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Towards a definition and classification of terrestrial provisioning services related to crop cultivation and forestry

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Preface

This paper is prepared to support the discussions on ecosystem services definition and classification for SEEA Experimental Ecosystem Accounting, The pursued classification is targeted at supporting the identification, definition and classification of ecosystem services for environmental economic accounting (SEEA). The paper provides a background to the classification of terrestrial ecosystem services, and it sketches a number of very preliminary proposals for the definition and classification of these ecosystem services, as a basis for discussion. Specifically the paper focusses on agriculture and forestry related ecosystem services. Livestock production is not included for reasons of a lack of time. If we are extending this discussion to livestock, then there are also complex interactions to consider between livestock and crops, for example, often with mutual benefits, hence including livestock requires a further extension of the typology.

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Introduction

Background

This note is prepared in order to move forward with the classification of provisioning ecosystem services for the purpose of SEEA Experimental Ecosystem Accounting (SEEA EEA). In SEEA ecosystem accounting it is important to have a clear definition and comprehensive and consistent classification of ecosystem services (ES), in order to guide the compilation of the physical and monetary ecosystem services use and supply account. The focus of the note is on services related to agriculture and forestry activities.

Ecosystem accounting specifically aims at capturing the *flow of contributions to human production, consumption and wellbeing, including both material and non-material contributions, in relation to the condition of these ecosystems*. The SEEA EEA does not intend to provide assessments of 'the total value of nature' – the focus is on measuring the contribution of ecosystems to human consumption and production in a manner that is consistent with national accounts. The information of the SEEA EEA on ecosystem services and ecosystem assets is comprehensive, systematically organized, intended to be made broadly accessible, often new for policy makers and the public alike, but not meant to provide the sole information basis for ecosystem management.

The ecosystem services classification of the SEEA EEA to be developed is meant to support ecosystem accounting. This means it is developed in such a way that it captures the various services provided by ecosystems within the framework of the System of National Accounts (SNA). The SNA has been developed over a period of over 50 years and is the global standard for national economic statistics including indicators such as GDP.

Objectives of the paper

Having a common understanding of the definition of each service as well as a classification of ecosystem services is an important aspect in the further development of the SEEA EEA framework. Classifications can provide important guidance to ensure that an appropriate breadth and depth of measurement is undertaken or, at least, that individual measures are understood within a broader context. A classification can operate as a checklist and be applied in initial discussions by considering each ecosystem type (ET) and noting those ecosystem services that are considered most likely to be generated from that ET. The resultant "baskets" of services for each ET can aid in discussion of the role of accounting, the structuring of information, the assessment of resources required for compilation and generally communicating the message about the relationship between ecosystems and economic and human activity.

This paper presents selected background information relevant for the definition and classification of provisioning ecosystem services for SEEA specifically agriculture- and forestry-related services including the System of Environmental-Economic Accounting for Agriculture, Forestry and Fisheries (SEEA-AFF), as Internationally Agreed Methodological Document in support of the SEEA CF. Section two records key challenges pertaining to these services as identified in previous discussions related to defining and classifying ecosystem services. This leads to a set of recommendations for definition and classification of provisioning ecosystem services for SEEA EEA.

The paper draws strongly from the SEEA EEA framework, and the SEEA EEA Technical Recommendations (TR) as well as technical discussions held in Glen Cove mid 2018. Further insights presented in the note are based on a review of the relevant scientific literature, the various classification systems proposed in global ecosystem assessments (MA, TEEB, IPBES), the CICES classification, and

the various documents produced in the context of the UN SEEA consultation process on ecosystem services classification (e.g. UN et al., 2016; Obst et al., 2017).

Challenges in defining provisioning ecosystem services

It is clear from comparing the various classification systems that there are remaining challenges in coming to a broadly acceptable categorization and list of ecosystem services, even for the specific purpose of ecosystem accounting. As noted above, the purpose of this document is to explore how to best design a classification for the purpose of ecosystem accounting, and to put forward several preliminary proposals for such a classification as a basis for discussion – focusing on terrestrial provisioning services. Earlier discussion identified the following relevant challenges:

- Clarify the boundary between ecosystem services and benefits, especially in relation to cultivated products[1]
- Clarify linkages of ecosystem services to users and beneficiaries
- Describe approaches to the allocation of ecosystem services to individual ecosystem assets in situations where services are generated in landscapes with a mix of ecosystem types.
- Specific for agriculture and forestry is also that the service can be generated in relatively pristine environments (e.g. timber harvesting in a previously primary forest) as well as in intensively managed ecosystems (e.g. a greenhouse) and a whole gradient in between. This is expressed in Figure 1 below. A classification system needs to accommodate identifying services provided in this broad range of ecosystems.
- Clarify definitions of intermediate services (such as pollination) and related concepts of intra- and inter- ecosystem flows and ecosystem processes, considering also the measurability of these intermediate services.

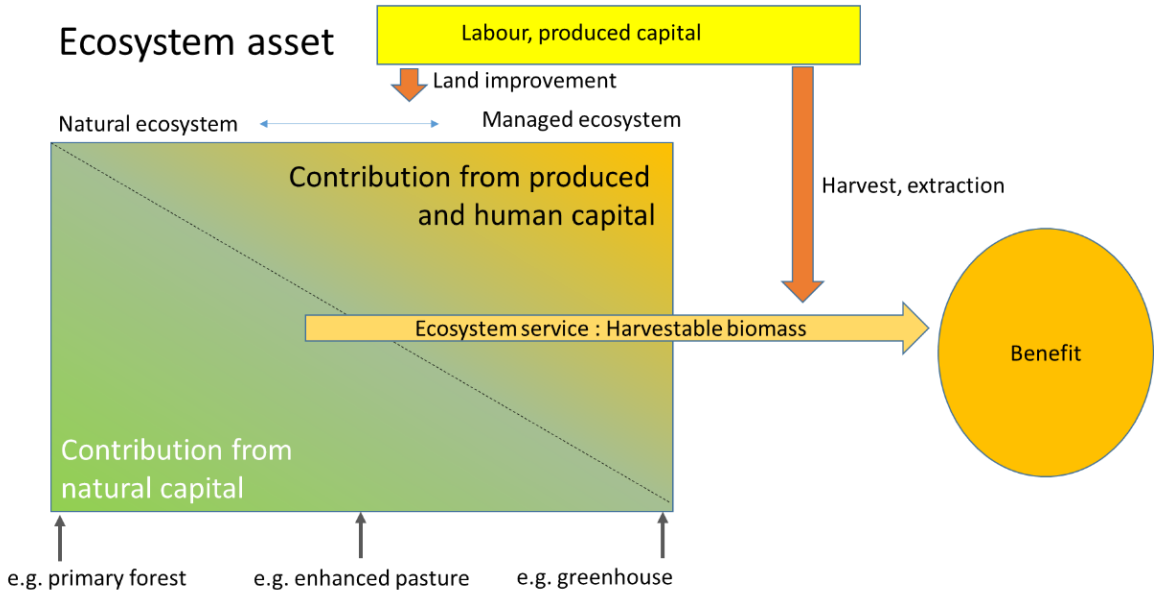

Figure 1. Ecosystem services generated in agricultural and forest landscapes. The concepts are relevant for croplands, rangelands and forests. Cultivated systems may be more or less intensively managed, ranging from shifting cultivation plots with high natural inputs to greenhouses with high human inputs.

[1] If cultivate products are treated as benefits, then there is a need to consider how to define the ecosystem service or services that underpin this benefit. This may be related, for instance, to biomass accumulation as an ecosystem service. However there may also be other ecosystem services that are releavnt for this benefit, depending upon the cropping system applied.

Grasslands may be more or less intensively used, ranging from grazing in Australian bushland to grazing in Netherlands pastures. Forests include pristine natural forests up to short rotation acacia plantations. The relative importance of human inputs versus natural inputs varies considerably between these systems. Human inputs are required for land improvement (e.g. construction a greenhouse) as well as extraction (harvesting, timber felling). Note that at the natural systems end, the production system is benefiting from natural growth, whereas at the intensive cultivation end most of the natural flora and fauna have been replaced by a man-made biomass production system. It is relevant that man-made production systems have replaced original natural ecosystems, as in the case of plantation forestry replacing a grassland ecosystem, and shrimp farming replacing a mangrove ecosystem.

SNA treatment of agriculture and forestry

The SNA (2008) provides the following details:

- "The growth and regeneration of crops, trees, livestock or fish which are controlled by, managed by and under the responsibility of institutional units constitute a process of production in an economic sense. Growth is not to be construed as a purely natural process that lies outside the production boundary. Many processes of production exploit natural forces for economic purposes, for example, hydroelectric plants exploit rivers and gravity to produce electricity" (note that the criterion pertaining to control by an institutional unit is relaxed in SEEA ecosystem accounting). (6.136).
- "The measurement of the output of agriculture, forestry and fishing is complicated by the fact that the process of production may extend over many months, or even years. Many agricultural crops are annual with most costs incurred at the beginning of the season when the crop is sown and again at the end when it is harvested. However, immature crops have a value depending on their closeness to harvest. The value of the crop has to be spread over the year and treated as work-in-progress. Often the final value of the crop will differ from the estimate made of it and imputed to the growing crop before harvest. In such cases revisions to the early estimates will have to be made to reflect the actual outcome. When the crop is harvested, the cumulated value of work-in-progress is converted to inventories of finished goods that is then run down as it is used by the producer, sold or is lost to vermin." (6.137)
- "Some plants and many animals take some years to reach maturity. In this case, the increase in their value is shown as output and treated as increases in fixed capital or inventories depending on whether the plant or animal yields repeat products or not. The value of the increase in the plants or animals should take account of the delay before the yield from them is realized. Once the plant or animal has reached maturity, it will decline in value and this decline should be recorded as consumption of fixed capital" (6.138).

  This is supplemented by the SEEA Central Framework (SEEA CF)(3.54 and following paragraphs) as quoted below. It is also further elaborated in the SEEA for Agriculture, Forestry and Fisheries (SEEA AFF). The following bullet points are quotes from the SEEA CF:

- "Biological resources require special consideration in the determination of the boundary between the environment and the economy. To ensure consistency with the production boundary, a distinction must be made between those resources that are considered to be cultivated as part of a process of production (cultivated biological resources) and those resources that are not produced (natural biological resources)[2].

[2] For timber resources the distinction between natural and cultivated timber resources is particular important because it affects the recording of timber resources. In particular, because the growth of natural timber resources is considered to be outside of the production boundary, they are considered non-produced assets on the balance sheet. On the other hand, growth of cultivated timber resources is inside the production boundary, and hence the timber resources are considered as inventories or work-in-progress. Given the different asset types and the difference in the timing of recording of production, maintain the distinction between these types of timber resources is useful (SEEA AFF, para 3.149).

- The criteria used to make the distinction between natural and cultivated include the extent of direct control, responsibility and management over the growth and regeneration of the biological resource. These criteria are discussed in greater detail in SEEA CF chapter V with regard to timber resources (sect. 5.8) and aquatic resources (sect. 5.9). A consistent application of the criteria should be maintained for the purposes of both asset accounts and physical flow accounts.
- Applying the distinction is important because the accounting treatment varies depending on whether the resource is natural or cultivated. For natural biological resources, the resources are considered inputs to the economy at the time they are extracted, following the logic underlying the presentation in table 3.3. However, cultivated biological resources are not considered natural resource inputs and are instead treated as growing within the economy.
- This difference in treatment has implications for the recording of other physical flows. For natural biological resources, the use of oxygen and nitrogen, and the uptake of soil nutrients and water are treated as flows within the environment and only the actual harvest of resources is considered to flow into the economy.
- For cultivated biological resources, a complete accounting of physical flows requires the recording of the nutrients and other substances absorbed from the environment as natural inputs, since the biological resources themselves are already "in" the economy. The physical flows resulting from metabolism (e.g., photosynthesis and respiration) and transpiration either are embodied in products or return to the environment as residuals. "

Note, however, that in practice it will often be near to impossible to identify recording of the nutrients and other substances absorbed from the environment as natural inputs, since these cover main nutrients as N, P and K, but also micro-nutrients such as for example S and B. These flows will also vary substantially between different locations, and would be particularly difficult to keep track of over large scales.

Furthermore, on felling residues, the SEEA CF specifies (2.90):

- During the extraction of some natural resource inputs, not all extraction is retained in the economy, for example, in fishing operations, there is an amount of discarded catch and in timber harvesting there is an amount of felling residues. The extraction that is not retained in the economy is considered to have returned immediately to the environment. These flows are termed natural resource residuals. The classification of ecosystem services must be aligned with the SEEA framework and the SEEA EEA TR. The SEEA EEA framework and the TR provisionally distinguish the three categories of provisioning, regulating and cultural services (which is fairly well aligned with other existing systems such as CICES and the classifications of the MA and TEEB).

Criteria for the identification and classification of provisioning ecosystem services[3]

The following statistical/technical requirements and assumptions underlie the development of clear definitions and an ecosystem services classification system for SEEA EEA including for provisioning services. In turn, these requirements are grounded in the general requirements for SEEA as formulated in the SEEA EEA Framework. These various points have been discussed during the Technical Forum, and the directions obtained from these discussions are included in the text below.

- In the SNA, a distinction is made between ecosystem services supplied in a natural and in a cultivated ecosystem. This is not consistent with the manner that ecologists are perceiving

[3] Extracted from Hein, L et al., 2018: Towards a definition and classification of ecosystem services for SEEA. UNSD technical discussion paper.

ecosystems, which in general involves the acknowledgement that all ecosystems on the planet are to a lower or higher degree influenced by people. It was discussed during the Forum if and how this distinction needs to be brought forward in the SEEA EEA. A preference seemed to emerge in the discussions in the forum that preferably this distinction is not made, however further discussions and deliberations are required to assess this. This issue needs to be further worked out in an issues paper on ecosystem services definition and classification. Note that the previous chapter, Figure 1, indicates that there is a continuum of ecosystems along a gradient of more or less human influence.

- The classification of ecosystem services must be aligned with the SEEA framework and the SEEA EEA TR. The SEEA EEA framework and the TR provisionally distinguish the three categories of provisioning, regulating and cultural services (which is fairly well aligned with other existing systems such as CICES and the classifications of the MA and TEEB).
- In addition, the definition of ecosystem services as contributions to human benefits provided by ecosystems must be maintained (as postulated in the SEEA EEA and the SEEA EEA TR, and as also applied in the TEEB and IPBES frameworks). In the thinking of the SEEA EEA, ecosystems include both natural and human influenced systems (as in the figure above). It is also critically important that the relation between services and (SNA and non-SNA) benefits is clarified. In principle, every service is connected to one or more benefits. These benefits may either be included in the SNA, or may be outside the boundary of the SNA (the service would in both cases be connected to an economic user).
- Service classification should be such that services belong to one and only one group ('exclusive'), class and type of ecosystem service, even though one type of ecosystem service may result in different benefits. This raises an issue with CICES 5.1, where there is a distinction between the class 'Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes' and the class 'Cultivated plants (including fungi, algae) grown as a source of energy'. For example, palm oil is produced both as a source of food and energy and would fall into two classes in CICES. At the same time, the participants in the Forum indicated that it would be helpful to support their pilots of SEEA EEA to have a list of ecosystem services to consider (as in MA, CICES, IPBES). The system developed in NESCS to identify interactions between ecosystems, uses and users can further assist in developing this list.
- In SEEA, the ecosystem service comprises an interaction between the ecosystem and an economic unit. The quantity of service extracted from the ecosystem must equal the quantity used by the economic unit, in order to balance the accounts. Harvest losses, in line with the SNA, are therefore seen as part of the ecosystem service supplied by the ecosystem. They are subsequently returned as residues from the economy to the ecosystem. Note that they are returned as residues (e.g. felling residues) not necessarily as ecosystem elements that existed before the harvest (e.g. trees). harvest losses, refer only to e.g. felling/harvesting residuals, and do not include damage to remaining vegetation, and soil resources that may also affect the forest ecosystem during or following logging.
- However, the physical amount of ecosystem service extracted from the ecosystem, e.g. the timber harvested, may or may not be equal to the physical amount of the benefit, e.g. the amount of timber produced by the side of the forest. The difference is composed of harvesting losses and/or felling residues, which are generally returned to the ecosystem (and may serve as mulch or plant nutrients). Note that this logic does not impede that there are further losses of products in the economy (e.g. there may be food losses, or losses of wood when timber is transformed to tables). A question for further discussion and consideration in the individual ecosystem services papers is if the core accounting framework, or its associated accounting table needs to be revised in order to record residues in the SEEA EEA framework. Note that in forest harvesting/logging, residual damages refers to damages to standing or growing commercial timber species. This is apart from tops and branches that were left in the forest resulting from harvesting.

- The concepts of intermediate and final services. This is relevant for, in particular, regulating services, that can be both final and/or intermediate ecosystem services depending upon context. For instance, the regulation of water by upstream forests may benefit people directly by reducing flood risks to houses and infrastructure, and it may provide water for irrigation during the dry season. The SEEA EEA TR provides guidance on how to differentiate between these two types of services, which could be further elucidated in an issues paper on ecosystem services definition and classification.
- With regulating services, it is important that 'supporting' services or 'options for NCP' (in the terminology of respectively the MA and IPBES) are differentiated from regulating services. Following the SEEA EEA TR, supporting services are ecological processes that do not have an ex-situ impact. For example, pollination of wild plant species in a forest patch is a supporting service. Where the plants themselves are harvested, the ensemble (ecosystem) of the forest fosters growth of the plant species including by pollination. There is no use singling out pollination as an ecosystem service: when services are aggregated by ecosystem type including both pollination and plant harvests would lead to double counting when valued. Pollination becomes a regulating service where a patch of land provides a (perennial or seasonal e.g. winter) habitat for a pollinator species that pollinates plants in another ecosystem type (e.g. a nearby cropland). In this case, loss of the patch of vegetated land would lead to a decline in crop production in another ecosystem type. The pollination service, in the case of one ET maintaining pollination in a nearby ET, is an intermediate regulating service (a service from one ET to another ET). Hence, supporting services can be seen as an intra-ecosystem service, and intermediate services are an inter-ecosystem service. Regulating services can either be intermediate ecosystem services or final ecosystem services (in case they provide a direct benefit to people, for instance in the case of air pollution). This needs to be reflected in the definition of regulating services to be further worked out in an issues paper on ES definition and classification.
- Finally, the definition of services and benefits need to result in measurable indicators. There is no point developing a comprehensive measurement system for SEEA EEA if the indicators are not measurable and the system cannot be implemented.

Considerations and preliminary proposals for definition and classification of provisioning ecosystem services related to agriculture and forestry for SEEA

Including pollination and potentially pest control as an intermediate service. The SEEA EEA TR indicates how intermediate services can be recorded in the accounting framework and how this supports a better conceptualization of the connections and dependencies between ecosystem assets. In particular, this allows the ecosystem accounts to recognize the contributions of all ecosystems and associated ecosystem processes wherever the service is delivered and wherever the beneficiary happens to be and to understand the potential impacts of economic production and consumption on ecosystem assets.

An intermediate service always requires a biological or physical interaction between different ecosystem assets (and typically between different ecosystem asset types). Pollination in croplands may depend upon insect pollinators that require shrublands or forest habitat, for instance for shelter. If the shrublands or forests would be converted, the pollination service to the croplands would be diminished or lost. Hence, the ecosystem assets 'cropland' benefit from the biological interaction involving the visitation by insect pollinators, that otherwise depend upon the ecosystem assets 'shrublands' to provide them with a nesting or winter habitat. In the case of forests regulating water flows, the interaction is of a physical nature, involving modifications of water flows in the landscape.

Many if not all regulating services can be either final or intermediate: in some contexts they may have a beneficial effect directly on people (either supporting production and/or consumption) and in other contexts on other nearby or downstream ecosystems providing ecosystem services to people. This

beneficial effect can involve for example, the mediation of nuisances, wastes or toxic substances, protection from extreme events, and the regulation of marine and atmospheric composition and conditions. Pollination taking place within an ecosystem asset by species living entirely within that ecosystem asset can be considered a supporting service. It would therefore not be recorded in the SUTs of the SEEA EEA. Since it does not involve an interaction between ecosystem assets it is not a regulation service.

It needs to be noted that double counting needs to be avoided. In the case of pollination of agricultural crops, adding pollination services and the biomass accumulation of crops would lead to double counting. Hence, when values are apportioned to individual ecosystem assets or ecosystem types - the value of the intermediate service could potentially be appointed to the ecosystem asset playing the largest role in maintaining the service, and the value should be deducted from the ecosystem asset providing the final ecosystem service. It seems appropriate to cap the value of the intermediate service to not more than the value of the final service, in order to avoid negative values and also since the value of an intermediate input cannot be realistically higher, certainly not in the long term, than the value of the final output. However further thinking is required on this, both conceptually and from a measurability perspective. For instance, it could even be capped lower than that, as effectively the max WTP of the producer to replace this service will be the point above which production is rendered unviable. Also depends how you are defining "value" in this sentence. Even so this approach will always risk being an overestimate, since there is still an attribution problem given that the production value is a function of multiple inputs.

There is no strict need to differentiate between cultivation in cultivated and in natural systems in SEEA EEA. Since the SEEA EEA relaxes the condition that only services produced under control of an economic actor are included, there is no strict need to maintain this distinction in SEEA EEA. The advantage is that there is no need to come up with a distinction between cultivated and natural ecosystems, which is something that is hard to establish given that in reality there is a continuum between purely natural and fully managed ecosystems (see the figure above). It is also consistent with the notion that also in natural systems some degree of land improvement will usually have taken place.

It needs to be further examined if and how investment in land improvement (in addition to costs for harvesting or extracting ecosystem services) need to be considered in SEEA EEA. A resource rent as indicator for the return on natural capital may be calculated both for the current, in some cases, enhanced or modified, ecosystem, with or without considering the costs that were incurred to modify or enhance the ecosystem. It may in practice be very hard to define these costs given that they sometimes occurred many decades or even centuries ago. It needs to be further discussed if and how this can best be done. As for recording the supply of ecosystem services: the options are: (i) recording the physical flow of ecosystem services in relation to the total extraction from the ecosystem and only correcting the monetary value of ecosystem services for both investments in land improvement and harvesting costs; OR (ii) applying some kind of ratio to reduce also the physical flow of ecosystem services as per the amount of human inputs involved in land improvement and/or harvest. For this latter approach, JRC has proposed using the ratio of energy supplied by people (e.g. in the form of inorganic fertilizer (also labour?)) compared to the amount of energy from solar radiation. Further discussions are needed on the practical implications of this approach, as well as to identify potential alternative approaches.

Residuals including or excluding crop and felling residuals. There are two options, either (i) to consider ecosystem services net of any felling or harvest residues; or (ii) to consider the flow of products from the fields as ecosystem services and the harvested crops to be the benefits. The issue has been partially dealt in the Crop and Timber provisioning services application and revision, which applies the second approach. In this latter case there is a physical difference between the ecosystem service and the benefit, which may appeal to the user of the account. However it adds a further layer of complexity, and it may be data intensive to collect data on felling and crop residues, and this information as such may not usually be useful in support of ecosystem management (i.e. resources would be spent on collecting information which is not useful). It seems as if points 5.5 and 5.6 are related, but further discussions are needed to progress on this topic. In addition, in the process of harvesting, apart from

felling and harvest residues, damages also occur in the ecosystem, and this is typical in tropical forest harvesting. Extensive damage to adjacent vegetation, and to soil occur thus reducing the future flow of biomass accumulation and regulating services. In the Philippines, for instance, after timber harvesting or logging, what remains are called growing residuals, meaning growing second growth forests.

Measurement and valuation

Defining measurement and valuation approaches first requires a further conceptualization and definition of this type of services. However a few observations can be made, based on ongoing efforts aimed at compiling ecosystem accounts:

For measurement in physical units, a critical choice is if the measurement is linked to the actual contribution of the ecosystem, i.e. supporting crop growth by means of for instance maintaining hydrological and nutrient cycling processes or if a proxy indicator for the service is used based on the benefit, e.g. based on the amount of crop produced. It has also been suggested to establish a physical indicator based on the relative share of human versus natural inputs, e.g. linked to energy inputs from farm management versus form sunlight (e.g. related to the use of fertilizers). Further debate is needed to establish the best physical indicator.

It is in many cases easier to establish a monetary than a physical indicator for the ecosystem service. Valuation for instance may be based on the resource rent, which reflects the return on natural capital using a residual approach (i.e. by deducting return on labor and capital from the gross revenue). However an issue is that the resource rent often turns negative in the case of crop production and forestry. A specific issue is that labor costs are rewarded based on actual wages, however these wages are, especially in remote, rural areas with few alternative income opportunities, influenced by the demand for work in the agricultural and forest sectors. In specific cases, therefore, wages may be high compared to alternative employment opportunities in the area, and the returns on the economic activity are allocated to wages rather than reflected in a resource rent (*note: this aspect needs to be further thought through and worked out, if it is to be maintained in the Discussion papers*). An alternative valuation approach for agriculture and forestry therefore is to use the lease paid by farmers of forestry companies to use land for crop production or timber harvesting. This is the approach that is selected in the Netherlands SEEA EEA accounts for the return on natural capital related to crop production in agricultural land.

Furthermore, in addition to resource rent, it can be considered to use gross and net value added as additional monetary indicators. These provide additional, complementary information on the value of the service, including the rewards for labor used in producing the benefit connected to the service. This is particularly relevant in areas with few alternative income opportunities (as is often the case in rural areas). In addition, it needs to be considered that policy makers and users of the accounts will tend to compare the monetary value of the SEEA EEA accounts with the GDP in order to obtain an idea of the relative importance of natural capital. Of course GDP should not be compared to resource rent, but in practice it has proven difficult to explain the difference. It may be better to also include a monetary indicator reflecting GVA or NVA generated based on ecosystem services. A question is of course what to do with value indicators for regulating services – do they compare better to GVA, NVA or resource rent? This latter question is in any case a question that deserves further attention.

Key Questions for further debate

1. **How to deal with the large variation in production systems, from near natural to fully human controlled ?** Clearly, SEEA EEA should accommodate the analysis of all of these systems, in a consistent and coherent manner. Ideally, the SEEA EEA should also be fully aligned with the SNA

where the distinction between natural and cultivated systems is made, even though it is often hard to specifically pinpoint the boundary between the two in practice.

2. **How to integrate livestock in the system**, especially in case of integrated livestock – cropping systems. This note did not yet touch upon the livestock sector, which also varies from near natural grazing systems to very intensive systems. In many cases there is also a continuous interaction with other agricultural systems (or silvicultural systems), e.g. animals are fed crop residues and manure is returned to the fields. These are essential for farming, and a question is how these interactions relate to ecosystem services.

3. **Which indicator to use for measuring ecosystem services in physical terms.** Ideally this indicator should reflect not the benefit but the contribution of the ecosystem to the benefit. In practice, in cropping and forest systems, the contributions of the ecosystem involve a great many processes (from water infiltration regulation to storing and releasing nutrients to providing physical space etc.). It is the combination of these processes that support economic activities that lead to the production of crops and timber (and livestock) – and it is very hard to capture these contributions in one or more distinct and measurable indicators.

4. **Which approach to use for valuing these kind of services.** As explained in paragraph 7.4 a resource rent approach often leads to a very low or sometimes even negative value. Alternatives are using GVA and NVA as additional, complementary indicators and basing values on leases paid for land. However these options are not always available.

5. **How can crop and felling residuals and damages to trees and soil related to timber harvesting be accounted for ?** A question is if residuals are included in the ecosystem service or if they should be excluded. On the one hand, if the total amount (of timber or crops) extracted in an ecosystem would be seen as the service (hence including the residuals) this would lead to some first clarification of the physical difference between the service and the benefit (the benefit should logically be related to the amount harvested excluding felling or crop residues). On the other hand it would involve significant additional measurement efforts if ecosystem services related to crop and forest harvesting would be connected to extractions including felling residues. In many cases, data on the amount of residues may not be available, and a practical question is if the extra amount of effort required to produce accounts in this way would outweigh the benefits of the additional information obtained (given that data shortages are a real barrier to producing SEEA EEA accounts).

6. **How to account for the value of intermediate ecosystem services such as pollination?** Especially when values for crop production and forestry related ecosystem services are low, the case for allocating some of this value to ecosystems to provide pollination services (e.g. by being a habitat for bees) is hard to make. Related to this question is the issue of how to include pollination and other intermediate service (e.g. pest control) in the accounts (e.g. is this a service provided by one ecosystem - such as a hedgerow - to the farmer? Or to another ecosystem?).

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