DEPARTMENT OF ECONOMIC AND SOCIAL AFFAIRS
STATISTICS DIVISION
UNITED NATIONS

System of Environmental Economic Accounting

System of Environmental-Economic Accounting– Ecosystem Accounting

Key proposals for refining SEEA EA

Version 2.0

May 2021

Disclaimer:
This document has been prepared under the guidance of the SEEA Experimental Ecosystem Accounting Technical Committee under the auspices of the UN Committee of Experts on Environmental Accounting (UNCEEA). It is part of the work on the Revision of the System of Environmental-Economic Accounting 2012—Experimental Ecosystem Accounting being coordinated by the United Nations Statistics Division. The views expressed in this document do not necessarily represent the views of the United Nations.

Introduction

A final version of the SEEA EA was submitted for consideration at the UNSC meeting in March 2021. It was explained that there would be changes to that version based on discussion and outcomes of the UNSC meeting and based on further review to ensure high-quality text was provided in the white cover version and final publication.

This document describes a range of proposed changes that are either (i) intended to respond to the outcomes from the UNSC meeting in particular concerning the status of the chapters concerning valuation; or (ii) have emerged since early February 2021 (when the UNSC version was finalised) as experts have read and considered the draft further. These latter proposed changes have been subject to initial consideration by the SEEA EA Technical Committee at their meeting in April 2021.

The proposals presented in this note have been also integrated into a full, track changes version of the SEEA EA which incorporates a large number of other editorial changes and clarifications which do not involve any changes in the interpretation of the text submitted to UNSC in March 2021.

In addition, it is noted:

- Work is almost finalised in the re-design the figures throughout the document
- Work is needed to finalise the tables, references and glossary
- Work is underway to finalise a stylised example that will be presented as an annex to the main document and in an accompanying spreadsheet to show the linkages among the accounts for a simple case of roughly 6 ecosystem types and 6 ecosystem services.
- Text is required to finalise section overviews for Sections B, C and E.

Finally, it is noted that official editing of the document will take place in the second-half of 2021. Based on the experience from the SEEA Central Framework process, there may be a significant number of changes to the wording, but not meaning, compared to the white cover version.

Proposed changes with respect to the status of the valuation chapters

As requested by UNSC, the following changes are proposed concerning the explanation of the status of the different chapters of the SEEA EA, especially concerning the status of the chapters on valuation (Chapters 8-11).

It is anticipated that, as in the SEEA Central Framework the outcome of the UNSC decision and the status of the chapters will be described in the Foreword and the Preface – these have not yet been drafted.

It is noted that none of the chapters of the SEEA Central Framework refer to the UNSC decision of March 2012 nor discuss the relative status of the chapters. The inclusion of such text in the SEEA EA will deviate from this, nonetheless it is clear from the UNSC report Decision 8, point (e) that such text is required:

> (e) Requested the Committee to make clear the different statuses of chapters 1-7, 8-11 and 12-14, both within the introduction and the chapters themselves

The following proposals are made with respect to responding to the UNSC request. They were endorsed by the SEEA EA Technical Committee meeting on 28 April.

Section A: Introduction and overview – Insert a new second paragraph (highlighted)

Section Overview

The *System of Environmental-Economic Accounting—Ecosystem Accounting* (SEEA EA) is a spatially-based, integrated statistical framework for organizing biophysical information about ecosystems, measuring ecosystem services, tracking changes in ecosystem extent and condition, valuing ecosystem services and assets and linking this information to measures of economic and human activity. It was developed to respond to a range of policy demands and challenges with a focus on making visible the contributions of nature to the economy and people.

The United Nations Statistical Commission at its fifty-second session in March 2021 adopted SEEA EA chapters 1-7 describing the accounting framework and the physical accounts as an international statistical standard and recognised that chapters 8-11 of the SEEA EA describe internationally recognised statistical principles and recommendations for the monetary valuation of ecosystem services and assets. SEEA EA chapters 12-14 were noted as describing the applications and extensions of ecosystem accounting.

The SEEA EA complements the measurement of the relationship between the environment and the economy described in the *System of Environmental-Economic Accounting 2012—Central Framework* (SEEA Central Framework) (United Nations et al., 2014a). The SEEA, encompassing the SEEA Central Framework and the SEEA EA, provides a system that complements the System of National Accounts (SNA) using accounting principles to integrate physical and monetary measures concerning the environment in a way that allows for comparison to the data from the national accounts.

Section 1.3.2 Development of the SEEA EA – Include a new paragraph following para 1.24 to describe the final step in the development of the SEEA EA

1.24 The revision process was carried out under the auspices of the Committee of Experts with technical leadership provided by the SEEA EEA Technical Committee. Four key revision areas were established, namely spatial units, ecosystem condition, ecosystem services and monetary valuation and accounting. Five working groups led research and discussion across these four research areas with work commencing in early 2018. Twelve primary discussion papers and numerous issue notes were drafted for review by various technical experts across the disciplines noted above. Using this content and feedback, chapters were drafted for consideration by the SEEA EEA Technical Committee and subsequently released for two rounds of global consultation that took place through 2020. The novelty of this process was the active engagement with many expert communities, global environmental and sustainability initiatives, and the hosting of various in-person and virtual forums on ecosystem accounting. This breadth of engagement has enriched the design and content of the ecosystem accounting framework and provides a basis for its ongoing implementation and refinement.[1]

1.25 Based on the feedback received through the global consultation process, a final draft of the SEEA EA was submitted to the fifty-second session of the United Nations Statistical Commission in March 2021. At that session, the UN Statistical Commission adopted SEEA EA chapters 1-7 describing the accounting framework and the physical accounts as an international statistical standard and recognised that chapters 8-11 of the SEEA EA describe internationally recognised statistical principles and recommendations for the monetary valuation of ecosystem services and assets. SEEA EA chapters 12-14 were noted as describing applications and extensions of ecosystem accounting.

[1] The materials created and discussed through the revision process can be accessed at https://seea.un.org/content/seea-experimental-ecosystem-accounting-revision

Section 1.7: Structure of the SEEA EA – Include new text in the opening paragraph.

1.68 The SEEA EA comprises five sections A-E. Sections A-C comprise the international statistical standard describing the accounting framework and the physical accounts. Section D describes internationally recognised statistical principles and recommendations for the monetary valuation of ecosystem services and assets. Section E describes applications and extensions of ecosystem accounting.

1.69 (formerly in 1.68) Section A provides the introduction (Chapter 1) and the overview of the ecosystem accounting framework and associated principles (Chapter 2). Collectively, these chapters describe the background and rationale for ecosystem accounting and place this work within the broader context of work on the measurement of the relationship between the environment and the economy. The various parts of the ecosystem accounting framework introduced in Chapter 2 are described in greater detail in later chapters.

Section D: Monetary valuation and integrated accounting for ecosystem services and assets – Including the following text in the section overview

There is wide evidence of user demand for estimating the monetary value of the environment's contribution to the economy and people. There is also a demand for integrated assessments of the connection between the environment and the economy, in particular understanding changes in broad measures of wealth resulting from managed/human and natural causes, for example, from climate change and biodiversity loss. At the same time, monetary valuation will not be appropriate in all decision-making contexts and, in all cases, it will be relevant to use associated biophysical data on stocks and flows.

Among statisticians, the use of monetary values of environmental stocks and flows in the measurement and assessment of the environment has long been a point of discussion and contention. The existence of multiple perspectives on this issue is well recognised. There are differences of view concerning (i) the underlying framing for valuation of environmental stocks and flows; (ii) the potential of monetary valuation to support decision making; (iii) the ability to produce reliable estimates in monetary terms in practice; and (iv) the role of NSOs in producing fit for purpose statistics in this area of measurement.

While these different perspectives exist, there is wide support for the exchange value based approach to the monetary valuation of ecosystem services and ecosystem assets described in Chapters 8 – 11. The descriptions in these chapters are recognised as describing internationally recognised statistical principles and recommendations for the monetary valuation of ecosystem services and assets. Importantly, the valuation approach is coherent with the concepts of the SNA and adapts these concepts to the environmental context. ~~used in the SEEA EA is based on existing theory and concepts adopted by the SNA, which have been adapted to the environmental context.~~ The recommendations in Chapters 8-11 on valuation reflect the latest knowledge, methods and techniques to measure and organize biophysical information about ecosystems. It is expected that this knowledge, as well as the data sources and techniques used to compile the accounts will evolve over time as a result of the widespread adoption of these accounts. Consequently, as with all statistical methodology documents, it will be necessary to refine and revise it in the future.

In describing valuation based on exchange values, the SEEA EA recognizes that this provides monetary values that exclude welfare measures that may be commonly included in monetary values of the environment. Chapter 12 has been drafted to support understanding the connections among the various approaches to measurement and analysis in monetary terms.

More generally, as highlighted in the opening chapters of the SEEA EA, it is emphasized that monetary values from the accounts, and the wider economic values just described, will not fully reflect the importance of ecosystems for people and the economy. Assessing the importance of ecosystems will therefore require consideration of a wide range of information

beyond data on the monetary value of ecosystems and their services. This will include data on the biophysical characteristics of ecosystems, for example of extent and condition, and data on the characteristics of the people, businesses and communities that are dependent on them.

It is recognized that there are concerns about estimating monetary values in practice due to data constraints and the application of valuation techniques. These factors will require compilers to consider issues of data quality and uncertainty before compiling and disseminating accounts in monetary terms. It may be appropriate in initial releases to label data in monetary ecosystem accounts as experimental.

To support the compilation, application and interpretation of monetary values, a range of technical guidance is available and will be enhanced as part of the research and development agenda of the SEEA EA.

Chapter 11, Introduction –Include some words on the status of the text and also to distinguish Chapter 11 material from that in Chapter 12.

11.1 The discussion of combining ecosystem accounting data with standard economic data is increasingly relevant as countries, both nationally and multi-nationally, are recognizing the losses of some ecosystem services and are developing policy instruments to mitigate and reverse this trend. The combination of ecosystem and economic data supports a richer discussion of the connection between ecosystems and people, underpins the development of indicators showing the relationship such as the contribution of ecosystem services to measures of economic production and allows the derivation of adjusted national accounting aggregates such as degradation adjusted measures of net domestic product (NDP).

11.2 Building on the ecosystem accounts described through Chapters 3 to 10, this chapter describes principles and recommendations for the integration of ~~ways in which~~ ecosystem accounting data and data from the standard SNA accounts ~~can be integrated~~. Integration is considered with respect to the supply and use tables and the sequence of institutional sector accounts, including balance sheets. All of these accounts are labelled as extensions to the SNA accounts recognising the intent to complement the data presented in the SNA.

11.3 Historically, the approaches to more detailed integration of ecosystem-related information with the national accounts have focused on the valuation of degradation and the appropriate recording of this "cost of capital" in the accounts of different sectors. This is a characteristic of the previous approaches outlined by national accountants (see, e.g., (Council, 1999; A. Harrison, 1993; Vanoli, 1995). As explained in the SEEA 2012 EEA and the recent literature (e.g., (Edens & Hein, 2013; Obst et al., 2016), the emergence and application of the concept of ecosystem services has enabled a reconceptualization of the integration of ecosystem-related data with the system of national accounts. This basis for integration underpins much of the discussion in this chapter.

11.4 The monetary valuation of ecosystem services and ecosystem assets using exchange values is required for integration with the national accounts. However, as explained consistently through Chapters 8, 9 and 10, in many instances data from the ecosystem extent and condition accounts and concerning the physical flows of ecosystem services are required to better understand relevant ecological thresholds and limits. Also, the coverage of the extended accounts will be limited to the ecosystem services that are within scope of measurement. Finally, the use of exchange values will provide monetary values that are suitable for the compilation of extended accounts but, in other contexts, alternative valuation concepts and presentations may be more appropriate. Complementary approaches to monetary valuation which are considered to reflect applications and extensions of the SEEA EA accounting framework are discussed in Chapter 12.

11.5 Data from the ecosystem accounts also complement data from the SEEA Central Framework especially concerning environmental pressures (e.g., concerning emissions) and policy responses (e.g., concerning environmental protection expenditure, environmental

taxes and subsidies). These types of data are needed for a complete assessment of the environmental-economic relationship. The potential to combine data from the SEEA Central Framework and the SEEA EA is discussed in Chapter 13 using selected policy themes as the entry point.

Section E: Applications and extension of SEEA EA – Include the following in the section overview

Section E: Applications and extensions of the SEEA EA comprising chapters 12 – 14 has been drafted to support a shared understanding among compilers and users of the how data from the various ecosystem accounts may be applied to support analysis and decision-making. These chapters are not part of the international statistical standard, nor do they represent internationally recognised principles and recommendations.

Three different areas of application and extension are covered in this section. The first covers complementary approaches to valuation. The measurement of monetary values based on exchange values as described in chapters 8 – 11 supports comparison with the accounting values of the national accounts and a range of other uses described in chapters 8-11. However, there are limits to the range of economic values included in these measures and there are a number of applications which exchange based values cannot support directly. The discussion in chapter 12 recognizes that there are other approaches to monetary valuation and a number of other valuation concepts, such as welfare values and total economic values, that have been extensively used in decision making such as for cost-benefit analysis, scenario assessments or the development of environmental markets.

Describing these complementary approaches to valuation aims to support account compilers understand the different ways in which valuation may be considered and how the compilation of ecosystem accounts relates. Further, for users of the accounts, this discussion is intended to place various valuation approaches in the context and hence clarify the potential of ecosystem accounts to support analysis and decision making. A body of research on complementary approaches to accounting for the environment is also emerging, for example the work advancing the complementary accounts network (Badura et al 2017; Turner et al 2020). Developing and enriching the relationship among different measurement approaches will support the supply of coherent data and underpin support for decision makers.

Chapter 12, Introduction – Include words on the status of the text in paragraph 12.3.

12.3 In this context, this chapter considers how the monetary ecosystem accounts presented in chapters 8-11 can be related to, and potentially support, other approaches and applications in monetary terms. This chapter does not describe statistical standards or principles and recommendations for statistical outputs. Section 12.2 describes a set of complementary tables that can be obtained when taking a welfare-based approach to valuation, and explains the links between these approaches and the ecosystem accounts. Section 12.3 describes alternative measures of income, wealth and degradation that can be derived when making different assumptions regarding the attribution of costs or the institutional arrangements underlying valuation. Section 12.4 describes linkages with corporate assessments of natural capital.

Other proposed changes to content

The following are the main changes proposed in terms of refining the text based on conversations and feedback since Feb 2021. The SEEA EA Technical Committee will provide a final view on these changes at its 26 May meeting.

- Chapter 2: Inclusion of four stylised ecosystem accounts (extent, condition, ecosystem services flow and monetary ecosystem asset account)
- Chapter 4: Inclusion of definition of ecosystem extent copying definition in Chapter 2
- Chapter 7: Clarify allocation of collective use of public ecosystem services
- Chapter 9: Definition of Gross Ecosystem Product
- Chapter 9: Description of value transfer techniques in Section 9.5

The following presents the changes proposed for each case.

Chapter 2: Stylised ecosystem accounts

Context: It was proposed through the revision process that chapter 2 provide a quick indication of the structure of the various ecosystem accounts in the same way as the SEEA Central Framework Chapter 2 provides some stylised supply and use tables and asset accounts.

Proposal: With this goal in mind, the following tables have been introduced with additional sentence to introduce them as required. So other changes in text are required. The set of ecosystem types will link directly to the stylised example which is currently under development.

2.39 **Ecosystem extent accounts** organize data on the extent or area of different ecosystem types. Data from extent accounts can support the derivation of indicators of composition and change in ecosystem types and thus provide a common basis for discussion among stakeholders including discussions related to conversions between different ecosystem types within a country. Compilation of these accounts is also relevant in determining the appropriate set of ecosystem types to underpin the structure of other accounts. Chapter 3 describes how ecosystem assets are delineated, including the classification of the various ecosystem types. Ecosystem extent accounts are discussed in Chapter 4. A stylised ecosystem extent account is shown in Table 2.1.

Table 2.1: Stylised ecosystem extent account

	Ecosystem types						Total
Accounting entries	Forests	Lakes	Wetlands	Coastal areas	Cropland	Urban areas	
Opening extent							
Additions to extent							
Reduction to extent							
Closing extent							

2.40 **Ecosystem condition accounts**. A central feature of ecosystem accounting is its organization of biophysical information on the condition of different ecosystem types. The ecosystem condition account organizes data on selected ecosystem characteristics and the distance to a reference condition to provide insight into the ecological integrity of ecosystems. It can also organize data relevant to the

measurement of the capacity of an ecosystem to supply different ecosystem services. The structure of the ecosystem condition account is described in Chapter 5. A stylised ecosystem condition account for the condition at the end of an accounting period is shown in Table 2.2.

Table 2.2: Stylised ecosystem condition account

	Ecosystem types						Total
	Forests	Lakes	Wetlands	Coastal areas	Cropland	Urban areas	
Abiotic ecosystem characteristics							
Biotic ecosystem characteristics							
Landscape level characteristics							
Closing condition value							

2.41 **Ecosystem services flow accounts – physical terms.** The supply of final ecosystem services by ecosystem assets and the use of those services by economic units, including households, enterprises and government, constitute one of the central features of ecosystem accounting. Using a supply and use table structure, the ecosystem service flow accounts record the flows of final ecosystem services supplied by ecosystem assets and used by economic units during an accounting period, and also allow for the recording of intermediate service flows between ecosystem assets. Chapter 6 describes ecosystem services concepts and the reference list of ecosystem services. Chapter 7 discusses the ecosystem services flow account in physical terms.

2.42 **Ecosystem services flow accounts – monetary terms.** Commonly, estimates of ecosystem services in monetary terms are based on estimating prices for individual ecosystem services and multiplying through by the physical quantities recorded in the ecosystem services flow account in physical terms. Conceptual and measurement definitions and treatments on the monetary valuation of ecosystem services is discussed in Chapters 8 and 9. A stylised ecosystem services flow account that can be compiled in physical or monetary terms is shown in Table 2.3.

Table 2.3: Stylised ecosystem services flow account

	Ecosystem types						Total
Accounting entries	Forests	Lakes	Wetlands	Coastal areas	Cropland	Urban areas	
Supply of ecosystem services							
Provisioning services							
Regulating & maintenance services							
Cultural services							
Use of ecosystem services							
By Businesses							
By Governments							
By Households							

2.43 **Monetary ecosystem asset accounts**. Asset accounts are designed to record information on stocks and changes in stocks (additions and reductions) of assets. The ecosystem monetary asset account records this information in monetary terms for

ecosystem assets based on the monetary valuation of ecosystem services and applying the net present value approach to obtain values in monetary terms for ecosystem assets at the beginning and end of each accounting period. The measurement of changes in asset values due to, for example, ecosystem enhancement, ecosystem degradation and ecosystem conversion are also included in this account. These accounts are described in Chapter 10. A stylised monetary ecosystem asset account is shown in Table 2.4.

Table 2.4: Stylised monetary ecosystem asset account

	Ecosystem types						Total
Accounting entries	Forests	Lakes	Wetlands	Coastal areas	Cropland	Urban areas	
Opening value							
Ecosystem enhancement							
Ecosystem degradation							
Ecosystem conversions							
Other changes							
Net change in value							
Closing value							

Chapter 4: Definition of ecosystem extent

Context: A definition of ecosystem extent is provided in the summary of the ecosystem accounting framework in Chapter 2 (para 2.13) but this cannot be found in the chapters associated with this concept – Chapters 3 and 4. It is proposed to include the definition at the opening of Chapter 4, para 4.1.

Proposal:

4.1 A common starting point for ecosystem accounting is the organization of information on the extent of different ecosystem types within a country or other ecosystem accounting area (EAA), and how that extent is changing over time. ***Ecosystem extent is the size of an ecosystem asset in terms of spatial area.*** These data are summarised in an ecosystem extent account.

Chapter 7: Allocation of collective services

Context: Para 7.32 discusses the allocation of collective services. The agreed treatment here is not in question, however the application of the treatment to the appropriate level of government may arise as an issue depending on the ecosystem service. For example, when compiling accounts at a sub-national level, should the user of the global climate regulation service be the national government or the government that has jurisdiction at a finer scale? If this is not clarified this may lead to inconsistencies in aggregation and/or presentation. This question applies also to the treatment discussed in para 7.33.

This allocation issue does not arise in the national accounts since the attribution is based on the units undertaking the expenditure. One option is to leave this text unchanged but to provide advice in associated guidance material. Otherwise some additional text may be warranted.

Proposal: The proposal is to specify that the allocation should be made to the highest level of government. The following changes are proposed to paragraph 7.32.

For many ecosystem services that contribute to non-SNA benefits, the use of the ecosystem service is attributed to the receiver of the non-SNA benefit. In some cases, this is very direct, e.g., for recreation-related services. However, where the ecosystem service contributes to a non-SNA benefit that is considered "collective", the use of the ecosystem service is attributed to the highest level of general government in the EAA which is considered to use the service on behalf of society as a whole. Following the SNA, "*a collective consumption service is a service provided simultaneously to all members of the community or to all members of a particular section of the community, such as all households living in a particular region. … Collective services are the "public goods" of economic theory*." (2008 SNA, para. 9.4). Collective services will thus be both non-rival and non-excludable. The primary example of such an ecosystem service is global climate regulation, the benefits of which are obtained by all members of the community.

Chapter 9: Definition of GEP

Context: Para 9.17 discusses the definition of gross ecosystem product (GEP). On reflection, some clarity on the definition of GEP is considered necessary to ensure an appropriate treatment of intermediate services. The opening of the definition limits the focus to final ecosystem service thus excluding exports of intermediate services and the reference to "imports of ecosystem services" does not specify whether this is limited to final ecosystem services.

Proposal: Discussion has clarified that the conceptual basis of GEP should align with GDP in which case the focus should be on the overall/net contribution of the ecosystem assets within a country to well-being. This requires that net imports of intermediate services be deducted from the sum of final ecosystem services supplied by a country (or Ecosystem Accounting Area). Where net imports are small the sum of final ecosystem services is an appropriate measure.

Further, to support this definition, clarifying text has been added in paragraphs 7.15, 7.39, 7.46 and 9.15 concerning the sum of final ecosystem services and net imports of intermediate services. No change in concepts is required to accommodate these additions.

9.17 Aggregate measures of ecosystem services can be derived by summing across columns (i.e., to estimate the total supply or use of a single service) and by summing across rows (i.e. to estimate the total supply by an ecosystem type or the total use by type of economic unit). The aggregate measure ***gross ecosystem product (GEP) is equal to the sum of all final ecosystem services (i.e., used by economic units) at their exchange value supplied by all ecosystem types located within an ecosystem accounting area over an accounting period less the net imports of ~~ecosystem~~ intermediate services ~~from ecosystem assets outside the EAA~~.***[2] In cases where the net imports of intermediate services, i.e., imports less exports of intermediate services (see section 7.4.6) are small, GEP may be assumed to be the sum of final ecosystem services supplied by the EAA.

[2] This definition builds on the definition from Ouyang et al. (2020)

Chapter 9: Text on value transfer

Context: The content of this section was finalised at the end of the process based on written comments from the global consultation process. Unfortunately, it was not reviewed again by relevant experts.

While the content of this section does not impact on the conceptual aspects on the valuation of ecosystem services, the use of value transfer techniques to compile ecosystem accounts in monetary terms will be necessary in many situations. The introduction and framing provided in this section is therefore an important part of the SEEA EA. Additional guidance on applying value transfer will be developed and included in valuation guidance documents.

Proposal: An expert review process has now been completed including contributions from world leading experts in this area, Ian Bateman and Robert Johnston. The proposed text is below.

9.5 Spatial variation in values and value transfer for the purpose of ecosystem accounting

9.5.1 Introduction

9.18 Most commonly, the valuation of ecosystem services requires recognition that there will be variation in their values depending on the location and context in which the ecosystem services are supplied and used. The variation in ecosystem service values between locations occurs for a number of reasons. For example, the physical level of service provision may vary spatially such as when the global climate regulation service supplied through carbon sequestration by a forest varies from one side of a hill to another as solar energy varies with the aspect of that hill. Similarly, the recreation-related services supplied by a lake or river may vary depending on proximity to human populations; a lake near to a town may generate large recreational benefits while an ecologically identical lake located in a remote area might never be visited from one year to the next. Indeed, 'distance decay' in values over space is one of the most persistent and substantial determinants of ecosystem service valuation (Johnston RJ, et al, 2019; Badura T, et al (2020) (REFS). In addition, there are likely to be differences in access and property rights (institutional context) in different locations. As a final example, the value of an ecosystem service may also vary due to underlying preference heterogeneity that occurs over space; i.e., human populations in some areas may simply have different preferences than populations living in other areas. Overall, failure to account for the influence of location will frequently lead to significant error (Bateman, et al, 2006) (REFS).

9.19 Generally, the discussion of monetary valuation for ecosystem accounting is focused on the compilation of estimates in monetary exchange value terms for large regions or countries with the expectation that these values can support the development, implementation and/or monitoring of public policy. In contrast, much work on valuation has used economic welfare values and has focused on the valuation of ecosystems and ecosystem services for specific ecosystems or in relation to the potential effects of policies and programs, such as the introduction of a new tax or subsidy, or in relation to hypothetical events, for example the valuation of damages caused by oil spills or the effects of ecosystem restoration. Consequently, much data on the monetary value of ecosystem services is fragmented, covering only specific services over a large area, or multiple services in a more confined area, or valuing changes in the flow of ecosystem services following a specific event.

Commented [CO1]: When placed in the document, this section will commence at para 9.74

Commented [IJB2]: Johnston, R.J., Besedin, E.Y. & Holland, B.M. Modeling Distance Decay Within Valuation Meta-Analysis. *Environ Resource Econ* **72,** 657–690 (2019). https://doi.org/10.1007/s10640-018-0218-z

Badura, T., Ferrini, S., Burton, M., Binner, A. and Bateman, I.J. (2020) A new approach to capturing the spatial dimensions of value within choice experiments, Special Issue: Spatial dimensions of stated preference valuation, *Environment and Resource Economics*, 75, 297–322, https://doi.org/10.1007/s10640-019-00358-3

Commented [IJB3]: Bateman, I.J., Day, B.H., Georgiou, S. and Lake, I. (2006) The aggregation of environmental benefit values: Welfare measures, distance decay and total WTP, *Ecological Economics*, 60(2): 450-460. DOI: 10.1016/j.ecolecon.2006.04.003

9.20 Among the challenges for ecosystem accounting is how to reconcile and apply the information from existing studies to provide valid estimates of exchange value that may be applied consistently over large accounting areas, and that account for potential variations in ecosystem service values that occur over these areas. Indeed, while the consideration of larger areas might be thought to reduce error, this is not necessarily correct if the averages estimated for such areas are calculated in ignorance of spatial variation. The extent to which spatial variation in values can be accounted for will depend on data availability and the methodological considerations introduced here. If spatial variation in values cannot be adequately taken into consideration, then some applications of accounting data may not be appropriate.

9.21 Generally, there is a requirement for the ongoing expansion of work on estimating spatially explicit primary valuations to support the regular compilation of accounts. This is especially the case in order to minimise the use of primary data from other countries that have significantly different economic and institutional contexts. Although not discussed in this section, there is also a need to recognise that many primary valuations will not have been conducted with the intent to estimate exchange values as used in ecosystem accounting. The use of primary valuations will therefore need to consider the differences in valuation techniques and relevant assumptions described in Section 9.3 to ensure that the estimates are fit for accounting purposes.

9.22 This section provides a short overview of the relevant considerations and potential measurement approaches for ecosystem accounting concerning the spatial variation in values. A key message is that there is an extensive body of research and applied practice that can be used. At the same time, considering the issues from an ecosystem accounting perspective, highlights areas where further research will be required including concerning exchange values and marketed ecosystem services. More detailed discussion of relevant methods is available in technical guidance on valuation for ecosystem accounting.

9.5.2 Methods for incorporating spatial variation in values

9.23 To utilize data from specific locations in the estimation of monetary values in other locations, a set of techniques can be applied, collectively referred to as value transfer or benefit transfer techniques. There are two main approaches to value transfer: unit value transfers and value function transfers. Value function transfers may be further disaggregated into subgroups, including 'meta-analysis' function transfers and other types value function transfers (see Chapter 2 Johnston RJ., et al., 2015). These techniques have been developed over many decades in the environmental economics community. Johnston, RJ. et al. (2021) (forthcoming); Johnston RJ. et al. (2018), Boyle et al. (2010) and Johnston & Rosenberger (2010) provide reviews of the relevant literature.

9.24 A **unit value transfer** takes a single estimate of the monetary value of an ecosystem service (expressed in terms of a common measurement unit, e.g., hectare, tonnes, visits), or a measure of central tendency (e.g., mean, median) of several value estimates from different studies, to estimate the value of an ecosystem service in other locations. The validity of a unit value transfer approach will be limited when there is a range of differences between the value from the observed location and the other locations. Unit value transfers typically provide little or no internal capacity to account for these differences. Examples of the differences that can cause values to differ across locations can include:

Commented [CO4]: Johnston, R.J., Rolfe, J., Rosenberger, R.S., Brouwer, R., 2015. Benefit Transfer of Environmental and Resource Values: A Guide for Researchers and Practitioners. Springer, Dordrecht, The Netherlands

Commented [RJ5]: Boyle KJ, Kuminoff NV, Parmeter CF, Pope JC (2010) The benefit-transfer challenges. Annual Review of Resource Economics 2:161-182

Commented [CO6]: Johnston, R.J., K.J. Boyle, M. Loureiro, S. Navrud and J. Rolfe. (forthcoming). Guidance to Enhance the Validity and Credibility of Environmental Benefit Transfers. Environmental and Resource Economics.

- The physical characteristics of the sites that generates variation in the ecosystem services that the location provides such as, in the case of a lake, differing opportunities for recreation in general and angling in particular.
- The socio-economic and demographic characteristics of the relevant populations in the different locations. This might include income, educational attainment and age.
- The variation in the preferences of populations across different locations.
- The variation in institutional context governing rights of access to, use of and duties towards biodiversity, ecosystems and their services.
- The distance between the user of the ecosystem service and the supplying ecosystem asset, along with other geospatial differences that influence values in systematic ways (Glenk et al, 2020). Note also that the effect of distance will vary depending on the ecosystem service, for example the benefits of the global climate regulation service emerge irrespective of distance whereas the benefits from air filtration services arise only to people located close to (or downwind of) the supplying ecosystem.
- The variation in the availability of substitutes and complements. For example, in the case of recreational locations such as lakes. Two otherwise identical lakes might be characterised by different levels of alternative recreational opportunities. Other things being equal (by assumption in this example), the value of preventing a lowering of water quality at a lake where there are few substitutes should be greater than the value of avoiding the same water quality loss at a lake where there is an abundance of recreational substitutes. The reason for this is that the former is a scarcer recreational location than the latter.
- Differences across countries reflected in spatial and temporal variation in purchasing power.

9.25 Failure to adjust for location specific conditions affecting exchange value means that applying the unit value transfer approach works as a simple scaling factor for the changes observed in the physical supply and use table. Thus, an unadjusted unit value provides no additional information when reflected in a monetary supply and use table. Such linear monetary scaling may still be useful for compiling the monetary asset account for purposes that require only low accuracy, but care should be made to identify generalization errors and confidence ranges.

9.26 Since differences between locations such as those just listed will exist, adjustments are generally made to take the differences between locations into account. In the first instance adjustments may be made to account for income per capita and income elasticities to derive an **adjusted unit value transfer**. Meta-studies (such as (OECD, 2014)) indicate that adjusting for income per capita is a significant factor in being able to apply values from one location to others. This adjustment is likely to be of most significance if using primary data from another country. While data from other countries may be used in compiling accounts, it is advisable to use primary data from the country for which the accounts are being compiled wherever possible.

9.27 A more sophisticated form of value transfer is to undertake a **value function transfer**. These transfers can be categorized in different ways. Here, we group them into four primary categories based on the way the value functions are estimated. The first type estimates a value function using meta-analysis of prior valuation studies. The second type estimates a function concerning the relationship between value and the

Commented [CO7]: Glenk, K., R.J. Johnston, J. Meyerhoff and J. Sagebiel. 2020. Spatial Dimensions of Stated Preference Valuation in Environmental and Resource Economics: Methods, Trends and Challenges. Environmental and Resource Economics 75(2): 215-242.

ecosystem and economic context from a primary research study in one location and uses that function in other locations. The third type uses primary data from multiple locations across a region to generate an "umbrella" function that can be applied to other locations within the region (see for example, Bateman I et al (2013)). This approach has the advantage of using data sets that encompass both the location of the primary data site/s and the transfer site/s thus avoiding "out of sample" problems. This approach may also be referred to as value generalisation. The fourth type is known as structural value transfer (also called preference calibration). This type of transfer combines information from multiple prior primary studies using a utility theoretic structure that is assumed to apply to the prior studies. These different types of value function may encompass factors such as the physical features of the location, changes in population age structure between sites and differences in population density.

9.28 When used for value function transfer, **meta-analysis**, e.g., (Bateman et al., 2000; Boyle and Wooldridge 2018), takes information from a range of existing primary studies and then estimates a functional relationship that enables the values of ecosystem services to be predicted as a function of, *inter alia*, site and spatial characteristics, attributes and size of population affected, and the type of statistical methods used in the analysis of existing studies. This is then transferred to the new application in a procedure referred to as meta-regression-value-transfer, which gives a range of values to the new application depending on the characteristics embedded in the meta-regression.

9.29 This approach is well suited to developing estimates for additional sites and can be used to provide estimates at larger scales, including at the national level (see for example Corona J, et al. (2020) and Johnston RJ et al (2019)). Application of meta-analysis to the field of non-market valuation has expanded rapidly in recent years. Studies have taken place in respect of water quality, urban pollution, recreation, the ecological functions of wetlands, values of statistical life, noise and congestion.

9.30 At the same time, meta-analysis will sometimes use data from a variety of countries and variations between countries will need to be recognised. As well, it will be necessary to appropriately identify and select the studies to be used in the meta-analysis to ensure, for example, welfare consistency and commodity consistency (Johnston et al., 2018). Guidelines for the selection and coding of studies for economic meta-analysis are also available (see for example (Stanley et al., 2013)). Meta-analytic transfers using valuation studies from other countries outside the ecosystem accounting area should take care to adjust for particular differences in national jurisdiction affecting access and use rights.

9.31 The extent to which different value transfer methods can capture spatial variations in value and their general accuracy has been one area of extensive research. See for example, Bateman et al. (2006), Johnston et al., (2019), Johnston, Besedin, et al. (2017), and Schaafsma (2015) for discussions and a review of relevant work. Further, guidelines are being developed focused to more broadly improve the quality of estimates derived through the use of value transfer techniques (see (Johnston et al. (2020) and Johnston RJ et al (2021/forthcoming). Fundamentally, the quality of value transfer approaches will be influenced by the number, depth (in terms of number of data points) and quality of spatially explicit primary valuation studies. In turn this will likely depend on the type of ecosystem and the type of ecosystem service being considered. For example, while there are many studies of recreational use of ecosystems, there are not as many studies on the value of wetlands. Since different

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Commented [RJ9]: Boyle KJ, Wooldridge JM (2018) Understanding error structures and exploiting panel data in meta-analytic benefit transfers. Environmental and Resource Economics 69:609-635

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Johnston RJ, Besedin EY, Holland BM (2019) Modeling distance decay within valuation meta-analysis. Environmental and Resource Economics 72(3):657-690

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valuation studies are also often based on different assumptions, different valuation concepts and use different methods, there is a strong case for using the SEEA EA framework and its application through the practice of official statistics to develop consistently measured values across a variety of ecosystem services and locations. In developing these studies, co-ordination with the organisation of data in physical terms on ecosystem extent, condition and ecosystem service flows is highly recommended since this data will assist in consistently differentiating and classifying these data spatially and in ensuring consistent appreciation of the supply and use context for the ecosystem services.

9.32 When considering the direct applicability of existing value transfer research and findings to environmental accounting, it is important to consider the extent to which the types of values considered within the value transfer literature are consistent with those used within accounting applications. For example, much (although not all) of the available value transfer literature is based on stated preference methods. Stated preference methods establish hypothetical markets to quantify welfare values of changes in non-marketed ecosystem condition and/or services. For accounting purposes, it is necessary to simulate exchange values by combining these stated preference functions with ecosystem service supply/cost functions. Simulating exchange values therefore require the definition of credible institutional conditions for a market for the ecosystem in question (Barton et al. 2019). Institutional regimes are specific to ecosystems and resource characteristics (Ostrom 2010). Accounting principles state that accounting compatible prices should reflect current or feasible market institutions. Compilers should therefore recognize that transferring or generalizing valuation estimates from actual or hypothetical markets, to locations without markets, may potentially contradict national accounting principles. In particular, care should be taken where market simulation contradicts existing rights regimes. In these situations, simulated exchange values, and monetary accounts more generally, may be perceived as invalid by local rights holders. This is a particular issue in ecosystems with open access or common property rights (e.g. community fisheries and forests, communal greenspace).

9.33 The conceptual ideal of location-based valuation of all ecosystem services is clear. While this has been rarely possible due to resource constraints, rapid increases in the availability of spatial data and the ongoing advances in valuation methodologies will make this more possible in the future. As introduced in this section, there are well-researched value transfer techniques available for use in ecosystem accounting that can utilise available primary valuation studies. Further testing and best practice guidelines in defining credible market exchange conditions for value transfers should be part of the SEEA EA research agenda. To support appropriate use and interpretation of monetary estimates and to provide a sound basis for further research and development of data, clear documentation of the data sources, and the methods and assumptions applied in forming aggregate values for entry into the accounts will be required.

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