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SEEA Experimental Ecosystem Accounts

Chapter 5: Approaches to valuation for ecosystem accounting

(for discussion)

REVISION OF THE SYSTEM OF ENVIRONMENTAL - ECONOMIC ACCOUNTING (SEEA)

SEEA Experimental Ecosystem Accounts

Draft material prepared for the 7th Meeting of the Committee of Experts on Environmental-Economic Accounting (UNCEEA)

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DRAFT

Chapter 5: Approaches to valuation for ecosystem accounting

Material prepared in consultation with the Editorial Board for the SEEA Experimental Ecosystem Accounts and following discussions at the Expert Meetings on Ecosystem Accounts.

The following text has been drafted for discussion among UNCEEA members as part of the process of developing the SEEA Experimental Ecosystem Accounts. The material should not be considered definitive and should not be quoted.

Status of Chapter 5

It is intended that the valuation basis to be applied in the SEEA Experimental Ecosystem Accounts is consistent with the SNA and the SEEA Central Framework, i.e. market prices. At the same time the nature of ecosystems and the flows of ecosystem services means that valuation using observed, transaction based market prices is usually not possible. Thus, the question that must be answered is the extent to which alternative valuation methods that might be used for valuation purposes in ecosystem accounting are consistent with the SNA principles.

The intention in this chapter is to tackle this question in the following way.

> First, to outline clearly the SNA and SEEA principles on valuation. While at one level this may be seen as limited to observed market prices, the SNA describes at some length approaches to valuation where non-monetary transactions are constructed and where imputed prices must be used. Of particular relevance in the context of ecosystem accounting is the valuation of public goods – which are valued using the costs of production following the SNA.
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> Second, to describe the various valuation approaches that have developed and been applied in ecosystem accounting for the purposes of compiling monetary estimates of ecosystem services.
>
> Third, to assess the various approaches in terms of their consistency with the SNA valuation principles.
>
> Fourth, as appropriate and to the extent possible, to provide examples of the valuation of selected ecosystem services using relevant approaches.

At this time, material has been drafted concerning the first two matters on valuation principles and valuation approaches, noting that more work may be needed to ensure an appropriate coverage of alternative valuation approaches. The third stage of reviewing the various approaches in light of the valuation principles has not been completed although discussion on this topic did occur at the Expert Group meeting on Ecosystem Accounts held in Melbourne in mid May, 2012.

It is intended that discussions will be held with both national accountants and economists involved in the valuation of ecosystem services in the coming months. Draft material on the application of valuation approaches to specific ecosystem services will be developed as appropriate.

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5.1 Introduction

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5.2 Valuation principles in the SNA and the SEEA

General principles of valuation

5.1 For accounts in monetary terms the question of valuation is central. This paper provides an introduction to the principles of valuation that are used in the SNA and that are adopted in the SEEA. In the SEEA, as in SNA, the values reflected in the accounts are, in principle, the current transaction values or market prices for the associated goods, services, or assets that are exchanged. (2008 SNA, 3.118)

5.2 Strictly, market prices are defined as amounts of money that willing purchasers pay to acquire something from willing sellers. The exchanges should be made between independent parties on the basis of commercial considerations only, sometimes called "at arm's length". (2008 SNA, 3.119)

5.3 Defined in this way, a market price should be distinguished from a general market price that gives an indication of the "average" price for exchanges in a type of good, service or asset. In most cases, market prices based on the totality of transactions that actually occur will approximate the general "average" market prices just described.

5.4 There is a range of situations in which valuation is relevant. The two primary situations for the SEEA Experimental Ecosystem Accounts are the valuation of flows of ecosystem services and the valuation of ecosystems themselves. The measurement of the value of the flow of ecosystem services falls within a general SNA category of valuing transactions. The valuation of ecosystems falls within the SNA category of valuing assets. Each of these areas of valuation is discussed in turn noting that in both cases the general principle outlined above is applied.

Valuation of transactions

5.5 Following SNA, a transaction is an economic flow that is an interaction between institutional units (e.g. between corporations, households, governments) by mutual agreement or an action within an institutional unit that is analytically useful to treat like a transaction. (2008 SNA, 3.51) Mutual agreement does not imply the transaction is voluntarily entered into by both parties (for example, payments of taxation are obligated by law), rather mutual agreement implies the prior knowledge and consent of the parties. (2008 SNA, 3.53)

5.6 A large proportion of transactions are monetary transactions in which one institutional unit makes a payment (or receives a payment) stated in units of currency. Common monetary transactions include expenditure on the consumption of goods and services; payments of wages and salaries; and payments of interest, rent, taxes, and social assistance benefits. In many cases these monetary transactions represent "something for something" transactions – i.e. there is a *quid pro quo*. In other cases, for example taxes and social assistance benefits, no *quid pro quo* is involved. These transactions are known as transfers.

5.7 In the context of measuring ecosystem services the measurement of monetary transactions is not of direct relevance since there are no payments to an ecosystem in exchange for the various ecosystem services. Often there may be monetary transactions associated with the benefits obtained from the use of ecosystem services (for example sales of landed fish) but the connection with the value of the services is not direct. Consequently, of most relevance in the valuation of ecosystem services are the approaches to the measurement of non-monetary transactions.

5.8 Non-monetary transactions are transactions that are not initially stated in units of currency. The value of these transactions must therefore be indirectly measured or otherwise estimated. In some cases a transaction may be an actual one and a value has to be estimated to record it in the accounts. Barter transactions are a good example. In other cases, the entire transaction must be constructed and then a value estimated for it. These constructed transactions are referred to as imputed transactions. (2008 SNA, 3.75).

5.9 An important imputed transaction in the national accounts is the measurement of consumption of fixed capital (depreciation). This is constructed since the flow is one that is internal to an institutional unit and no actual monetary flows occur. Depreciation must therefore be estimated and this is done based on a range of information and assumptions concerning rates of value decline, estimated asset lives, likely replacement costs, etc.

5.10 Another good example of imputed transactions in the national accounts concerns the internal actions of households that are considered analytically useful to treat as transactions. For households, the production boundary of the SNA is defined such that all goods produced by persons within a household that are subsequently used by members of the same household for the purposes of final consumption are included in measures of output in a manner analogous to that for goods sold on the market. Examples of these goods include the growing of crops and animals for own consumption; fish and other animals caught; the collection of timber for use as fuelwood; the abstraction of water; and the building of furniture and making of clothes. In all of these cases, the activity is within the production boundary of the SNA and should be recorded even though no monetary exchange takes place.

5.11 In accounting terms this means that transactions must be constructed in which persons responsible for the production of the goods are deemed to deliver the goods to themselves (or members of their household) as consumers. Values must then be associated with them in order to enter them in the accounts. (2008 SNA, 3.87) The same logic also extends to the housing services produced by those households that own and occupy their dwelling – a transaction commonly referred to as imputed rentals.

5.12 With reference to ecosystem services, the logic of constructing transactions for these services has been outlined in Chapters 2 and 3, although it was not presented from that perspective. Put

in terms of the definition of transactions, flows of ecosystem services represent flows internal to an institutional unit or broader production function that are "analytically useful to treat like a transaction" (2008 SNA 3.51). The following paragraphs consider approaches to estimating values for non-monetary transactions that are discussed in the SNA.

Approaches to valuing non-monetary transactions

5.13 When market prices are not observable, valuation according to market-price-equivalents provides an approximation to market prices. In such cases, market prices of the same or similar items when such prices exist will provide a good basis for applying the principle of 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)

5.14 An example of this approach is the valuation of imputed rentals of owner-occupiers whereby, in general terms, the actual rentals paid by non-owner occupiers, provide the basis for the estimation of the imputed rentals paid by owner-occupiers. So that the value of the housing services can be measured as accurately as possible, adjustments are usually made for the location and size of the dwellings (e.g. by modelling actual rentals paid in different suburbs or regions and for houses with different numbers of bedrooms).

5.15 Where no sufficiently equivalent market exists and reliable market prices cannot be observed, a second best procedure must be used in which the value of the transaction is deemed equal to the sum of the costs of producing the good or service, i.e. the sum of intermediate consumption, compensation of employees, consumption of fixed capital (depreciation), other taxes (less subsidies) on production, and a net return on capital. (2008 SNA, 6.125)

5.16 The economic rationale for the use of the "cost of production" approach is that unless the producer can cover their costs, including covering the full user costs of capital (i.e. deprecation and net return), the production should not take place and hence the good or service would not be available on the market. In the absence of information to the contrary this is considered a reasonable assumption. Significantly, this approach to estimating market prices provides a decomposition of the concept of an SNA market price that is amenable to estimation.

5.17 In the context of ecosystem services, the economic rationale for the cost of production approach can be applied by using the components of a market price (i.e. the various costs of production) to decompose observed market prices for the benefits produced using ecosystem services. Thus, for example, the observed market price of a landed fish may be decomposed into its constituent costs of production, one of which will be the implicit cost of the fish itself from the ecosystem. This implicit cost represents the resource rent for the fish and may be considered a price for the ecosystem service. The measurement of resource rent is discussed in detail in the SEEA Central Framework in Chapter 5.

5.18 In the discussion to this point the underlying assumption is that the producers operate to secure a reasonable net return and participate in production cognisant of the market prices and associated costs of production. This assumption applies for both monetary and non-monetary transactions. Thus, for example, concerning the imputed rentals of owner-occupiers, it is assumed that the owners make a conscious choice to own the dwelling and hence avoid paying actual rentals to a landlord and in effect become their own landlord operating in the housing market.

5.19 At the same time the SNA recognises that there are a significant number of producers, particularly government producers, who do not operate with this market based rationale. Consequently, there are many goods and services, for example health and education services, that in many countries are provided for free or at nominal costs to the users. This type of production of goods and services is known as non-market production.

5.20 The SNA considers that the prices paid (including zero prices) for the output of non-market producers are not economically significant and may reflect neither relative production costs not relative consumer preferences. These prices therefore do not provide a suitable basis for valuing the outputs of the goods and services concerned. (2008 SNA, 6.130) Instead, the value of non-market output is estimated as the sum of costs of production as outlined above with the exception that, by convention, no net return on capital in included in the valuation. (2008 SNA, 6125)

5.21 In the context of ecosystem services, the valuation convention for non-market output of excluding a net return on capital implies that choices should be made as to whether the ecosystem services are considered part of market or non-market output.

Valuation of assets

5.22 Assets, strictly economic assets in an SNA context, are stores of value representing a benefit or series of benefits accruing to the economic owner by holding or using the entity over a period of time. (2208 SNA, 10.8) The prices at which assets are bought or sold on markets are a basis of decisions by investors, producers, consumers and other economic agents. Market prices are assessed by investors and producers in relation to their expectations of the flows of income they can derive from the assets. For example, investors in renewable energy infrastructure assets (such as wind turbines) and environmental assets (such as land) make decisions in respect of acquisitions and disposals of these assets in the light of their values in the market relative to the income they expect the assets to generate over time.

5.23 Ideally, observable market prices should be used to value all assets and every item should be valued as if it were being acquired on the date to which the estimate of the stock relates (usually the beginning and end of an accounting period). These two recommendations enable the values of different types of assets, including environmental, financial, and other economic assets to be compared in meaningful ways, and allow the formation of opening and closing values of stocks that can be used to assess national and institutional sector estimates of wealth in monetary terms.

5.24 The ideal source for asset prices are values observed in markets in which each asset traded is completely homogeneous, often traded in considerable volume, and has its market price listed

at regular intervals. Such markets yield data on prices that can be multiplied by indicators of physical stocks in order to compute the total market value of different classes of assets. These types of price observation are available for most financial assets, newly purchased produced assets including many types of transport equipment (such as cars and trucks), and livestock.

5.25 In addition to providing direct observations on the prices of assets actually traded, information from such markets may also be used to price similar assets that are not traded. For example, information on house and land sales may be used to estimate the value of houses and land that have not been sold.

5.26 It is noted that in some cases, observed market prices may cover the values of a number of assets. For example, prices for real estate will usually include both a value for the dwelling (or buildings) on a piece of land as well as a value for the land itself (in particular its size and location). The notion of composite assets is one that is explained further in SEEA Central Framework Section 5.6 and is of relevance in the context of ecosystems which, by definition, represent a combination of bio-physical components.

5.27 When there are no observable prices because the items in question have not been purchased or sold on the market in the recent past, an attempt has to be made to estimate what the prices would be if a regular market existed and the assets were to be traded on the date to which the estimate of the stock relates. There are two main approaches that are described in the SNA to deal with this situation.

5.28 The first approach is to use the written down replacement cost. The value of certain types of assets (primarily produced assets) will decline over time as the value at the time of acquisition, the acquisition price, is reduced by consumption of fixed capital (more commonly referred to as depreciation) over the asset's life. Furthermore, the acquisition prices of equivalent new assets will change. In theory, the value of an asset at any given point in its life is equal to the current acquisition price of an equivalent new asset less the accumulated consumption of fixed capital over its life. (2008 SNA, 13.23)

5.29 When reliable, directly observed prices for used assets are not available, this approach gives a reasonable approximation of what the market price would be were the asset to be offered for sale. The written down replacement cost approach is used in most countries to estimate the value of the fixed capital stock (i.e. the stock of produced assets such as buildings, houses and machinery and equipment). Consequently, this approach underpins measures of consumption of fixed capital used in the national accounts (for example to estimate the value of government output) and also measures of multi-factor productivity derived following a growth accounting approach.

5.30 In the context of environmental assets, this approach may be applied to estimate the value of the stock of cultivated biological resources that are fixed assets, for example, orchards.

5.31 The second approach is to use the discounted value of future returns. For many environmental assets there are no relevant market transactions or set of acquisition prices that would permit the use of the previous two approaches. Thus, although prices can be found to value the output from extraction or harvest of an environmental asset, no values for the asset itself, *in situ*, are available. In this situation, the discounted value of future returns approach, commonly referred to as the Net Present Value approach – or NPV – uses projections of the future returns from the use (usually extraction or harvest) of the asset. Typically these projections are based on the

history of returns earned from the use of the environmental asset. Assuming that returns earned in the current period are worth more to the extractor than returns earned in the future, the stream of expected returns is discounted to reflect the value a buyer would be prepared to pay for the asset in the current period.

5.32 In the valuation of ecosystems there is potential to consider the use of NPV approaches. The use of NPV may be appropriate to take into account the diverse set of ecosystem services which reflect both public and private services. The diverse set of services means that observed exchange values for an ecosystem encompassing the complete set of services are unlikely to be found. In some instances, valuations available on the market for certain tracts of land including agricultural land and forests, may provide some indications of value of the capacity to provide certain ecosystem service flows but an assessment of the value of an ecosystem must, in principle, cover all expected future flows of ecosystem services.

5.33 The SEEA Central Framework discusses NPV approaches at length in Chapter 5 in the context of individual environmental assets such as mineral and energy resources, timber resources and aquatic resources. The same general principles apply in the use of NPV approaches for ecosystem accounting purposes. The value of an ecosystem is, in theory, equal to the sum of the NPV of each ecosystem service and the value of an ecosystem obtained following this logic would be measured consistently with underlying SNA principles.

5.34 However, in the context of ecosystems the application of NPV approaches is a more complex task. For individual environmental assets there is usually an observed market price for the estimation of the resource rent which is a single income flow that must be projected and discounted to form an NPV estimate. For ecosystems, there is generally no single, identifiable income flow and thus it is necessary to consider the value of all relevant ecosystem services and how these services might be delivered in the future.

Boundaries of market price based valuation

5.35 The valuation approaches described in the SEEA, in particular the Net Present Value approach, provide reasonable proxies for observable market prices and consistency with the SNA, but do not take into account the full range of benefits (and costs) that might be considered relevant. For example, the value of a second-hand car in the market place will often be less than the value that the current owner places on the utility and flexibility of car ownership. At the same time, the car's value to its owner may not reflect the impact of emissions from operating the car on the environment. Thus while the use of market prices allows comparison across asset types these prices may not reflect the value of the asset from an individual or societal perspective. This aspect of market based prices is often mentioned in relation to the valuation of environmental assets. This leads into the area of welfare accounting which is not the focus of the SEEA.

The decomposition of value into price, quantity and quality

5.36 The analysis of changes in value over time is an important aspect of accounting. Generally, the accounting structures consider changes in value by recording the different types of flows that may take place over an accounting period. Thus, for example, it is possible to determine whether changes in the total income of a household are due to changes in wages and salaries, receipts of interest, payments of taxes, or the receipt of social assistance benefits. Accounting structures ensure that the concepts of each of the elements of change are clearly defined.

5.37 An alternative way of considering changes in value is to recognise that changes may arise due to changes in prices or changes in quantity. Thus an enterprise's value of sales may increase either because the prices charged have increased or because quantities sold have gone up (or a combination of these factors). In some cases the accounting structures take this type of decomposition into account, specifically there is the recording of revaluations to explain the change between opening and closing values of assets. However, in many cases, such as the assessment of the reason for the enterprises increase in sales, there is no relevant accounting entry.

5.38 Thus for national accounting purposes, the decomposition of value into price and quantity components is undertaken with an index number framework. This framework also provides the basis for the direct measurement of price change (for example, the Consumer Price Index). Index number theory is well established but, at the same time, there are a number of choices that can be made in undertaking any decomposition of values.

5.39 The key issue from the perspective of ecosystem accounting is that the notion that values are simply composed of prices and quantities is an oversimplification that may work for the development of economic theory but does not work well for statistical measurement. The practical difficulty is that the items being valued will generally change in quality over time. For example, a new car purchased in 1990 is likely to be quite different in quality from one purchased in 2012 even allowing for general features such as engine size and number of seats. Thus simply tracking the purchase price of a car and using a quantity of one does not provide a good indication of the decomposition. A reasonable assessment must take into account the changes in quality.

5.40 The most dramatic example of this over the past 30 years has been the fairly stable price of computers that are of constantly increasing in speed and capacity. The rapid rise in quality must be considered and in fact, it turns out that there has been quite a dramatic fall in the price of computers when the increasing quality is taken into account.

5.41 For complex items, such as cars and computers, methods have developed to make assessments of the changes in quality on an ongoing basis. These approaches are known as hedonic approaches and rely on breaking up an item into its various "characteristics". Assessment of the change in each of the characteristics is then aggregated to form an overall assessment of whether the total value (i.e. purchase price) of an item is due to changes in quality.

5.42 Given the complexity of ecosystems, the application of similar types of methods to assess changes in overall value, may be appropriate. This would require the identification of the key characteristics of an ecosystem and the determination of methods of aggregating these

characteristics and both of these steps are not straightforward. It is noted also that the distinction between quantity and quality is inherent in the model for assessing the capacity of ecosystems where capacity is a function of extent and condition. Overall, the importance of accounting for changes in quality in both ecosystem services and ecosystem capacity suggests that it would be possible to take advantage of the well-established techniques in economic statistics for distinguishing between price, quality and quantity.

5.3 Summary of approaches to valuing ecosystem services

5.3.1 Basic concepts

Monetary values

5.43 In neo-classical welfare economics, value is related to the price of the good or service in an open and competitive market, as a function of demand and supply. Accordingly, for traded ecosystem services, under perfect market conditions, market price reflects the marginal economic value of the service.

5.44 The total economic value related to the supply of an ecosystem service (or any other good) is the sum of the consumer and the producer surplus. The individual consumer surplus equals the willingness-to-pay of a consumer for a good minus the price the consumer faces for that good. The aggregate consumer surplus reflects the surpluses obtained by different consumers at a given market price. Consumer surplus is not included in SEEA and therefore there is a need to disentangle the consumer surplus from valuation estimates resulting from the application of certain valuation methods.

5.45 The producer surplus indicates the amount of net benefits a producer gains, given his production costs and the (market) price he receives for his products. In the valuation of ecosystem services, the producer surplus needs to be considered if there are costs related to "producing" the ecosystem good or service, which include both the costs related to maintaining the ecosystem and the costs related to the extraction or use of the service. In case an ecosystem services approach is used to analyse activities such as agriculture or fisheries, the full production costs of the fisherman (boat, equipment, labour, etc.) or farmer (land, machinery, inputs, labour, etc.) need to be accounted for.

5.46 There are several types of economic value that can be attributed to ecosystem services. In general, the following four types of value can be distinguished: (i) direct use value; (ii) indirect use value; (iii) option value; and (iv) non-use value.

5.47 (i) Direct use value arises from the direct utilisation of ecosystems, for example through the sale or consumption of a piece of fruit. All provisioning services, and some cultural services (such as recreation) have direct use value.

5.48 (ii) Indirect use value stems from the indirect utilization of ecosystems, in particular through the positive externalities that ecosystems provide. This reflects the type of benefits that regulating services provide to society.

5.49 (iii) Option value relates to risk. Because people are unsure about their future demand for a service, they are willing to pay to keep the option of using a resource in the future – insofar as they are, to some extent, risk averse. Option values may be attributed to all services supplied by an ecosystem.

5.50 (iv) Non-use value is derived from attributes inherent to the ecosystem itself. Three aspects of non-use value are generally distinguished: existence value (based on utility derived from knowing that something exists), altruistic value (based on utility derived from knowing that somebody else benefits) and bequest value (based on utility gained from future improvements in the well-being of one's descendants). The different categories of non-use value are often difficult to separate, both conceptually and empirically.

5.51 In principle, the four value types: direct use, indirect use, option and non-use value are exclusive and may be added. The sum of the direct use, indirect use and option values equals the total use value of the system; the sum of the use value and the non-use value has been labelled the 'total economic value' of the ecosystem. If all values have been expressed as a monetary value, and if the values are expressed through commensurable indicators, the values can be summed. In practice, however, few valuation studies have valued option values of ecosystem services, and there is still considerable debate on the quantification of non-use flows.

Ecosystem services as public or private goods

5.52 Provisioning services are typically private goods whereas many regulating and cultural services have a public goods character. Public goods involve the conditions of (i) non-excludability, meaning that is not possible to deny people to benefit from the ecosystem service and (ii) non-rivalry, meaning that one person's enjoyment of an ecosystem service does not diminish the availability of the service to others. Clean air or biodiversity are typical examples of public goods. Eco-tourism can be seen as a 'quasi' public good, to a degree it is non-rivalrous, but in principle it is excludable (e.g. by placing a fence around an ecosystem and charging entrance fees). The price mechanism for the provision of public goods does not function well: consumers do not have an incentive to pay and producers do not have an incentive to supply. Consequently, public intervention is needed to maintain or create an efficient allocation of such goods. Because public goods are not traded in a market, such goods require the application of non-market valuation methods.

5.3.2 General approaches to the valuation of ecosystem services in monetary terms

Defining the scope and objects of valuation

5.53 In estimating values for ecosystem services in monetary terms (often by translating physical flows into monetary values using prices), it is critically important to be specific about both the scope and object of valuation. The scope of the valuation in the case of ecosystem accounting needs to be aligned to valuation principles of the SNA (and the SEEA). This means valuation should be based on, in decreasing order of preference: observed market prices, revealed

market prices or stated preference studies. Consumer surpluses are not part of SNA valuations and should be excluded.

5.54 The initial objects of valuation in ecosystem accounting are the provisioning, regulating and cultural services provided by ecosystems. Supporting services, as identified in the Millennium Assessment can be defined as ecological processes that support the generation of other services and should therefore not be valued separately. Ecosystem services constitute flows from the ecosystem to the economy, and can be measured in terms of a quantity of physical or monetary units supplied per year. Aggregation over a specific time period, and discounting of future flows of services is required to define a net present value of an ecosystem. The aggregation of values of ecosystem services is not discussed in this section.

5.55 A general caveat is that economic valuation approaches tend to adopt a partial equilibrium framework, so that even when they reflect directly or indirectly consumers' budget constraints the broader impact on other markets and hence demand and supply of other goods and services is not tracked.

Monetary valuation of provisioning services

5.56 Provisioning services comprise, jointly with labour and produced capital, an input into the production process and are remunerated in the gross operating surplus generated. The gross operating surplus is that part of value added that remains after deducting the compensation of employees and the other taxes less subsidies on production. This operating surplus can be partitioned to show how much is due to produced assets and how much to natural assets. The part due to natural assets is the resource rent. The other part is called 'the user costs of produced capital'. (This partitioning is described in greater detail in SEEA Central Framework Section 5.4)

5.57 Resource rent is present in sectors that are able to harvest a yield from ecosystems. Under certain conditions, the resource rent can result in additional revenue beyond the normal compensation for labour, capital and other production factors.

5.58 However, a number of market conditions must be in place for estimates of resource rent to accurately reflect a price for the ecosystem services that takes into account the potential for degradation of the resource. These conditions include that the resource is being extracted / harvested in a sustainable way, that there is ownership of the underlying resource, and that the owner seeks to maximise their resource rent. Consistent with these observations it is noted that if new producers can easily enter and extract or harvest resources then it would be expected that these resource users will increase investment and production up to the point where the returns on produced assets in the activity will be equal to those in other, non-resource extracting activities.

5.59 Where these conditions are not met the resource rent is likely to understate the "true" price of the resource since any degradation of the resource will not be factored into the price required by the extractor to cover their extraction costs.

5.60 Assuming that appropriate operating conditions exist, the flows of provisioning services can be valued in monetary terms by analysing the resource rent they generate. The resource rent generated by the ecosystem needs to be distinguished vis-à-vis the user costs of produced

capital on the basis of establishing and deducting an appropriate return on other capital inputs. In general, it can be assumed that the resource rent will comprise a major part of the total economic rent in situations where the ecosystem services cannot be provided through the use of produced capital (and associated labour and other inputs), and where they comprise a limiting constraint on production possibilities.

5.61 To a degree, the value of present and future flows of provisioning services is reflected in the value of land on which these services are produced. This is most obvious in the case of agricultural land, where per hectare land prices reflect the possibilities to grow crops as a function of soil type, water availability, soil nutrient retention capacity, availability of pollinators, etc. If agricultural land is bought and sold with the single aim of agricultural production, the land price reflects the ecosystem's capacity to support agricultural production. Market transactions presumably account for the potential revenue that can be generated on that land given potential productivity, crop prices, prices of other inputs, etc. In general, land prices can be expected to reflect the capacity to generate market and non-market ecosystem services that accrue to the land owner. Using this information the annual rent payable on agricultural land should provide a basis from which to derive estimates of the value of the flow of ecosystem services over an accounting period.

5.62 For the provisioning services 'agricultural production' and 'aquaculture', the products resulting from the combination of the ecosystem inputs and other capital factors are traded in the market, but the flow of ecosystem services itself (i.e. the aggregate flow of nutrient, energy and water from the ecosystem to the harvestable crop) is not – even though the price of agricultural land reflects the potential to provide this service over time as discussed above. For these services, the resource rent may be used as proxy of the monetary value generated by the provisioning service. Cross-checking with land prices and associated payments of rent (or imputed rent) provides a potential method of verifying the value estimate for the ecosystem service.

5.63 For other provisioning services, such as for instance timber production, resource rents also represent a proxy for the upper bound of the monetary value generated by the ecosystem service. However, if the ecosystem service itself is traded in a market, a more direct valuation approach is possible. For instance, in the case of timber, both harvested timber and standing stocks of timber may be traded and priced in a market. In addition, there are often prices paid for trees just prior to harvesting (known as stumpage prices). The valuation of the ecosystem services in this situation may be derived following the methods outlined in SEEA Central Framework Section 5.8.

5.64 A sub-set of the provisioning services is not traded in a market, for instance because the goods involved are used for home consumption (e.g. timber collected for heating, crops grown for own-consumption). For these provisioning services surrogate prices should be established, for instance on the basis of the same goods traded on the market. Valuation approaches for such goods have been developed in the context of the SNA and are discussed in more detail in the material concerning valuation approaches in the SNA.

Monetary valuation of regulating services

5.65 There is increasing experience with establishing markets for regulating services, in particular for carbon sequestration, but to a smaller degree also for hydrological services, in particular the control of sedimentation. For carbon, there are a range of different markets operating in different parts of the world and with a different degree of maturity and market turn-over. The largest market is the European Carbon Trading Scheme, but this market does not include carbon sequestration in ecosystems. Indeed it is important to distinguish between markets that relate to the limited right to emit pollution and markets in ecosystem services themselves.

5.66 Carbon sequestered in ecosystems is mainly traded in the voluntary carbon market. Carbon markets are rapidly evolving. A new market scheme in New Zealand permits the trading of credits from forest carbon in a compliance scheme, but so far only small quantities of forest carbon have been traded. In compliance markets, the price of carbon is strongly influenced by the regulatory setting of the market, and prices have fluctuated rapidly in response to changes in these settings. Prices in the voluntary market have fluctuated less, typically being in the order of US$ 5 / ton CO_2. Note that, in the case of carbon sequestration and storage, carbon (C) and carbon dioxide (CO_2) can be converted at the rate of 1 ton of C equalling 3.67 ton of CO_2.

5.67 To date, most market transactions on forest carbon concern the sequestering rather than the storage of carbon in ecosystems. Recently, however, a number of pilot projects in the domain of REDD (Reduced Emissions from Deforestation and Degradation) have been started. These projects sell carbon credits from reduced carbon emissions to the atmosphere generated by activities aiming to reduce deforestation and/or degradation, hence to maintain the storage of carbon in an ecosystem. Payments are made, in the case of REDD, for reducing emissions compared to a baseline case representing business as usual emission rates, i.e. with no REDD project in place. The market for both the sequestration and storage of carbon in ecosystems is reflected in the way carbon services are defined for SEEA Experimental Ecosystem Accounts (draft Chapter 3). In order to establish a price for carbon, a first estimate can be based on the price raised in voluntary markets. Potentially, when compliance carbon markets mature and further allow the inclusion of carbon storage and/or sequestration in ecosystems, new (generally higher) prices raised in these markets can be used to value carbon.

5.68 For the other regulating services, there are generally no market prices available, and alternative approaches have to be followed to obtain an indication of the marginal value of these services. In the environmental economics literature, a broad range of non-market valuation techniques has been developed. A brief description of the methods most relevant in the context of ecosystem accounting is provided below.

5.69 Production function approaches. Production function approaches estimate the contribution of ecosystem services to production processes in terms of their contribution to the value of the final product being traded on the market. The general principle, i.e. disentangling the contribution from the ecosystem versus contributions from other production factors, is analogous to the use of the resource rent as a proxy for the monetary value of provisioning

services. Production function approaches are also used to value indirect use values generated by regulating services such as the storm and flood protection service, by disentangling their contribution to the generation of outputs traded in a market.

5.70 Hedonic pricing method. Hedonic methods analyse how environmental quality affects the price people pay for a good or factor. Hedonic pricing can be applied to reveal the value of local ecosystem services that contribute to the value of a property, as in the case of urban greenspace increasing local house prices. In this case, hedonic pricing involves decomposing sale prices of houses into implicit prices for the properties of the house (e.g. number of rooms, size of the lot, etc.), other factors, and local ecosystem services. The application of a hedonic analysis requires data on a large number of property sales where characteristics of the properties including the availability of ecosystem services vary.

5.71 Replacement cost method. This method uses the cost of replacing an ecosystem service as an indication of the monetary value of an ecosystem service. The application of the replacement cost method in environmental economics has been disputed because it does not express preferences. The method is somewhat more suitable in the context of ecosystem accounting that by definition excludes the consumer surplus. In general, there are three preconditions for the use of this method: (i) the alternative considered provides the same services; (ii) the alternative used for cost comparison is the least-cost alternative; and (iii) it should be reasonable to assume that an alternative for the ecosystem service would be demanded by society if it were provided by that least-cost alternative. This method is of particular relevance for the flood protection service, in the cases where it can plausibly be assumed that alternative flood protection measures would have to be taken in absence of an ecosystem (e.g. dunes, mangroves, coral reef) providing the flood protection service.

5.72 Averting behaviour methods. Averting behaviour methods are used as an indirect method to evaluate the willingness of individuals to pay for improved health or to avoid undesirable health consequences. Averting behaviour models are based on the presumption that people will change their behaviour and/or invest money to avoid an undesirable outcome resulting from ecosystem degradation. The incurred expenditures provide an indication of the monetary value of the perceived change in environmental conditions. Contrary to the replacement cost valuation method, the averting behaviour method is based on individual preferences. For example, in the presence of water pollution, a household may install a filter on the primary tap in the house to remove or reduce the pollutant. It is necessary for households to be fully aware of the impacts on them resulting from environmental changes in order for this method to be applicable.

Monetary valuation of cultural services

5.73 For tourism and recreation, and biodiversity conservation, a different valuation approach is needed. Generally tourism is valued with the travel cost method, but this method results in the measurement of the consumer surplus generated for visitors to ecosystems and is not relevant in the context of SEEA. Analysing the benefits accruing to visitors of ecosystems in a manner consistent with SNA is not straightforward, potentially this can be done by analysing entrance fees. For ecosystems where no entrance fees are collected, potentially there is scope to

estimate surrogate entrance fees by comparing ecosystems to comparable areas where such fees are charged.

5.74 In terms of analysing benefits accruing to the recreational sector, a challenge is to disentangle the contribution of the ecosystem to the overall recreational experience, potentially with a production factor approach. For the valuation of biodiversity conservation, which generates non-use value, stated preference methods are most commonly applied. Recently, several market schemes for biodiversity have been developed, which enhances valuation possibilities for biodiversity, as discussed below.

5.75 *Stated preference methods*. The most important approaches are the Contingent Valuation Method (CVM) and related methods (including choice experiments and conjoint analysis). Contingent valuation studies typically ask respondents to state a value they attribute to a certain ecosystem, ecosystem property or ecosystem service. Choice experiments ask respondents to compare an ecosystem, ecosystem property or service with a marketed good or service, and in conjoint analysis, survey respondents are typically given alternatives to consider (e.g. three management options with different implications for ecosystem services supply). For each of the stated preference methods, the set-up of the questionnaire is critical; respondents need to be presented a credible case for a potential payment for an ecosystem service. Econometric procedures reveal monetary values on the basis of choices or ranks.

5.76 The main advantage of stated preference methods is that, unlike other valuation methods, they can be used to quantify the non-use values of an ecosystem in monetary terms. There are two main points of criticism against CVM and related methods. First, CVM estimates are sensitive to the order in which goods are valued; the sum of the values obtained for the individual components of an ecosystem is often much higher than the stated willingness-to-pay for the ecosystem as a whole. Second, CVM often appears to overestimate economic values because respondents do not actually have to pay the amount they say they would be willing to pay for a service. Hence, monetary value estimates obtained with CVM and related methods need to be treated with some caution. In addition, these methods measure preference and are therefore not necessarily aligned with the SNA valuation principles.

5.3.3 Recent developments in ecosystem services valuation

5.77 The Simulated Exchange Value approach. The Simulated Exchange Value approach is an alternative approach to welfare based valuation which has been proposed by a team of Spanish economists in the specific context of green accounting in the forestry sector. The approach aims to measure the income that would occur in a hypothetical market where ecosystem services were bought and sold. It involves estimating a demand and a supply curve for the ecosystem service in question and then making further assumptions on the price that would be charged by a profit-maximising resource manager under alternative market scenarios. It then takes the hypothetical revenue associated to this transaction (but not the associated consumer surplus) as a measure of value of the flow of ecosystem services (see Figure 1).

5.78 The Simulate Exchange Value approach estimates the value of ecosystem services in terms of potential revenue and can therefore arguably represent a more consistent basis for including their value in national accounts alongside monetary transactions. A caveat is that economic

valuation studies tend to adopt a partial equilibrium framework, so that even when they reflect directly or indirectly consumers' budget constraints the impacts on other markets is not being tracked, so some consistency issue also applies to Simulated Exchange Value approaches.

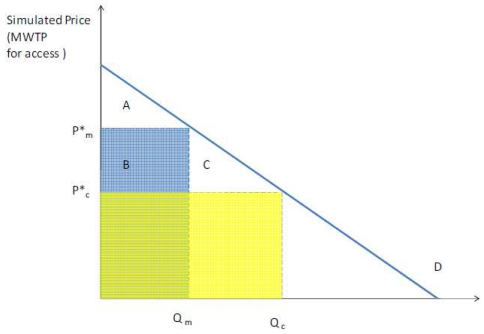

Figure 1 The Simulated Market Price Approach uses demand and supply curve information for the ecosystem service in question to estimate a hypothetical monopoly price (P*m) and competition price (P*c). It then estimates the associated revenue under the demand curve by multiplying these prices for the associated, hypothetical quantities. What the approach does not do is to include in these calculations consumer surplus (areas A under monopoly or A+B+C under competition in the picture).

5.79 New markets for biodiversity and other ecosystem services. Biodiversity is a public good providing a non-use value. It's definition is broad, and not necessarily well-aligned with society's preferences given that people tend to place different values on different species. It is therefore notoriously difficult to attribute a monetary value to this ecosystem service, with stated preference methods. However, several recent developments involving the establishment of markets for biodiversity provide an entry point for a better understanding of the monetary value of the service.

5.80 Market-conforming biodiversity mitigation mechanisms include mitigation banking of biodiversity credits, programs that channel development impact fees and offset policies. A limited number of biodiversity markets have been set up that fulfil the basic characteristics of a market: (i) the presence of buyers and sellers; (ii) a traded unit, reflecting biodiversity; (iii) a market clearing mechanism in which a price is established; and (iv) an institutional setting regulating the market and ensuring compliance. The traded unit in these markets are commonly credits related to species or to acreage of habitat conserved.

5.81 Examples of emerging biodiversity markets are (i) Conservation Auctions in Victoria, Australia; (ii) BioBanking, New South Wales, Australia; (iii) Conservation banking (US); and (iv) Wetland and Stream Mitigation Banking (US). The oldest of these schemes is the Wetland and Stream mitigation banking scheme, with total annual wetland and stream payments reported to be in the order of U$1.5 billion for 2008. These schemes allow establishing a surrogate market price for the biodiversity units traded in such markets, but in needs to be kept in mind that the price of the units strongly depend on the local ecological and institutional setting and that it cannot easily be translated to the value of biodiversity in other places.

5.3.4 Issues in valuation measurement

Benefit transfer

5.82 Benefit transfer involves taking an existing value estimate and transferring it to a new application that is different from the original one. There are two types of approaches to benefit transfer, respectively value transfers and function transfers. A value transfer takes a single estimate of the value of an ecosystem services, or an average of several value estimates from different studies, to estimate the value of an ecosystem service in a different context. A function transfers uses an estimated equation to predict the value of an ecosystem service in a new setting, correcting for different environmental factors on the basis of a regression model.

5.83 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. In addition, there is still relatively scarcity of data on the monetary value of ecosystem services, and different valuation studies may be based on different assumptions and using different methodological constructs. Hence, benefit transfer is prone to a high degrees of uncertainty, in particular if done poorly.

Uncertainty in valuation

5.84 There are significant sources of uncertainty in ecosystem accounting. These can be grouped in four main categories: (i) uncertainty related to physical measurement of ecosystem services and ecosystem capital; (ii) uncertainty in the valuation of ecosystem services and capital; (iii) uncertainty related to the dynamics of ecosystems and changes in flows of ecosystem services; and (iv) uncertainty regarding future prices and values of ecosystem services.

(i) uncertainty related to physical measurement of ecosystem services and ecosystem capital. It is clear that, given data scarcity for many ecosystem services, physical measurement of the flow of ecosystem services, in particular at aggregated levels, is prone to uncertainty. Most countries do not consistently measure flows of ecosystem services at an aggregated (national or even sub-national) scale, and services flows need to be estimated on the basis of point based observations in combination with spatial data layers and non-spatial statistics. At the same time, it is noted that information related to flows of provisioning services are generally, readily available.

(ii) uncertainty in the valuation of ecosystem services and ecosystem capital. A second source of uncertainty relates to the monetary value of ecosystem services. For provisioning services, a key aspect is that attributing a resource rent to ecosystems involves a number of assumptions regarding rent generated by other factors of production. For non-market ecosystem services, it is often difficult to establish both the demand for these services and to reveal the supply of these services by ecosystems, in particular at an aggregated scale.

(iii) uncertainty related to the dynamics of ecosystems and changes in flows of ecosystem services. Establishing the value of ecosystem capital requires making assumptions regarding the supply of ecosystem services over time, which in turn depends on the

dynamics of the ecosystem. Changes in ecosystem capital will often be reflected in a changed capacity to supply ecosystem services. In the last two decades, it has become clear that ecosystem changes are often sudden, involving thresholds at which rapid and sometimes irreversible changes to a new ecosystem state occur. Predicting the threshold level at which such changes occur is complex and prone to substantial uncertainty.

(iv) uncertainty regarding future prices and values of ecosystem services. Pricing benefits and costs that may accrue in the far-distant future is complex because it is extremely difficult to predict our circumstances in the future. The ecological implications of humanity's continuing modification of the climate and landscape are uncertain, and those implications are likely both to affect and to depend on how the future evolves. Uncertainties concerning values are even greater inasmuch as the methods of nonmarket valuation compound errors in estimation.

5.85 The best strategy to deal with the sources of uncertainty will vary per country as a function of data availability and relevant services selected for ecosystem accounting. Given the limited experience to date with analysing ecosystem services in both physical and monetary terms at the national level the approaches to limiting these uncertainties and maximise the robustness of ecosystem accounting will need to be further developed once more practical experience with ecosystem accounting has been gathered and evaluated. The experiences gathered with national level assessment of ecosystem services supply are also highly relevant in this context.[1]

5.3.5 Conclusions on valuation in ecosystem accounting

To be drafted

5.4 Examples of valuation for selected ecosystem services

To be drafted

[1] See for example the UK National Ecosystem Assessment (2010)