m grid cells of the Sentinel-2 LC map.

Land cover was mapped in 2015 and 2019 and changes in LC classes calculated for this accounting period. Sentinel-2 imagery was classified into four classes, namely built-up, tree canopy, low vegetation and water. The built-up class consisted of all man-made structures, paved surfaces and exposed soil. Tree canopy only consisted of vegetation taller than 5m. Low vegetation captured any vegetation below 5m, including grass and crops. Both freshwater and the sea were captured in the water class. These four classes are the most basic 'building blocks' that were considered relevant to Oslo's urban environment and that could be detected with a high level of accuracy from spectral imagery. The overall accuracy of the LC maps was 86%. The class accuracy was similar for the 2015 and 2019 LC maps, with the built-up class having the lowest class accuracy of 75% and 78% respectively. The other three classes ranged between 80-92% accuracy. At a 10m spatial resolution, built-up areas have an overlap with vegetation in the urban environment, which can result in misclassification.

Figure 9.1 The ecosystem accounting area (EEA) was Oslo municipality. A LULC map was created as the ecosystem asset unit (EA) (frame A). The 10m grid cells of the Sentinel-2 land cover map were the basic spatial units (BSU) (frame B).

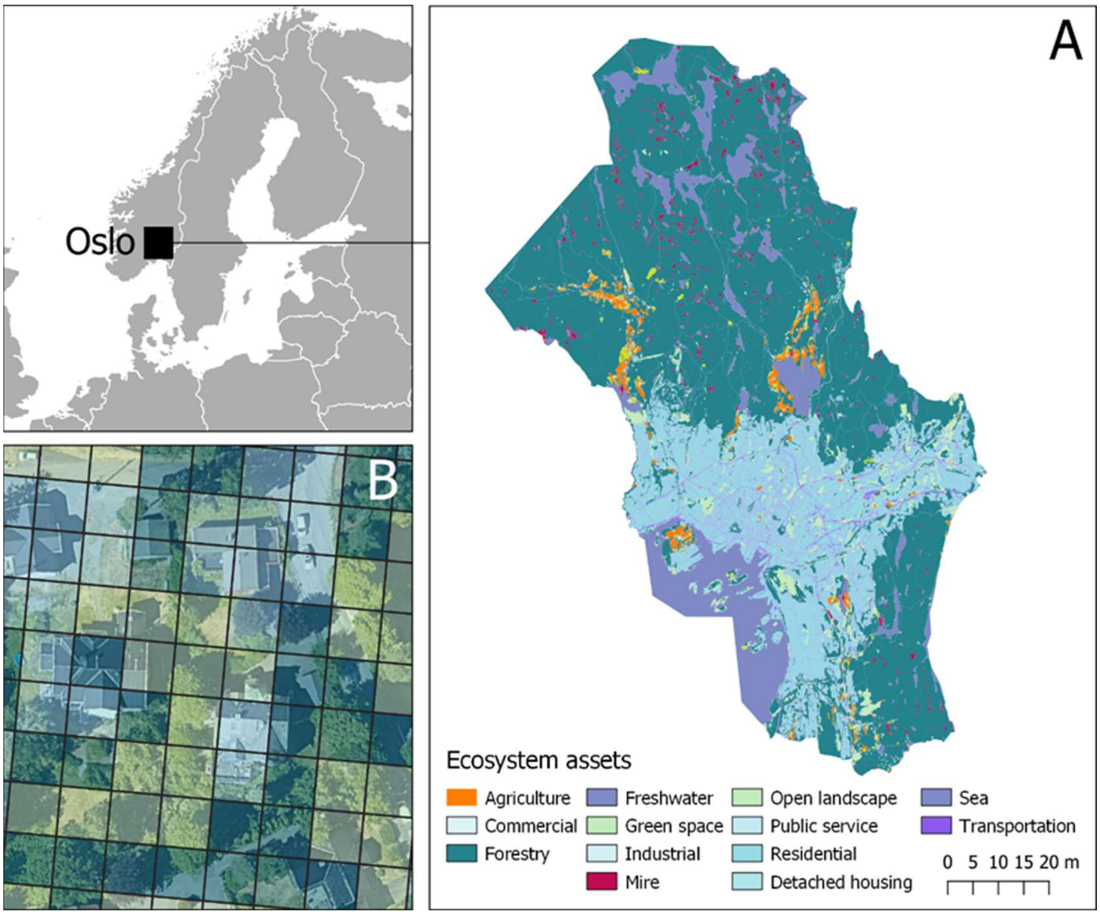
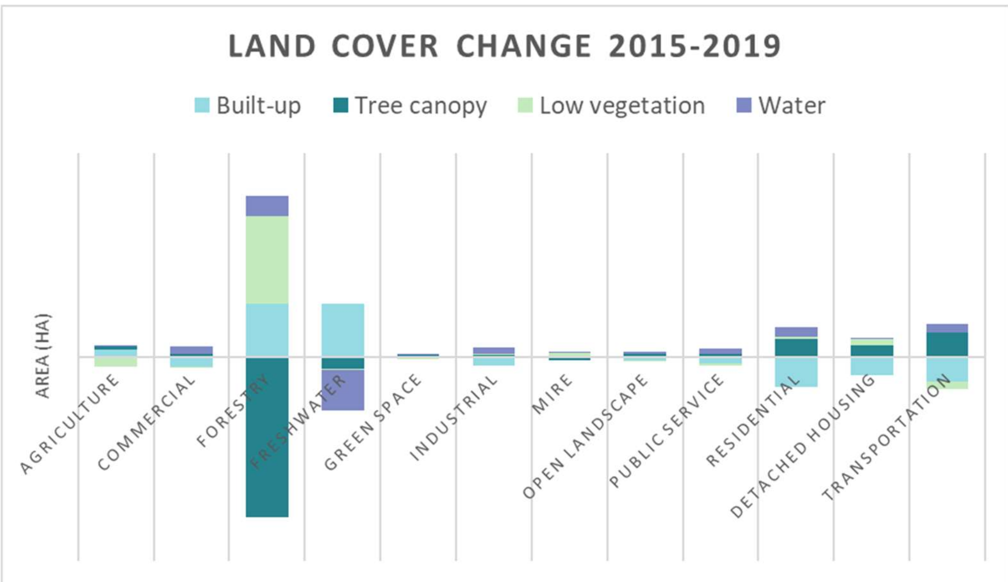


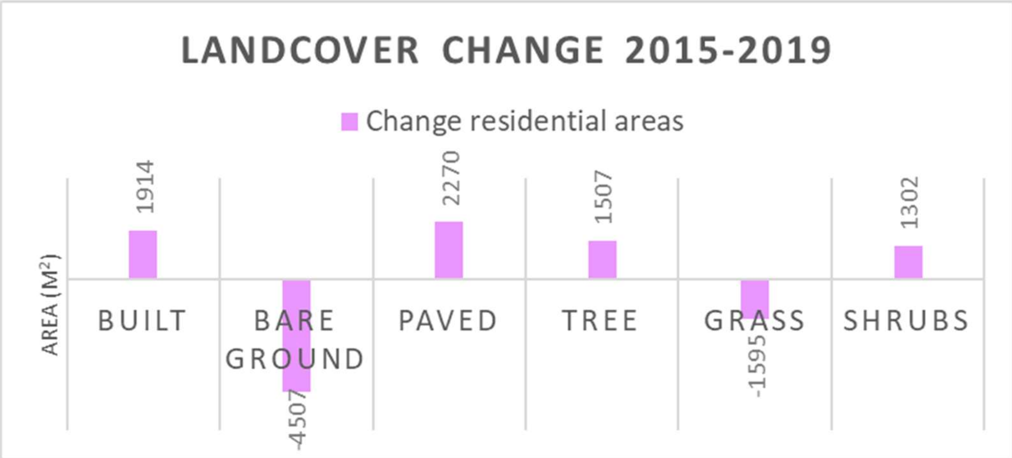
Figure 9.2 The extent accounts show the greatest change occurring in the forestry sector. Residential areas and transportation show greening over the period 2015-2019



The largest changes are occurring in the forestry sector of Oslo municipality. Figure 9.2 shows a pattern of harvesting (tree canopy replaced by low vegetation) and deforestation (tree canopy replaced by built-up areas). This is not surprising as the forestry sector comprises 57% of the municipality.

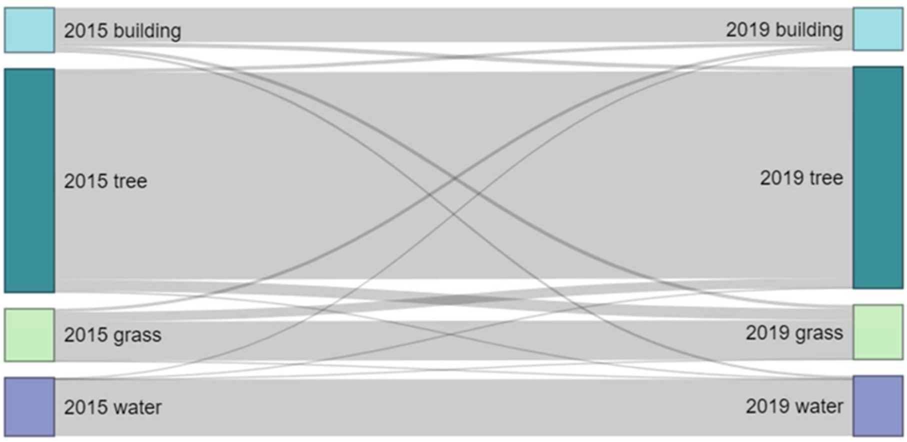
There is a known pattern of densification in the residential areas of Oslo and these results seem to contradict this, implying that the city is greening during this period. Validation was performed on these land cover changes and it was found that it is not the built-up areas that are being lost over time, but rather the exposed soil, which is included in the built-up class. The validation data indicates a shift from a construction phase to a more stable state in residential areas during the accounting period (Figure 9.3). There is a small increase in tree canopy and shrubs, which most likely cover grass, explaining the decrease in this class.

Figure 9.3 The validation data for residential areas showed a decrease in exposed ground and an increase in built and paved areas, indicating a shift from a construction phase to a more stable residential zone



The results in Figure 9.2 also show a loss of freshwater to the built-up class. A visual inspection showed that this is a result of lower water levels exposing ground around the edges of lakes. As mentioned previously, exposed ground was grouped in the built-up class in the initial LC classification. The Sentinel-2 LC water class had a high detection accuracy of 89-91%, but the misclassifications in this class are often due to confusion with building shadows in the city center. This means, that we see water in some sectors (ex. Industrial, commercial, public services) which is most likely a result of misclassified pixels where there were shadows.

Figure 9.4 The Sankey plot shows the flow of Sentinel-2 derived land cover between 2015-2019



It should be kept in mind that the changes that we see in Oslo over this accounting period are very small. The Sankey plot (Figure 9.4) illustrates the flow of land cover between 2015 and 2019 and the symmetry of the flows suggests that many of the so called changes may actually be misclassification of classes. Increasing the length of the accounting period will mean that more actual changes are captured. Urban environments tend to be relatively stable once established and actual changes are often not large enough to be distinguished from the noise in the satellite imagery. Another way to improve the classification accuracy is to increase the spatial resolution of the BSU (i.e. LC maps). By aggregating pixels, the noise in the data is reduced. Identifying the optimal spatial resolution for municipal extent accounts is needed in future research.

The misinterpretation of the satellite derived land cover change shows that additional land cover classes are needed in the initial land cover classification. Exposed soil should have a class of its own so that patterns in construction can be identified. This will also improve the ecosystem service models that use the Sentinel-2 land cover maps as inputs, such as runoff and urban heat reduction. The validation data also showed that grass and shrubs could benefit from separate classes. This would also be useful for mapping pollination potential. Differentiating shrubs from grass could be achieved by including LiDAR data in the classification model. Other data sources like Sentinel-1 can also improve the classification of some classes that are not easily distinguished using solely spectral data.

9.3 Policy use

There have been few policy drivers for ecosystem accounting at the municipal level. This is in part due to the lacking of promotion of ecosystem accounting at national level, as discussed earlier. The research project has aimed to complement the municipality's green accounts, demonstrating that green cover (NDVI) can be differentiated in vegetation types of importance for the ES that are municipal priorities. An indirect policy driver has also been Oslo's use of tree damage compensation methodology based on expert judgement. We have explored ways in which remote sensing and ecosystem service models can generate asset values at individual tree level for all trees in the built zone. Further, restrictions on felling large trees (DBH>90cm) in suburban areas imposed by the Planning and Building Authority in reaction to infill property development has been difficult to enforce. We have explored the extent to which Lidar and Sentinel-2 data has sufficient resolution and accuracy to account for tree loss at property level. Property level detection of land cover change is also necessary for ecosystem accounting information to support implementation of property level storm water fees (based on hydrological modelling of land cover at property level).

In summary, the general strategy of URBAN EEA has been to explore how remote sensing data compiled for ecosystem accounts could also respond to specific policy assessment needs of the municipality. As long as the municipality has no normal statistics production for ecosystem services, it is necessary to link this work to specific policy instruments. More recently, a national environmental NGO SABIMA has called on municipalities to achieve 'area neutral development', meaning that the net change in land use for urban development and infrastructure should be zero or positive. The aim of "area neutrality" may see a rising interest in ecosystem accounting, as some approach to comparing land cover qualities, functions and ultimately services will be needed.

Table 9.1 Oslo's extent accounts were derived from Sentinel-2 land cover maps for LULC types.

Oslo municipality	Extent account (ha)	Agriculture	Commercial	Forestry	Freshwater	Green space	Industrial	Mire	Open landscape	Public service	Residential	Res – detached housing	Transportation
	Opening account 2015	31	475	167	25	42	518	1	117	593	1802	915	2005
Built-up	Net change	28	-38	208	209	-4	-36	3	-12	-26	-117	-71	-100
	Closing account 2019	59	437	375	234	39	481	4	104	567	1686	843	1905
	Opening account 2015	129	41	25815	291	140	33	408	232	194	771	585	570
Tree canopy	Net change	12	12	-631	-46	9	9	-15	12	12	70	46	94
	Closing account 2019	141	53	25184	246	148	42	393	244	206	841	631	664
	Opening account 2015	877	54	1601	29	205	54	241	461	445	860	655	600
Low vegetation	Net change	-41	0	341	-4	-6	1	11	-6	-8	8	24	-29
	Closing account 2019	837	54	1943	25	200	55	252	455	437	868	679	571

9.4 Lessons learned and conclusions

- The most important outcomes

Among the practical recommendations for this work, is how often it is worthwhile for the municipality to recompile urban ecosystem accounts. Too frequent compilation risks not detecting trends. The study shows that this must be based on a combined consideration of the rate of land cover change and the size of land cover classification error.

- What should be avoided and what should be replicated

We highly recommend avoiding trend analysis without validation. As we saw in the extent accounts, the LC maps showed that built-up areas were decreasing in the residential area, however the validation data showed that it was exposed soil and not buildings that were being lost over the accounting period. Validating the results is essential.

- What could be done better

In addition to the technical improvements of the methodology, starting with clear policy questions allows one to determine the level of accuracy and reliability that is needed to answer the questions. It defines what types of information that are acceptable and ultimately is a more efficient use of resources.

- The bottlenecks to accounting

The first bottleneck to ecosystem accounting in a municipal setting is the lack of a mandate for it within the main law mandating municipal government landuse planning – the Planning and Building Act (PBL).

There are no regulatory requirements to supply ecosystem services to inhabitants the way there is for municipal utilities such as water and sewage, and garbage removal. Consequently there is no policy demand for ecosystem services accounting. Currently, most municipalities do not even compile LULC accounts, despite being charged with landuse planning. This is left to Statistics Norway, which until the URBAN EEA project, only accounted for changes in buildings within the urban built zone.

From a technical point of view the jury is still out on whether ecosystem accounting can provide high enough resolution to support municipal decisions at property permitting level. It seems more likely that accounts may provide strategic support at a 4 year municipal planning level. Conclusions from this paper suggest that such a period is a minimum for detecting land cover change in Oslo.

Overall, Sentinel-2 derived land cover maps hold much potential for ecosystem accounting. We were able to map land cover in the complex urban environment with sufficient accuracy. These maps can be updated as often as desired at almost no cost and with little effort. The maps are not only comparable over time, but also between different municipalities. The same method can also be applied to much larger areas, including national scale. The land cover maps have also been used as inputs for several ecosystem service models in Oslo, including pollination suitability, recreation potential, stormwater runoff, urban heat reduction and biodiversity potential. We anticipate that with the inclusion of the bare soil and shrub LC classes, the identification of the optimal spatial resolution to minimize noise in the data, and the most suitable accounting period, urban ecosystem extent can be mapped with high confidence.

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10 Conclusions

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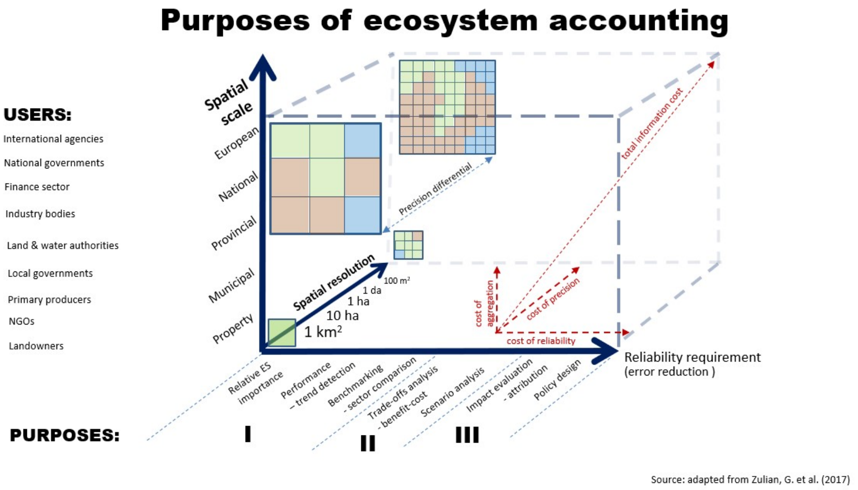
As these proceedings went to press the System of integrated Environmental and Economic Accounts – Ecosystem Accounts (SEEA EA) had been sent for global consultation with a view to obtaining approval in the UNCEEA for an international accounting standard. We hope the examples of ecosystem accounting in these proceedings will continue to be useful also after the approval of a standard. Whereas the SEEA EA is a standard for national accounts, these proceedings illustrate how the same accounting principles can be applied at supra- and sub-national level. While an international accounting standard will require adoption by NSOs, core and complementary accounts will take years to implement for many countries.

Implementing SEEA EA will require budgetary allocations from Finance ad Environment Ministries to National Statistical Offices (NSO), new agreements with statistics producers outside NSOs and new information systems for geographical information. The process of adoption can be speeded up by National Statistical Offices demonstrating how the information can inform existing planning and policy needs at differetn governance levels. It can be speeded up by encouraging non-NSOs to test similar accounting standards, thereby multiplying the resources allocated to this effort. NSOs must on their side demonstrate to stakeholders at different levels the purposes of accounts beyond the national accounts concern of identifying the contribution of ecosystem service to the national economy. Emphasis on public awareness raising about the importance of nature's contributions to people can be strengthened. How can regional and local governments benefit from NSO statistics while also contributing to compilation through their own efforts? How can the information in physical accounts contribute to policy impact analysis, benefit-cost analysis of policies and planning, scenarios analysis and policy design?

Moving forward on implementation of SEEA EA it will be important for NSOs to recognise that other stakeholders have needs with different precision and reliability requirements. Compilation of accounts will require different spatial and temporal resolution of accounting data (Zulian et al. 2017). National and international agencies providing funding for ecosystem accounts should recognise the different costs of information to meet these requirements (Figure 10.1). Ecosystem accounts have primary, secondary and tertiary purposes, and further work is needed to demonstrate how they can all draw on a common set of extent, condition and physical ecosystem service accounts. These proceedings provide examples sorted by purposes in Table 10.1.

Figure 10.1 Purposes of ecosystem accounting



The papers presented during the session covered ecosystem accounting applications spanning the supra-national EU, national and sub-national/local level.

Table 10.1 Accounting purposes covered by the papers in the session

Scale	Case study	Awareness raising Relative importance of ES across sectors Contribution of ES to economy	Performance Trend detection	Comparison between sectors Benchmarking	Trade-offs analysis	Scenario analysis	Impact Evaluation - policy attribution	Policy Design
EU	EU (La Notte et al.)							
National	Canada (Wang et al.)							
	Czech Republic (Grammatikopolou et al)							
	Germany (Grunewald et al.)							
	Uganda (King et al.)							
Sub-national	Province: Andalucía (Campos et al.)							
	CIty: Oslo (Nowell et al.)							
	Watershed XXX (Hristova et al.)							

Note: the purposes indicated in the table represent purposes explicitly referred to in the contributions in the session. The accounts in the different cases may have purposes that were not evaluated in the papers in this collection

At the EU level La Notte and co-authors present an application of six ES accounts. The authors identify how the accounts, used for descriptive analysis, can address questions concerning the value per ecosystem type, the allocation to specific end-users, the drivers of change over time (in terms of ES potential and ES demand) and how unsustainable practices and ES unmet demand could be an important source of information for strategic planning. Overall, through INCA and LISBETH, it is shown that ES accounts could contribute to different phases of the policy cycle.

Papers from Canada, Czech Republic, Germany and Uganda address national level applications. The example from Wang and colleagues highlights the challenge of not having a national policy driver for environmental accounts. They describe a situation in which the lack of policy driver means a lack of dedicated human and monetary resources for timely compilation of information and necessary interdepartmental collaboration. In turn, this makes the demonstration of policy usefulness of accounts challenging. Although not explicitly stated in the paper one gets the sense that this is a 'low equilibrium' situation for ecosystem accounting practice at national level, in which a policy driver is needed to unlock the potential. Grammatikopolou and co-authors demonstrate trend/change detection in land use and land cover accounts and identification of the contribution of ES to the economy, most likely for awareness raising purposes. They also point out the lack of political demand for ecosystem accounting. They suggest there is a lack of political urgency combined with a lacking understanding of the usefulness of accounts, in addition to technical challenges in harmonizing data sources. Grunewald and colleagues present several thematic accounts from Germany. They demonstrate accounting for change in provisioning services from agricultural land, choosing a longer time period (6 years) in order to be able to detect trends. In urban accounting the study uses two complementary valuation methods to show that the amenity value of ES of urban green spaces is many times the residential land value. This has direct relevance for municipal landuse planning and policy design. They also discuss a stepwise approach, starting with accounting compatible exchange values, then extending to welfare-based value metrics for example for policy scenario analysis (combined with physical information from the accounts). A third example in the German study is the use of habitat restoration costs and habitat equivalency based on a national biotope point regulation as a monetary valuation approach for biodiversity accounts. Identifying the restoration costs of a no-net habitat loss policy is a practical path to awareness raising about the costs of biodiversity targets for the national economy, based on market values. The legal recognition of habitat equivalency overcomes the accounting critique of restoration costs not having a clearly defined reference level. The biotope point regulation at national level also provides a good example of a clear policy purpose for accounting, in assessing achievement of no net habitat equivalency loss, also providing data on spatially explicit trade-offs across ecosystem locations. King and colleagues show how accounting for expenditure associated with wildlife tourism in Uganda fulfills the purpose of identifying ecosystem contributions to standard macro-economic units, and benchmarking at sector level how wildlife tourism sector compares to other sectors in terms of value multipliers. It can identify trends in habitat and species loss that are key to tourism revenues; potentially inform policy design in identifying export revenue generating opportunities, local job creation and poverty alleviation opportunities. The study emphasizes the importance of early engagement with stakeholders to identify clear policy entry points and analytical objectives of ecosystem accounts, help steer the development of the accounts and to foster ownership and build demand for the future production of the accounts.

Papers from Spain, Bulgaria, and Norway provide regional and local level applications. Campos and co-authors demonstrate how accounting measures such as 'Environmental net operating surplus/margin' and 'Environmental work in progress used' identify the ES components embedded in total products consumed at market prices by economic activities. The extension of concepts of economic activity to ES raises awareness in the economic statistics community. Identification of the pervasiveness of zero market value ES also raises awareness about their importance for subsistence livelihoods, providing a strong social rational for ecosystem accounts. The authors refer to a number of ways in which Andalucías ecosystem accounts are recompiled for policy and management purposes: government of Andalusia uses the information in the ongoing updating of the Andalusian forest plan, other sectorial forest plans and forestry technical assistance by public environmental administrations. Lessons learned in Andalucía are being adopted by other regional goverments. In the Bulgarian case Hristova and colleagues report on the use of accounting at catchment scale to quantify flood supply service of upland areas to potentially flooded demand areas downstream. The mapping of supply and demand areas provides evidence to strengthen upland conservation policy position in debates. In the final example from the session, Nowell and co-authors discuss change detection challenges of extent and condition accounts in the context of urban ecosystems in Oslo, Norway. They show that remote sensing data may struggle to detect change in extent and condition of urban green infrastructure that is significant for urban planning. The paper discusses the importance of identifying policy-relevant threshold values for change detection, and evaluating at what temporal and spatial resolution accounting data are able to support policy in a meaningful way (not simply statistical change, but policy significant change).

A general lesson across all papers is the presence of multi-faceted options for policy support offered by ecosystem accounts. Given their complexity and the large cost of collecting primary data and compiling it for regular use, the papers demonstrate how essential it is to identify the policy oriented purposes of accounts in the institutional context at hand. The papers together give the sense that it would be a mistake to try to implement all the accounts in a SEEA standard 'from the bottom up", or to implement the complete set of accounts uncritically, without primary and secondary purposes being clearly identified from the outset. The identification of purposes is essential for calibrating the data collection spatial and temporal resolution of accounts. This is need in order to meet whatever change or difference detection requirements are needed to discriminate alternatives defined by the purpose (e.g. to identify a significant trend against a baseline).

It is also important to identify complementarity of purposes at different governance scales. Broadly speaking aggregate compilation of ecosystem service contributions and their changes over time are useful for screening for problems, while spatially disaggregate compilations are needed for assessing policy impacts and supporting policy design. The cases demonstrate that aggregate compilations of ecosystem service contributions to the national economy are the primary purpose for national statistics offices. However, the main policy drivers of accounts in practice may well originate in specific ecosystems, at locations with specific local management and government challenges. The cases consistently highlight a need for fora and mechanisms to jointly identify these top-down and bottom-up agendas for ecosystem accounting.

Finally, a number of papers point out the lack of political drivers of accounts, seeming to place the burden on policy-makers for lacking progress. The papers in this compilation show that practical applications useful for decision-support are available, and that a responsibility also rests on researchers' shoulders to put even more effort into demonstrating the usefulness of ecosystem accounting to policy-makers.

List of abbreviations and definitions

CICES	Common International Classification of Ecosystem Services
CLC	CORINE Land Cover
ES	Ecosystem Services
EGS	Ecosystem Goods and Services
EO	Earth Observation
INCA	Integrated system for Natural Capital Accounting
MAES	Mapping and Assesment of Ecosystems and Services
SEEA EEA	System of integrated Environmental and Economic Accounting - Experimental Ecosystem Accounts
SNA	System of National Accounts
SUT	Supply and Use Tables
UNFCC	United Nations Framework Convention on Climate Change
UNSD	United Nations Statistical Division

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