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Chapter 9: Accounting for ecosystem services in monetary terms

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Disclaimer:
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9.1 Introduction

9.1 Recording monetary values for ecosystem services underpins the compilation of two of the core ecosystem accounts: the ecosystem services supply and use account in monetary terms and the ecosystem monetary asset account. This chapter describes the ecosystem service supply and use account in monetary terms and a range of matters concerning the valuation of ecosystem services building on the principles described in Chapter 8.

9.2 The ecosystem service supply and use account in monetary terms records the monetary value of transactions in ecosystem services using the exchange value concept. The data from this account can be used to understand the relative economic significance of different ecosystem services, support aggregation of ecosystem services to compare the role of different ecosystem assets, understand changes in monetary value over time, underpin comparison of the relative economic significance of different ecosystem services to different users and support understanding the relative significance of ecosystem services in different locations, e.g. across countries.

9.3 Entries in the monetary account are recorded in line with the definitions, treatments and measurement boundaries for ecosystem services in physical terms described in Chapters 6 and 7. Key features of these treatments are discussed in Section 9.2. As noted in Chapter 8, the monetary valuation of ecosystem services requires the use of imputation in many cases where unit prices for ecosystem services cannot be observed on markets. There is a wide range of valuation methods that have been developed but not all are suitable for the task of imputed exchange values. Section 9.3 summarizes the methods that can be applied in an ecosystem accounting context. Section 9.4 introduces the ways in which different methods can be applied to impute exchange values for different types of services and Section 9.5 describes a few key measurement issues to be considered in valuing ecosystem services in monetary terms.

9.2 Ecosystem services supply and use account in monetary terms

9.4 Estimates of the monetary value of ecosystem services are recorded in the ecosystem services supply and use account. This account has the same structure as the ecosystem services supply and use account in physical terms described in Chapter 7. These accounts record transactions in different types of ecosystem services between ecosystem assets and economic units. The structure and classification of the various components (e.g. concerning ecosystem services and ecosystem assets) should be consistent between the two accounts.

9.5 The ecosystem services supply and use account in monetary terms is shown in Table 9.1. The scope of the account is determined by the set of ecosystem assets (EA) located within the ecosystem accounting area (EAA) which are reflected as the suppliers of the ecosystem services. The set of users in the account is focused on economic units (businesses, governments, households) that are resident in the ecosystem accounting area but allows for use by non-resident economic units (e.g. cultural services provided to visiting tourists from outside of the EAA) and also for use by other ecosystem assets – i.e. intermediate services. This scope of users is required to ensure that the supply of ecosystem services by resident EA is fully allocated to users.

Table 9.1: Ecosystem services supply and use account in monetary terms

			Ecosystem type (based on Level 3 - EFG of the IUCN Global Ecosystem Typology)																					
			Terrestrial							Freshwater			Marine				Transitional							
			Tropical-subtropical lowland rainforests	Boreal and temperate montane forests and woodlands	Seasonally dry tropical shrublands	Trophic savannas	Semi-desert steppes	Ice sheets, glaciers and perennial snowfields	Croplands	Permanent upland streams	Large permanent freshwater lakes	Large reservoirs	Seagrass meadows	Epipelagic ocean waters	Continental and island slopes	Submerged artificial structures	Tropical flooded forests and peat forests	Deepwater coastal inlets	Rocky shores	Coastal shrublands and grasslands	Artificial shores	Coastal river deltas	TOTAL SUPPLY BY RESIDENT ECOSYSTEM ASSETS	Supply from non-resident ecosystem assets - Imports	TOTAL SUPPLY
SUPPLY			T1.1	T2.1	T3.1	T4.1	T5.1	T6.1	T7.1	F1.1	F2.1	F3.1	M1.1	M2.1	M3.1	M4.1	TF1.1	FM1.1	MT1.1	MT2.1	MT3.1	MFT1.1			
Selected ecosystem services (initial list)																									
Provisioning services																									
	Biomass provision	Crop provision																							
		Grazed biomass provision																							
		Timber provision																							
		Non-timber forest products provision																							
		Fish and other aquatic products provision																							
Regulating and maintenance services																									
	Global climate regulation																								
	Local (micro and meso) climate regulation																								
	Air filtration																								
	Soil retention / erosion control																								
	Water purification																								
	Water regulation for base flows																								
	Water regulation for mitigation of extreme events																								
	Pollination																								
	Pest control																								
	Nursery population and habitat maintenance																								
Cultural services																									
	Tourism recreation related services																								
	Local recreation related services																								
	Amenity services																								
	Education, scientific and research services																								
	Spiritual / religious services																								
	Habitat and species appreciation services																								
TOTAL SUPPLY																									

NB: The list of ecosystem services presented is indicative only. In due course the table will include an agreed set of ecosystem services.

Table 9.1: Ecosystem services supply and use account in monetary terms (cont)

			Selected economic units										TOTAL FINAL ECOSYSTEM SERVICES		Ecosystem types (realms)				TOTAL INTERMEDIATE SERVICES		TOTAL USE
			Agriculture	Forestry	Fisheries	Electricity and gas supply	Water collection, treatment and supply	Manufacturing	Services	Government	Households	Non-resident units - Exports			Terrestrial ecosystems	Freshwater ecosystems	Marine ecosystems	Transitional ecosystems			
USE																					
Selected ecosystem services (initial list)																					
Provisioning services																					
	Biomass provision	Crop provision																			
		Grazed biomass provision																			
		Timber provision																			
		Non-timber forest products provision																			
		Fish and other aquatic products provision																			
Regulating and maintenance services																					
	Global climate regulation																				
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	Soil retention / erosion control																				
	Water purification																				
	Water regulation for base flows																				
	Water regulation for mitigation of extreme events																				
	Pollination																				
	Pest control																				
	Nursery population and habitat maintenance																				
Cultural services																					
	Tourism recreation related services																				
	Local recreation related services																				
	Amenity services																				
	Education, scientific and research services																				
	Spiritual / religious services																				
	Habitat and species appreciation services																				
TOTAL USE																					

NB: The list of ecosystem services presented is indicative only. In due course the table will include an agreed set of ecosystem services.

9.6 The supply and use table also allows for the use of final ecosystem services by resident economic units in cases where these services are supplied by non-resident EA. For example, resident household may travel to other countries and receive cultural ecosystem services in those countries.

9.7 Entries in monetary terms should be recorded using the exchange value concept, applying a common currency unit and pertaining to a single accounting period in which values are recorded in the prices of that period (i.e. nominal values). Separate supply and use accounts can be compiled for different accounting periods to establish time series for different ecosystem services.

9.8 Entries recorded in the monetary supply and use account should mirror those recorded in the ecosystem services supply and use account in physical terms described in Chapter 7. Thus:

- The definition and measurement scope of each ecosystem service is the same as in the physical SUA, including the treatment and recording of intermediate services, imports and exports of ecosystem services, subsistence production of agricultural and related products and abiotic flows.
- The flow recorded in quantitative terms in the physical SUA should be consistent with the valuation in monetary terms.
- The allocation of ecosystem service supply to the various users of ecosystem services is consistent with the allocation in the physical SUA.
- The accounting period is the same as for the physical SUA.

9.9 While the set of ecosystem services included in the monetary supply and use account would generally align with the set of ecosystem services included in the physical supply and use account, it is possible that some flows of ecosystem services are considered more difficult to value in monetary terms and hence the number of ecosystem services included in monetary terms may be smaller.

9.10 Generally, estimates of exchange values for each ecosystem service will be obtained by multiplying a measure of the service flow in quantitative terms by a unit price estimated using an appropriate method among those described in Section 9.3. Commonly, it will also be necessary to adopt benefit transfer techniques wherein an estimated unit price for an ecosystem service supplied in a sample of locations is applied across multiple locations, taking into account different environmental and socio-economic contexts.

9.11 In some cases, the exchange value of an ecosystem service will be estimated directly rather than by using separate price and quantity estimates. For example, measures of resource rent may be used to impute exchange values of biomass provisioning services, and hedonic methods may be used to measure amenity services. In these cases, compilers should ensure that an estimate of the corresponding flow in quantitative terms is included in the physical supply and use account. This will serve to maintain a coherence in the accounting system and will support assessment of changes in the ecosystem asset, including for example, ecosystem degradation.

9.12 Since the entries in monetary terms are in a common currency, it is possible to derive aggregate measures of ecosystem services either for a basket of ecosystem services supplied by an ecosystem asset/type; or for a basket of ecosystem services used by an economic unit/industry.

9.13 It is important that compilers document the scope of the ecosystem services included in the accounts and highlight ecosystem services that have been excluded from the scope of measurement. This is required so that users of the accounts can readily appreciate and interpret the aggregate measures of the monetary value of ecosystem services.

9.14 Depending on the approach taken for compilation, it may be possible to produce maps of different ecosystem services showing where they are supplied within an ecosystem accounting area (EAA).

*<<**Note to reviewers**: The SUA can be used to derive aggregate and indicators such as gross ecosystem value added. At this stage, there has been limited discussion of the most relevant aggregates and indicators to be described in the revised SEEA EEA and hence no discussion is included here. Proposals for consideration will be included in the second round of global consultation.>>*

9.3 Techniques for valuing transactions in ecosystem services

9.3.1 Introduction

9.15 Section 8.2 describes the conceptual basis for valuing ecosystem services for ecosystem accounting in terms of exchange values. More precisely, the goal is to obtain estimates of the value of ecosystem services as the output of ecosystem assets (EA), which may be recorded as either final consumption or intermediate consumption of economic units depending on whether the ecosystem service is used in the production of other goods and services.

9.16 In practice, it is generally necessary to impute exchange values for their application in accounting. Over the last decades, a range of techniques have been developed for placing monetary values on non-marketed goods and services. This section provides an overview of the different techniques and describes the way in which they can be used to impute unit prices consistent with the exchange value concept. Figure 9.1 summarizes the techniques that can be used to obtain exchange values.

Figure 9.1: Summary of techniques for imputing exchange values for ecosystem services

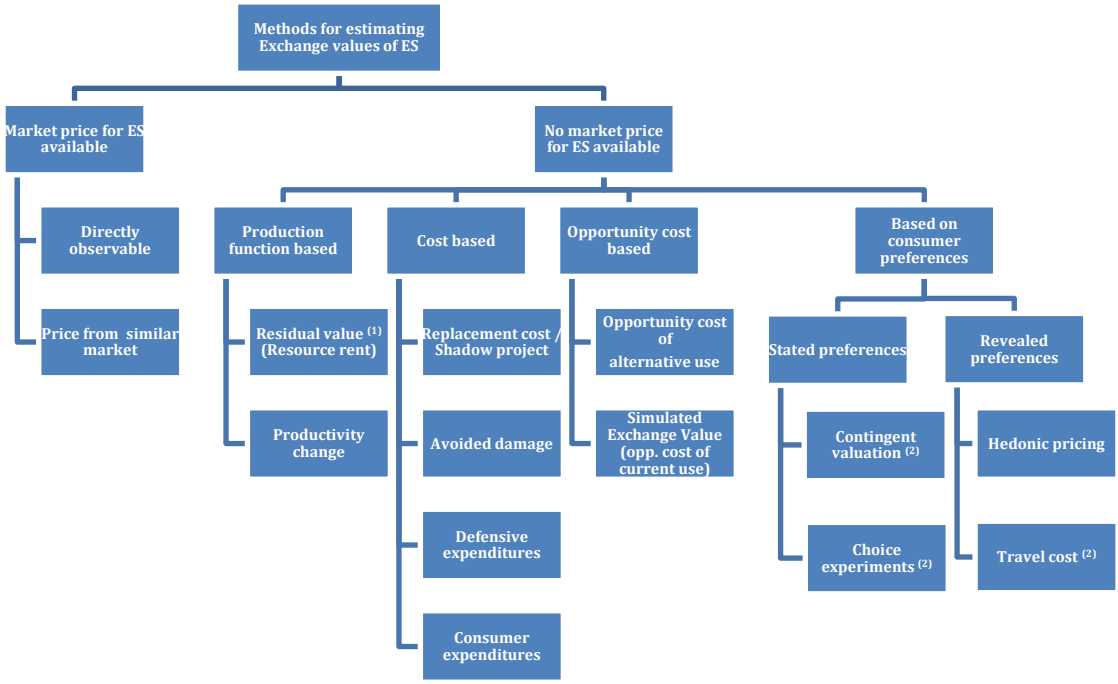

Figure notes:
(1) Irrespective of the methods used, economic input costs (including labour, produced capital and intermediate inputs) need to be deducted to arrive at the ecosystem service. The residual value is included as an independent method for its use in arriving at exchange values for the ES that are intermediate inputs to existing SNA outputs.
(2) Travel cost and stated preference methods provide exchange values when used as part of the simulated exchange value method (see text).

9.17 In summary, the most convenient technique to apply for valuation is one based on a market price of the ecosystem services whether directly observed or using a price from a similar market. This technique will be discussed in sub-section 9.3.2.

9.18 When no market price is available for an ecosystem service, which is the most common situation, it is possible to impute an exchange value or an appropriate unit price which can be multiplied by the relevant quantity to estimate the exchange value. Some techniques in this context can also be used to measure the total welfare value, including consumer surplus, associated with the ecosystem service. However, the techniques are discussed here exclusively in relation to their ability to support the imputation of exchange values for ecosystem accounting purposes.

9.19 Techniques used when no market prices are available are divided into those based on: (i) the production function concerning the use of the ecosystem service in the production of other goods and services (SNA benefits), (ii) costs as inputs, (iii) opportunity costs (i.e. foregone benefits), (iv) revealed preferences and (v) stated preferences.

9.20 Although techniques in the first two categories potentially reveal the preferences of the society, identified for example through decisions of governments, the techniques themselves do not aim to estimate a demand function[1] based on the preferences revealed by individuals through their consumption habits (as required under revealed preference theory). Thus, techniques based on revealed preference theory are grouped separately in categories four and five.

9.21 The different techniques can in principle be applied to the estimation of unit prices for a single ecosystem service arising from a single, spatially explicit, ecosystem asset or ecosystem type. However, within a SEEA context, the general aim is to estimate values for multiple ecosystem services across multiple ecosystem assets and ecosystem types. In principle, aggregation across ecosystem services and ecosystem types is possible even where different valuation techniques are used, provided the different techniques are focused on applying the same valuation concept (i.e. exchange values). However, it should be recognized that different techniques may generate substantively different estimates of exchange values and hence, convergence-validity between methods would need to be checked to quality-assure all estimates.

9.22 From Chapter 8, an ecosystem service is defined as the contribution provided by ecosystem assets to benefits. Accordingly, the exchange value of an ecosystem service should only represent the ecological contribution on ecosystems, i.e. excluding all economic inputs (including labour, produced capital and intermediate inputs). Whenever relevant, for example in using the resource rent method, all costs should be deducted.

9.3.2 Techniques where a market price of the ecosystem service is available

9.23 **Directly observed prices**. As stated above, the most convenient method to apply for valuation is one based on a direct observation of the market price of the ecosystem service when that

[1] Reflecting the maximum willingness to pay for different quantities of the ecosystem service

is available. For example, if a wetland provides services of water purification and the owners or managers of that wetland are able to charge the utility that draws the water for municipal uses, there is a price for the service provided by the ecosystem and it can be used directly to value it. Stumpage values charged to timber logging businesses are also an example of directly observed prices.

9.24 Another example of directly observed prices relates to land rental prices in agriculture where markets exist to rent land for crop production or grazing. Such rental prices may be used to underpin the valuation of relevant biomass provisioning services. Values associated with sales of agricultural land may also be used by converting the transacted land values into an annual flow. In general, this will provide a value for a bundle of ecosystem services. Thus, in applying this method it will be necessary to isolate the contribution of individual services, for example, using the hedonic price method described below.

9.25 The SNA does not require exchange values to come from competitive markets, for example exchange values from monopoly or oligopoly conditions are recorded in the national accounts without adjustment. However, where directly observed prices are considered not economically significant[2] (such cases may arise in the context of fees paid to enter a national park, for example), the observed price should not be used and alternative valuation techniques should be applied.

9.26 In applying directly observed prices, it is important to clarify whether the price observed corresponds to the ecosystem service itself or whether input costs need to be deducted to arrive at a price for the ecosystem service.

9.27 **Prices from similar markets**. When market prices are not observable, valuation according to market price equivalents may provide an approximation to market prices. *"Generally, market prices should be taken from the markets where the same or similar items are traded currently in sufficient numbers and in similar circumstances. If there is no appropriate market in which a particular good or service is currently traded, the valuation of a transaction involving that good or service may be derived from the market prices of similar goods and services by making adjustments for quality and other differences"* (2008 SNA, 3.123). For example, when non-timber forest products (e.g. mushrooms) from one forest are marketed but those from a similar forest are not, the prices observed in the former can be used to value the non-timber forest products from the latter allowing for differences in products and other factors. Another example concerns observed prices from emission trading systems which may be used to value carbon sequestration services by forest ecosystems even if these ecosystems are not explicitly covered by the emission trading system.[3]

9.3.3 Production function based methods

9.28 The methods considered in this sub-section are based on the production function concerning the use of the ecosystem service in the production of other goods and services, which should ideally be spatially-explicit. This function is used either to calculate a residual value or resource rent to value the environmental change by observing the physical relationships (e.g., the dose-response relationship) existing between an environmental change and a receptor

[2] *"Economically significant prices are prices that have a significant effect on the amounts that producers are willing to supply and on the amounts that purchasers wish to buy"* 2008 SNA, 22.28

[3] Ideally the observed price from the emission trading system should be adjusted to take into account the impact that including the removals of carbon by the forestry sector would have on the price. The depth of the market should also be considered in these contexts.

(e.g., erosion/agricultural production, pollution/health, water quality/fish catches, and so forth).

9.29 **Residual value method (Resource rent).** The residual value or resource rent method places a value on an ecosystem service by taking the gross value of the final products to which the ecosystem service provides an input and then deducts the cost of all other inputs, including labour, produced capital and intermediate inputs (see formula below). Assuming that the gross values of outputs and inputs are estimated as exchange values, the imputed value will be consistent with exchange values. As stated above, irrespective of the methods used, economic inputs need to be deducted to arrive at the contribution of the ecosystem service. The residual value is included as an independent method for its use in arriving at exchange values for the ES that are intermediate inputs to existing SNA outputs.

9.30 The resource rent is calculated by deducting consumption of fixed capital, return on produced assets and labour of self-employed persons from gross operating surplus. Following the SEEA Central Framework:

Output
less intermediate consumption
less compensation of employees
less other taxes on production
plus other subsidies on production
Equals gross operating surplus
less consumption of fixed capital (depreciation)
less return on produced assets
less labour of self-employed persons
Equals resource rent
= depletion + net return on environmental assets

9.31 There are a number of difficulties with this technique. First, the residual may reflect a combination of other non-paid and indirect inputs and thus distinguishing the value of the ecosystem service contribution may be difficult. Second, the estimate is also subject to errors in calculating the value of all the ´paid´ inputs. Third, and most importantly, the size of the residual will be directly affected by the institutional arrangements surrounding the use of the ecosystem. Where open access to resources is permitted, it is well accepted in economic theory and in practice that the resource rent will tend towards zero thus resulting in a value of the ecosystem service that is very low or zero.

9.32 At the same time, since this method must be applied based on data from the SNA and the value of the ecosystem service is implicitly reflected in measures of gross operating surplus, it is the case that the exchange values estimated using this technique will reflect the current institutional context.

9.33 **Productivity change method**. In the productivity change method, the ecosystem service is considered an input into the production function of a marketed good. Thus, changes in the service will lead to changes in the output of the marketed good other things being equal. The value of the change in the ecosystem service is therefore estimated as the change in the market value of production consequent upon a change in the supply of the ecosystem service. This is the marginal product of the ecosystem service and is multiplied by the output price of the marketed good to derive an estimated exchange value for the ecosystem service. The productivity change method has been used to value the services provided by water and other inputs in agriculture, mostly in locations where detailed data to estimate production functions are available. It provides an imputed price consistent with the exchange value concept and it is particularly suited for the estimation of the ES that are intermediate inputs to existing SNA outputs although where there are multiple goods identifying the production function and marginal product of an individual ecosystem service may be difficult.

9.3.4 Cost or expenditure based methods

9.34 The methods discussed in this section are based on the estimation of costs, in the sense of inputs or expenditures. These costs are the result of a change in the supply of the ecosystem service or change necessary to maintain the current flow of ecosystem services.

9.35 **Replacement cost.** The replacement cost method estimates the cost of replacing the ecosystem service by something that provides the same benefits. It is also known as the substitute cost or alternative cost approach. The replacement cost refers to the cost of available substitutes for the particular ecosystem service. The substitutes can be either a consumption item (e.g. creating a new park when the current one is no longer available) or an input factor (e.g., sorghum substituting for non-priced forage in the case of a rangeland grazing ecosystem services). In either case, if the substitute provides an identical service, the value of the ecosystem service is the cost of using the substitute to provide the same benefits.

9.36 The validity of the replacement cost approach to estimate exchange values depends upon three conditions being maintained: i) the substitute can provide exactly the same function as the ecosystem service being substituted for; ii) the substitute used is actually the least-cost alternative; and iii) evidence indicates an actual willingness to pay for the alternative to the ecosystem service if it were to be no longer supplied. In the example of the non-priced forage noted above, evidence should show that the manager of the rangeland would actually pay for sorghum at the estimated price if the forage were not available.

9.37 A variant of the replacement cost method is the shadow project method which refers to the costs of providing the same ecosystem service elsewhere. Possible alternatives for the design of a shadow project include: asset reconstruction (e.g., providing an alternative habitat site for threatened wildlife); asset transplantation (e.g., moving the existing habitat to a new site); or asset restoration (e.g., enhancing an existing degraded habitat). The three conditions noted above apply to this method also.

9.38 **Avoided damage costs.** The avoided damage costs method estimates the value of ecosystem services based on the costs of the damages that would occur due to the loss of these services. Similar to replacement costs, the focus will generally be on services provided by ecosystems that are lost due to human activity impacting on environmental condition, particularly through pollution. To obtain exchange values, equivalent conditions to those detailed for the replacement cost method need to hold noting that not all approaches to valuing damages will be consistent with exchange values. The avoided damage method is particularly useful for regulating services such as erosion and flood control, sedimentation control, air purification, and carbon sequestration.

9.39 **Defensive expenditure.** The defensive expenditure method is based on the assumption that individuals and communities spend money on preventing or mitigating negative effects and damages caused by adverse environmental impacts. This is the case, for example, of extra filtration for purifying polluted water, air conditioning for avoiding polluted air, and so forth. The majority of examples are applications to the valuation of reduced mortality and morbidity. The expenditures incurred are considered a lower bound estimate of the benefits of mitigation, since it is assumed that the benefits derived from avoiding damages are at least equal to the costs incurred to avoid them. The imputed price will be consistent with exchange values. An advantage of this technique is that it is easier to estimate the expenses incurred than to estimate the environmental damage. A disadvantage is that defensive expenditures are not very sensitive to the differences in environmental quality, so they are not spatially sensitive in the way damage functions could be.

9.40 Similar to defensive expenditures are cases of averting behaviour, which individuals undertake activities to avoid the impacts of a poor environment. The costs involved include, for example, time spent indoors, when the preference would have been to go outside, in addition to the kinds of equipment installation referred to above.

9.41 **Consumer expenditure approach.** The consumer expenditure approach estimates the exchange value of recreation related ecosystem services by aggregating the expenditures incurred by households or individuals to reach and access a recreational area. In this approach it is assumed that the actual spending of households represents an approximation of the value provided by these ecosystem services but a challenge in applying this method is determining the share of the expenditures that relates to the ecosystem contribution.

9.3.5 Opportunity Costs and Simulated Exchange Values

9.42 The two approaches considered in this section have much in common being focused on the measurement of foregone benefits. Although the name 'opportunity cost' suggests a relationship with the cost-based methods considered above they are conceptually different. Cost-based methods relate to expenditures or inputs, while 'opportunity cost' methods refer to forgone benefits.

9.43 **Opportunity costs of alternative uses**. This approach imputes prices of ecosystem services by measuring the forgone benefits of not using the same ecosystem asset for alternative uses. For example, the value of ecosystem services arising from not harvesting trees for timber can be measured by using the forgone income from selling timber. Thus, this approach measures what has to be given up for the sake of securing the ecosystem services. The opportunity cost approach is most useful when considering the ecosystem services that can be linked to certain purposes such as the protection of habitats, cultural or historical sites. The values obtained can be considered exchange values provided that (i) the valuation of the forgone benefits is based on exchange values and (ii) that the institutional context considered is sufficiently realistic such that the alternative scenario can be analyzed. A difficulty with the opportunity costs approach is determining an appropriate alternative use.

9.44 **Simulated Exchange Value (SEV) method**[4]. The simulated exchange value estimates the opportunity cost of not trading on the market the ecosystem services associated with the current use of the ecosystem asset, given the current ecosystem management objectives. For example, if the manager of a National Park decides not to charge visitors, the opportunity cost estimated with the SEV are the foregone benefits arising from not charging the visitors any entrance fee.

9.45 The SEV method is applied by using results from demand functions for the relevant ecosystem service (for example estimated using the travel cost method or stated preference methods discussed below) to calculate the unit price for the ecosystem service that would occur if it was actually marketed. This requires combining the information on the demand function with a supply function and an appropriate market structure (institutional context). Standard microeconomic methods are then used to yield the imputed price, which can be used to estimate the exchange value of the ES as output (Caparrós et al., 2017). The method can be applied at various degrees of complexity and using alternative market structures.

[4] Details of the SEV using contingent valuation data can be found in Caparrós et al. (2003, 2017). For SEV and choice experiments, see Oviedo et al. (2016).

9.3.6 Revealed Preference Methods

9.46 Revealed preference methods estimate the demand function of non-marketed ecosystem services by examining the purchasing behaviour of consumers of related marketed goods or services (i.e. revealed preference methods are based on revealed preference theory). The main techniques that fall into this category that are relevant for ecosystem services valuation are the hedonic price method and the travel cost method.[5]

9.47 **Hedonic pricing**. The hedonic pricing method estimates the differential premium on property values/rentals (or for other composite goods) derived from proximity to some environmental characteristic. In order to obtain a measure of how the environmental characteristic affects the value of houses or other properties, all other variables of the house (number of rooms, central heating, garage space, etc.) are standardized. Moreover, any unit of housing is completely described by geographical, neighbourhood and environmental attributes.

9.48 In the context of ecosystem accounting, the decomposition of the rental price into the part explained by the ecosystem service and the part explained by the remaining variables of the house can be used to estimate an exchange value for the ecosystem service as output or intermediate consumption. If the study is based on house prices, the value needs to be transformed into an equivalent annual rent to obtain an estimate of the exchange value. This technique may also be applied in other land value contexts.

9.49 **Travel cost method.** The travel cost method (TCM) estimates the demand function for recreation by observing the number of trips that take place at different costs of travelling. Costs of travelling include data on the expenditures incurred by households or individuals to reach a recreational site, entrance fees and the opportunity cost of time to travel and visit the site. Subtracting the actual costs incurred (i.e. excluding opportunity costs of time) from the estimated demand function gives the consumer surplus for a given number of visits. To impute an exchange value for use in ecosystem accounting, the TCM results must therefore be applied using the simulated exchange value method.

9.3.7 Stated Preference Methods

9.50 Stated preference methods do not utilize information on the behaviour of people in existing markets but rather use information from questionnaires to elicit likely responses of people by asking them to state their preferences in hypothetical situations. Stated preference methods are generally based on discrete choice models[6], and there are two broad types: contingent valuation and choice experiments. These are introduced below. These methods are the only ways of establishing values for non-use aspects of ecosystems.

9.51 A typical application of these methods yields values that include consumer surplus[7]. Consequently, to use the results of these methods to derive exchange values, it is necessary to apply them using the simulated exchange value method.

9.52 **Contingent valuation method**. The contingent valuation (CV) method is a survey-based stated preference technique that elicits people's behaviour in constructed markets. In a contingent valuation questionnaire, a hypothetical market is described where the good in question can be traded. This contingent market defines the good itself, the institutional context in which it would be provided, and the way it would be financed. Respondents are asked about their willingness to pay for, or willingness to accept, a hypothetical change in the level of provision

[5] More details about the methods can be found in OECD (2018)
[6] The pros and cons of different specifications are discussed in various publications; in particular, see Johnston et al. (2017).
[7] More precisely, Hicksian variations, as Hicksian demand functions are obtained

of the good, usually by asking them if they would accept a particular scenario. Respondents are assumed to behave as though they were in a real market (OECD, 2018).

9.53 **Choice experiments**. Choice experiments are those where an individual is offered a set of alternative levels of supply of goods or services (typically two or three), in which the characteristics vary according to defined dimensions of quality and cost. By analyzing preferences across these different bundles of characteristics, it is possible to obtain the value placed by the individuals on each of the characteristics, provided (i) the bundles include a cost variable; and (ii) a baseline bundle is included that represents the status quo.

9.4 Valuation approaches for different ecosystem services

9.4.1 Introduction

9.54 For the compilation of the ecosystem services supply and use account in monetary terms the different valuation techniques described in section 9.3 must be applied to individual ecosystem services. Table 9.2 provides an overview of the techniques that are typically applied to different broad groups of ecosystem services. In practice, the technique that is applied will depend on data availability. The following sub-sections provide general guidance on the issues to be considered in undertaking monetary valuation of provisioning, regulating and maintenance and cultural services.

Table 9.2: Summary of valuation methods for exchange values by broad type of ecosystem service

Approach		Method	Description	Provisioning services	Regulating & maintenance services	Cultural services
Market Data for ES Available		Directly observable	Observed transaction prices for the ES	X	X	X
		Similar markets	Observed transaction prices for the ES in similar markets	X	X	X
No Market Data for ES Available	Production function	Residual value (Resource rent)	Deducting cost of inputs from gross value of the final products (1)	X		X
		Productivity Change	Change in the market value of a product consequent upon a change in the supply of the ecosystem service		X	
	Cost-based	Replacement Cost/ Shadow Project	Cost of replacing the ecosystem service		X	
		Avoided damage costs	Cost of damage that would occur if the ecosystem service was lost		X	
		Defensive expenditures	Expenditures incurred in preventing adverse environmental impacts		X	
		Consumer expenditures	Expenditures to reach recreation area			X
	Opportunity cost based	Opportunity cost of alternative uses	Forgone benefits of not using the same ecosystem asset for alternative uses	X	X	X
		Simulated exchange value (2)	Forgone benefits of not trading in the market the ecosystem service associated with the current use of the ecosystem asset	X	X	X

	Revealed preferences	Hedonic price	Econometric analysis of property data to derive demand curve for environmental characteristics			X
		Travel cost (2)	Econometric analysis of visitor expenditure data to derive demand curve for recreation			X
	Stated preferences	Contingent valuation (2)	Statistical analysis of answers on WTP for a hypothetical environmental change	X	X	X
		Choice experiments (2)	Statistical analysis of answers on WTP for hypothetical environmental changes (multiple alternatives)	X	X	X

Table notes:
(1) Irrespective of the methods used, human inputs need to be deducted to arrive at the ecosystem service value. The residual value is included as an independent method for its use in arriving at exchange values for intermediate consumption.
(2) Travel cost and stated preference methods provide exchange values when used as part of the simulated exchange value method (see text).

9.4.2 Valuation of provisioning services

9.55 Provisioning services include living resources harvested from unmanaged terrestrial and aquatic natural systems (uncultivated biomass) to highly managed plantations, aquaculture and livestock systems (cultivated biomass). While the ecosystem assets themselves may be involved in the generation of multiple services, including regulating and maintenance and cultural services, the valuation of provisioning services should deal only with estimating the value related to the physical flows (e.g. fish) that are harvested for non-recreational, consumptive use. The relevant measurement boundaries for provisioning services are described in Chapter 6.

9.56 The biomass harvested is within scope of the production boundary of the SNA and hence exchange values for the relevant products are included in current measures of economic production. The valuation of ecosystem services is therefore focused on identifying the contribution of the ecosystem to the biomass product values which are themselves based on data on quantities traded, market prices and input costs.

9.57 In a number of situations, there may be significant flows of ecosystem services associated with subsistence agriculture, forestry and fisheries, that is, when the outputs from growing and harvesting activities are not sold on markets but directly consumed by households. A broad range of products may be relevant in this regard, including all types of non-timber forest products. Following the conceptual scope of the SNA, the production associated with these activities should be included in the national accounts estimates of output, with exchange values estimated on the basis of the prices of similar goods sold on markets.[8] The methods described below for similar provisioning services can be used for the valuation of the ecosystem services associated with subsistence production and consumption on the basis of these estimated market prices.

9.4.3 Valuation of regulating and maintenance services

9.58 There is a wide range of regulating and maintenance services. In some cases, the contribution of these services is an input to SNA benefits, for example services of soil retention with respect to agriculture and water regulation of extreme events with respect to businesses potentially affected by flooding. In other cases, the services are contributions to non-SNA benefits,

[8] The handbook on measuring the non-observed economy (OECD, IMF, ILO and CIS Interstate Statistical Committee, 2002) provides guidance on measurement approaches in this area.

especially concerning improvements in human health, e.g. air filtration. In all cases, there are few, if any, distinct markets for the services and identifying their relative contribution within existing market prices is likely to be challenging. Finally, most regulating and maintenance services exhibit considerable variation in their supply depending on local contexts and hence the measurement of the flows in biophysical terms will generally require biophysical modelling at relatively fine spatial scales.

9.59 Notwithstanding these challenges, measurement in biophysical terms is quite feasible (see Chapter 6) and pricing of these ecosystem services is well practised. Cost-based methods are the most commonly used methods using either the replacement cost of the service or the avoided damages, avoided mitigation costs or defensive expenditures.

9.60 In some cases, regulating and maintenance services can be valued based on observed market transactions, such as in using data from payments for ecosystem services schemes or emissions trading schemes. However, there will be limits to where this approach can be used to estimate exchange values depending on the institutional arrangements involved or the way in which services are quantified within the schemes (e.g. often management actions are used as a proxy for quantities).

9.4.4 Valuation of cultural services

9.61 As explained in Chapter 6, there are important connections between people and ecosystems that are not provisioning or regulating in nature. The term cultural services is used to encompass many of these connections. Generally, identifying the broad motivations and benefits that people obtain from these connections is relatively straightforward – for example personal health and well-being or the conservation of threatened species for future generations. However, isolating the ecosystem contribution to these benefits and hence identifying the exchange value for the ecosystem services is less straightforward.

9.62 Generally, it is necessary to consider the monetary valuation of cultural services from a demand or consumption perspective. The most common methods for estimating the demand are revealed preference methods based on travel cost and stated preference methods based on contingent valuations and choice experiments. However, it will not be possible to use the results from these valuation methods to estimate exchange values directly and hence the simulated exchange value method should be used in combination.

9.63 Other approaches to estimating cultural services include hedonic pricing where, for example the value of amenity and local recreation services may be determined from the assessment of local house prices. Also, using residual value or productivity changes approaches, it is possible to estimate the exchange value of the contribution of ecosystem services to the output of businesses involved in facilitating people's interactions with nature, for example island resorts or canoe hiring firms. The consumer expenditure method may also be considered to provide an exchange value for recreation related services. Finally, it may be possible to use information on voluntary transactions (e.g. donations) made in support of achieving environmental outcomes to be used to supporting measurement of services concerning people's appreciation of specific species or habitats.

9.5 Considerations in the monetary valuation of ecosystem services

9.5.1 Spatial variation and the use of benefit transfer methods

*<<**Note to reviewers**: To provide general context and introduction to the use of benefit transfer methods in ecosystem accounting the following text is provided. This text is repeated from the SEEA EEA 2012 (paragraphs 5.123-5.127). The topic of benefit transfer is the subject of ongoing research and specific work on the translation of this research to an ecosystem accounting context is due for completion by mid-2020. It is anticipated that this recent text will be summarised for inclusion in the revised SEEA EEA and in related compilation guidance. In addition, the topic of benefit transfer was addressed in the SEEA EEA Revision discussion paper 5.1.>>*

9.64 The discussion of valuation for ecosystem accounting is focused on the development of estimates in monetary terms for large regions or countries that may be used for the development, implementation and/or monitoring of public policy. Much work on valuation has focused on the valuation of ecosystems and ecosystem services in smaller, more targeted settings for specific ecosystems or in relation to particular events, for example the valuation of damages caused by oil spills. Consequently, much data on the value of ecosystem services is fragmented, covering only specific services over a large area, or multiple services in a more confined area, or changes in the flow of ecosystem services following a specific event. In general, great care must be taken when value estimates for ecosystem services or ecosystem assets are extended to other areas.

9.65 To utilize data from specific locations in the estimation of values in other locations, a set of techniques can be applied, collectively referred to as benefit (or value) transfer techniques. There are three main types of approaches to benefit transfer: value transfers, benefit function transfers and 'meta-analysis' function transfers. A value transfer takes a single estimate of the value of an ecosystem service, or an average of several value estimates from different studies, to estimate the value of an ecosystem service in a different context. Rather than transfer the single estimate of value, a benefit function transfer takes the function estimated from a primary research study in one context and applies it in another context.

9.66 A more comprehensive way to carry out benefit transfers is to use meta-analysis, which takes all existing studies and then estimates a relationship that gives changes in the values of ecosystem services as a function of, *inter alia*, site characteristics, attributes and size of population affected, and the type of statistical method 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. This approach is well suited to developing estimates for additional sites but may need to be supported with other techniques in order to provide estimates at larger scales, including at the national level.

9.67 The values provided by ecosystem services are often strongly dependent on the biophysical, economic and institutional context, which makes it difficult to assume that value estimates of specific services apply also in a different context. Furthermore, ecosystems are likely to be highly interdependent. The value of one unit of an ecosystem is therefore likely to be contingent on the existence or proximity of other ecosystem components. In these situations, asset values are known to be interdependent rather than unique (as is the case with values revealed on regular markets). Given the likelihood of differences in quality of ecosystem services between ecosystems, a simple value transfer based on average prices is unlikely to

be appropriate and a benefit function-transfer or a meta-analysis function transfer is likely to be required.

9.68 At the same time, the number of point estimates of value or functions available for transfer is dependent on the type of ecosystem service being considered. For example, while there are many studies of recreational use, there are not as many studies on the value of wetlands. Different valuation studies are also often based on different assumptions and using different methodological constructs leading to differing levels of confidence in the estimates produced. Given, the limited data points for certain ecosystem service types, the variability in approaches and the lack of common functional variables across studies, benefit transfer is prone to a high degree of uncertainty, particularly if done poorly. Therefore, there must be focus on increasing the number of observations and different valuation studies to improve the overall quality of outcomes, in addition to efforts aimed at improving benefit transfer methods.

*<<**Note to reviewers**: It is proposed that in addition to the discussion of benefit transfer, section 9.5 also include a discussion of uncertainty in valuation (a topic also discussed in SEEA EEA 2012) and on approaches to assessing the merits of different valuation methods. For all of these topics there will be connections associated with identifying the key determinants of value relevant for different ecosystem services.*

Another related topic concerns the links between the valuation of ecosystem services using exchange values and the measurement of externalities and ecosystem disservices. This topic was the focus of SEEA EEA Revision discussion paper 5.5. It is intended that this topic be considered in Chapter 12 within a broader discussion of complementary approaches to environmental valuation. There will also be relevant material included in Annex 8.1 on the conceptual relationship between exchange values used in accounting and welfare focused valuations.>>

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