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Comparison of crop provision and wood provision ecosystem services

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Contents

Introduction

The paper addresses parallel methods for the assessment of the ecosystem service of crop provision (agricultural production) and timber provision ecosystem services. Methods for the isolation of ecosystem contribution in physical and monetary terms will be discussed. Similarities and differences are discussed and the communication issues regarding the results of the alternative approaches for given ecosystem services will be described.

The selection of the valuation methods for ecosystem services are based on the suggestions outlined in UN SEEA EA and Guidance Notes on accounting for ecosystem services by Eurostat relevant to the implementation of the regulation of environmental economic accounting[1]. The discussion is based on the work done in the frame of Eurostat grants "Development of the land account and valuation of ecosystem services regarding grassland ecosystem" (831254-2018-EE-ECOSYSTEMS), "Development of the ecosystem accounts" (881542-2019-ENVECO) and "Development of the environmental accounts" (Eurostat Grant-101022852-2020-EE-ENVACC). Proposals are given in the last chapter.

Comparison of the concepts and evaluation in physical terms of crop provision and wood provision ecosystem services

Forest ecosystem is characterized by the multitude of ecosystem services it offers both provisioning, regulating and cultural services. Agricultural ecosystem is however generally characterized by the crop provisioning ecosystem service.

Definitions:

Crop	The Guidance Note on Accounting for the Crop Provision Ecosystem Service [2] (version February 2023) states: "The ecosystem service crop provision is defined as the ecosystem contribution to plant growth as approximated by the amount of harvested crops for different uses. This includes food and fibre production, fodder and energy, and grazed biomass, as set out under Annex III, Table A, Section 1.1 and Section 1.2. "
Timber	The Eurostat Guidance Note on Accounting for the Wood provision Ecosystem Service [3] (version February 2023) suggests to define wood provision as "*the ecosystem contributions to the growth of trees and other woody biomass*". The proposed Forest accounts legal module defines net increment as follows: "*Net annual increment of timber is defined as the average annual volume growth of live trees, calculated from the stock of live trees (growing stock) available at the start of the year less the average annual mortality*".

In the case of a forest, an important fact is that the forest ecosystem cannot provide all these services simultaneously in equal volumes. Thus, wood, the main provisioning service of the forest ecosystem, competes with regulatory and cultural services. For example, a forest that has undergone clear-cutting no longer has the biological characteristics of a forest ecosystem and cannot provide the regulatory and cultural services typical of a forest ecosystem. The fact that the wood supply service does not occur in isolation from other forest ecosystem services, and often reduces the ability to provide other services, makes accounting for forest ecosystem services more complex. According to the proposal of the Guidance Note, the annual growth of wood is recommended as a mandatory indicator in European context for accounting for wood, the main supply service of the forest ecosystem. The main drawback of the proposed headline indicator is that the growth of wood (in other words, the increase in biomass)

[1] According to the definition of the proposal for the amendment of Regulation (EU) 691/2011

[2] Eurostat – Unit E2. Doc. Doc. ENV/EA/TF/2023_1/2. Crop provision ecosystem service – guidance note. Version prepared for the Task force on ecosystem accounting after a written consultation by the Environmental accounts working groups (WG EA and MESA) (February 2023)

[3] Eurostat – Unit E2. Doc. Doc. ENV/EA/TF/2023_1/2. Wood provision ecosystem service – guidance note. Version prepared for the Task force on ecosystem accounting after a written consultation by the Environmental accounts working groups (WG EA and MESA) (February 2023)

is not directly related to the wood cut from the forest and entering the economy. An alternative and more real economy-based approach would be to account for the removals (second proposed indicator for ecosystem accounting in relevant guidance note). According to this definition accounting of wood supply services would be based on the wood that actually enters the economy (i.e. felling volumes). Functioning accounting exists for removals and is more easily available than data on annual growth.

To justify the proposal to use this alternative accounting indicator for the wood supply service of the forest ecosystem, we draw the parallel between the forest accounting service flow estimation and current approach for crop provisioning services of agricultural ecosystems which suggests to define crop provision as *„the ecosystem contributions to plant growth as approximated by the amount of harvested crops for different uses"*. Detailed description of the methodologies for accounting wood and crop supply in physical terms and the results can be seen in ANNEX 1 and ANNEX 3 respectively.

When applying the proposed logic of forest accounting (increment) to accounting for agricultural production, it should be "increase in agricultural biomass" without *"approximated by the amount of harvested crops"*. Of course, the comparison does not take into account the special features of forest and agricultural ecosystems and the different length of crop growth cycles. However, it highlights an alternative approach in accounting for agricultural production, the application of which could also be considered in accounting for the wood provision service of the forest ecosystem.

Why is it important? From the point of view of accounting and forest statistics, the difference is not quantitatively large. In 2019, the net increment of the forest was 12 362 x 10^3 m^3 and the removals were 11 779x10^3 m^3. The difference is 583 x 10^3 m^3, which is about 5%. It is qualitatively very important, when analysing the services of the forest ecosystem in a complex way, and not only the wood supply service in isolation. Namely, the increment does not provide information about the quality of the forest, because the cutting (removals) takes place in old (i.e. ripe for cutting) forests, where both emission and especially cultural ecosystem services are high. However, the increment takes place in a significant part in young forests, which cultural services and biological value (especially habitats for biological species) are of considerably lower value compared to old forests. Thus, the age structure of forests can continuously deteriorate, while the annual increment of wood exceeds the removals.

As mentioned above the fact must be recognized when accounting for forest ecosystem services, that the forest supply service (wood) is competitive with other services or excludes others. If the goal is a complex evaluation of forest ecosystem services, forest statistics based on increment provide wrong message. The annual increment in young forest and old forest can be approximately the same but the link to the condition of a forest will be missing. The statistics based on increment do not show the decline of other ecosystem services because of deforestation or due to a change in the age structure of the forest. This is especially important if the goal is to evaluate the forest ecosystem services of a specific delimited land area.

There are other alternatives suggested to approximate the ecosystem contribution to the provisioning of the services but these are not yet theoretically mature enough to consider as a standard. Alternatives for ecosystem contribution in physical values can be an estimation of 'the various types of ecosystem contributions such as those concerning nutrients, water, soil retention, pollination etc. which will be used in different combinations in different contexts' (SEEA EA paragraph 6.87).

To obtain the real contribution of ecosystem to the provisioning a service, different approaches can be considered and these have been discussed in the task force[4] as possible memo items for reporting.

First approach is to consider all of the harvested biomass but supply the data with additional information on crucial variables, such as human input of fertilizers, irrigation water, pesticides and/or fuel, limiting redundancy which would help interpret trends in crop provision over time and avoid that

[4] Eurostat – Unit E2. Doc. Doc. ENV/EA/TF/2022_4/8. Guidance note on crop provision – second draft. Version prepared for the Task force on ecosystem accounting 15-16 September 2022 (September 2022)

e.g. increasing yields sustained by excessive human inputs are interpreted as a positive trend in ecosystems and their ability to provide services, when, in reality, these might lead to a degradation of ecosystem condition. Second option would be to apply emergy approach which was developed in the INCA project (2016-2021), where the ecosystem contribution to crop provision was estimated using the 'embodied energy' ('emergy') approach, which converts all human and natural inputs needed to produce crops from their original units (e.g. kg for fertilizers) into common emergy units[5]. Third, also an approach to estimate ecosystem contribution on the bases of organic agriculture has been discussed as well.

Crop service	Crop service , ecosystem contribution	Timber service	Timber service, ecosystem contribution
harvested biomass		increment-based method	
	all harvested biomass, less inputs	removals	
	emergy approach		
	organic agriculture		

In conclusion, comparison shows that different logic is applied for the crop and wood provisioning services. Using increment-based method is not the best method for approximation of timber ecosystem service as a false impression may arise that the use of supply services does not have a significant impact on the total value of ecosystem services of a particular forest. Other alternatives may be considered in a future to approximate the ecosystem contribution to the provisioning of the services.

Comparison of the concepts in monetary terms of crop provision and wood provision ecosystem services

Analysis of alternatives for the evaluation methods of crop provision

In the case of hardly any other ecosystem service (hereinafter ES), the contribution of the ecosystem and the economic system to the creation of value is so intertwined as in the case of the crop provisioning ES. It can be argued that the introduction of this ES made it possible to carry out one of the biggest changes in the (economic) history of mankind - the transition from a hunter-gatherer economic formation to an agricultural formation. The exceptional importance of the crop provisioning ES is also shown by the fact that the output of this service for an individual is food, which is one of the basic needs of people, and its constant consumption is inevitable. However, the intertwining of the economy and the ecosystem contribution in the case of crop provisioning service does not make it easy to separate the contribution of ecosystem from the contribution of economic system and present it separately.

If one of the obstacles in finding the value of regulating and cultural ecosystem services (in addition to conceptual problems from the point of view of classical economic accounting) is the lack of data on the practical expression of corresponding ecosystem services, detailed statistics are available for the crop provision service. The quantification of the crop provision service of the ecosystem should not create ambiguities (which is not the case for several other ecosystem services), because the materialized output of the service is agricultural production, which is accounted for in conventional physical units, which are either mass or volume of production. There is also data on the price of production and the rent of agricultural land, the availability of which enables the financial equivalent of the ecosystem contribution to be found on the basis of agricultural statistics or the rent of land. The statistics on agricultural production and the production process are comprehensive and reflect well the economic data related to production and production process. This is also to be expected, because the

[5] See https://publications.jrc.ec.europa.eu/repository/handle/JRC116334, chapter on crop provision for details and https://publications.jrc.ec.europa.eu/repository/handle/JRC116274

prerequisite for receiving various subsidies related to agricultural production common in the European Union is the timely submission of economic data in a way that meets the requirements. In summary, it ensures the comparability of agricultural statistics within the EU.

However, the existence and availability of data related to production does not help to solve important conceptual questions related to the supplied services of ecosystems:

1) what is the real contribution of the ecosystem to the output of the supplied service (production as a commodity with market value);
2) whether and if, to what extent, the contribution of the ecosystem is reflected in the price of production (as the output of the provisional service).

These conceptual questions have been raised and discussed by Statistics Estonia and Estonian experts in the London Group article "Two Languages or Two Narratives: Comparison of the Selected Market Price and Revealed Preferences Valuation Methods to the Stated Preferences Method" in 2020[6].

Agricultural products such as crops, crop residues, fodder crops, and grazed biomass are classified according to CICES as ecosystem provisioning services. To calculate the monetary value, of ecosystem service environmental economists recommend using revealed preference methods in case of provisioning services. The revealed-preferences method is based on the real shopping behavior of people. According to environmental economists the monetary value of an environmental goods is considered to be equal with the consumer surplus that the demanders on the market are willing to pay for the environmental goods. Market output method, resource rent and rent price are basically all revealed preference as such. [7] These valuation methods all give different monetary equivalent to the value of the crop production ES.

Rent price, resource rent and market output methods have been used to calculate the monetary value of crop production services. Below the results of the calculations, advantages and disadvantages of these methods are presented based on the experience gained from their application. The advantages and disadvantages were presented with the aim to make the decision on which of these methods would be the most suitable for the calculation of the monetary value of crop provision according to the proposed definition. More detailed description of the methodologies and results can be seen in ANNEX 2.

1. The rent price method is based on the assumption that the rent of cropland or grassland is attributable to the ecosystem as it is a market-based agreement between the owner and the renter that shows the willingness to pay to use the service. The availability of data and simplicity of calculations are the advantages of this method. The disadvantage is that the obtained result measures the potential service provision, not the actual output of crops and fodder. Since the physical unit for measuring the ecosystem service of crop production is, according to the guidance document, the weight of the crop in tons, the land rental price method is not the best possible method for evaluating the monetary value. In the point of view of environmental economics, the rent price method (comparable to market price method) is suitable for calculating the contribution of the ecosystem value, involved in the production of agricultural crops. The method uses real transactions on the market and observes actual consumer preferences. The method uses standard, accepted economic techniques. Consequently, the use of the rent price method for calculation of ecosystem crop production services would be fully justified.
2. The resource rent method is based on data from national accounts and agricultural statistics. This method is used for calculation of ecosystem service value by subtracting all costs for capital and labor from the total output. The main strength of the method is that the ecosystem service value

[6] Two Languages or Two Narratives: Comparison of the Selected Market Price and Revealed Preferences Valuation Methods to the Stated Preferences Method; UN London Group on Environmental Accounting, 2020; Kaia Oras (Statistics Estonia), Üllas Ehrlich (prof., Tallinn University of Technology), Kätlin Aun; (Statistics Estonia); Grete Luukas (Statistics Estonia), https://drive.google.com/file/d/1Ys-AH4HxYNANqrEJyzxeq73tEyAxJ3j9/view

[7] However, If the ecosystem service is valued directly through the market price of production, it is considered to be a market price method in order to distinguish the evaluation of market and nonmarket values.

is clearly defined and adequately evaluated. The fact that data in national accounts are quite aggregated and the need to use raw data to calculate the monetary value from the aggregated data is a drawback. Therefore the main obstacle to the practical application of this method is the lack of appropriate statistics and the need to use several assumptions for obtaining input data.

3. "Output of the agricultural activity (less the output of other than crop production agricultural activities) method" uses data from agricultural and national accounts to value crop production ecosystem service. The total value of crop production was calculated by using output data from national accounts and share of crop production from agricultural statistics. As national accounts data are aggregated and have only total output value of NACE A.01 it was necessary to distinguish only crop production and it was done using shares from agricultural statistics.

Table 1. Values of crop supply ecosystem service and ecosystem contribution by estimation approaches, million €, 2020 and their relative volume

Valuation method	Value of the crop production service	Value of ecosystem contribution	% of the market price-agriculture	% of the rent price evaluation method
Rent price		71.7	15.7	100
Resource rent		17.7	3.9	24.7
Output of the agricultural activity less the output of other than crop production agricultural activities	456.8			

From the data in table 1 it can be seen that the market output production is 457 million euros. Rent price method is assigning to ecosystem 16% compare to crop production output value. Financial equivalent of ES contribution of crop provisioning found by the resource rent method is lowest, 3.9 percent.

Looking at the results obtained with the methods based on the market price of agricultural production, resource rent and rent price of land as a means of production, it is apparently impossible to objectively decide which of the given methods reflects the value of the service of the ecosystem "more correctly" or "most according to reality", because we do not know what the objective reality is here. Financial equivalent of crop provisioning ES found by the resource rent method however seems too low: the results obtained using resource rent method attribute only approximately 4% of the market price output of production to the ecosystem, which seems unfair to the contribution of the ecosystem, especially if, for example, to assume that the share of both the economic system and the ecosystem in the agricultural production is equally divided between both. Also, it should be kept in mind that the residual element (profit) is part of the monetary flows related to economic capital. Hence, the question arises whether the actual ecosystem contribution is reflected in the market price of production and in the rental price of agricultural land at all.

Based on the experience gained and discussed above it seems most reasonable to currently use the rent price method, which compares to approximately 16% of the market price of production. With certain reservations, it can be assumed that the rent price reflects the market value of the land (agricultural ecosystem) as a component of the ecosystem contributing to agricultural production. The rent price method has also been preferred by Statistics Netherlands.[8] The reservation is that although rent price method should reveal willingness to pay in order to use ecosystem service, the rent price may also be dependent on the market situation and the rent price is also connected with the profit the renter gets.[9]

We still have an opinion that the nature's contribution for maintaining the quality of agricultural ecosystems is still underrepresented in current concepts. From this perspective analyzing the available

[8] Statistics Netherlands and WUR (2021), Natural Capital Accounting in the Netherlands – Technical report. Statistics Netherlands (CBS) and Wageningen University and Research (WUR)

[9] the rent price is affected by the same indicators of the economic system as the price of agricultural production. For example, the general price level of food, the supply-demand ratio, etc. If the land is a mean of production, then the rent certainly depends on the value of the expected production for the production of which the land is rented.

data and methods to calculate monetary value of crop production ecosystem service would be needed in future as well.

The contribution of ecosystem is precondition that the service can be used (crop can be produced) but the question is what contribution is captured in economy so that it can be calculated using market prices. The contribution of the ecosystem can be determined through the market prices of the production, assuming that the contribution of the ecosystem is included in the market price of the production. We have also discussed that the market price of agricultural production reflects only the contribution of the economic system to production, leaving out the contribution of the ecosystem earlier in the London Group article "Two Languages or Two Narratives: Comparison of the Selected Market Price and Revealed Preferences Valuation Methods to the Stated Preferences Method" in 2020[10].

One theoretical possibility was discussed and proposed in order to make calculations more relevant from the viewpoint of ecosystem contribution. Assuming that organic agricultural production is the most natural treatment of the ecosystem since human intervention (fertilizers, soil treatment, etc.) has been reduced to the minimum. Then using organic production yield, market prices and expenditures related to production would theoretically lead to more appropriate results of the ecosystem contribution. This approach could be tested further in the coming phase of development of the valuation of crop provisioning service.

Alternatives of monetary valuation of wood provision

In Europe, according to the definition of the proposal for the amendment of Regulation (EU) 691/2011, the ecosystem service wood provision is defined as the ecosystem contribution to the growth of trees and other woody biomass, shall be reported as net increment as defined in Annex VII in over-bark, in thousand m3. Annex VII references to the forest accounts in the same proposal for the amendment of Regulation (EU) 691/2011 where it defines net increment as follows: "Net annual increment of timber is defined as the average annual volume growth of live trees, calculated from the stock of live trees (growing stock) available at the start of the year less the average annual mortality".

For monetary valuation in ecosystem accounts, the service has been currently valued with stumpage prices calculated over increment and removals (harvested wood)[11]. The first is combined better with the physical indicator but the latter shows better the real flow that enters to economy. Stumpage prices are prices that are paid for standing tree for the right to harvest. Stumpage prices are direct market prices and therefore show exchange value. Description of the methodologies and results can be seen in ANNEX 4:

1) average net income (can be likened to resource rent, residual value in agricultural crops) based on increment 142.16 million euros; based on removals 135.46 million euros;
2) average stumpage price method (flows multiplied by stumpage price) based on increment 319.8 million euros, based on removals 304.72 million euros.

Thirdly, output value based method uses data from national accounts monetary supply table. Monetary supply table contains information of all products and services that has been supplied in an accounting year and also which institutional sector and NACE was the producer. Yet additional data was necessary to use as the supply table was too aggregated and in order to separate output of logs from other forestry products data from EKOMAR (business statistics, micro level) that include more detailed information about revenues, were used. So, in order to distinguish different products aggregated in supply table the

[10] Two Languages or Two Narratives: Comparison of the Selected Market Price and Revealed Preferences Valuation Methods to the Stated Preferences Method; UN London Group on Environmental Accounting, 2020; Kaia Oras (Statistics Estonia), Üllas Ehrlich (prof., Tallinn University of Technology), Kätlin Aun; (Statistics Estonia); Grete Luukas (Statistics Estonia), https://drive.google.com/file/d/1Ys-AH4HxYNANqrEJyzxeq73tEyAxJ3j9/view

[11] Statistics Estonia, 2023 "Development of the environmental accounts" (Eurostat Grant-101022852-2020-EE-ENVACC). Available from https://www.stat.ee/en/find-statistics/statistics-theme/environment/biodiversity-protection-and-land-use

share of revenues of different products of NACE 02 from EKOMAR were multiplied with the aggregated value. Only output of wood in the rough (logs and fuel wood) was considered in Table 2. Output of forest tree seeds, tree plants, non-wood products and services characteristic of the forestry and logging activity was not included. Total output of forestry industry can be seen in ANNEX 5.

Table 2. Values of wood supply ecosystem service and ecosystem contribution by estimation approaches, million €, 2019 and ecosystem contributions relative volume

Valuation method	Value of the timber production service	Value of ecosystem contribution	% of the market price of forestry output
1.Net income (resource rent)	135.5 (removals)	142.2 (based on net increment)	20.7
2. Stumpage price method (forestry account: value of timber minus the costs of forest felling) –	**304.7 (removals**)	319.8 (net increment)	46.6
3. Output value of the forest activity less the output of the side activities.	685.8		

Calculating the monetary value of timber provision ecosystem service could be possible using all proposed methods. All three are based on the market price of timber as an output of provisioning service, which is typical for finding the monetary equivalent of ecosystem provisioning services. But which of the three methods described above would best align with accounting for ecosystem provisioning services? When accounting for ecosystem provisioning services, it could be desired to adhere to methodological uniformity with provisioning services of other ecosystems. Next chapter outlines the comparison of the valuation methods of timber and crop ecosystem services.

Comparison of the valuation methods of timber and crop ecosystem services

Apart from the forest, the second major ecosystem that provides provisioning services is the agricultural ecosystem, the economic accounting of which supply service has been compared above with various alternatives of forest accounting. The currently used methodology for calculating the financial equivalent of the supply service of agricultural ecosystems (agricultural production) is based on the rent of agricultural production. Alternative approach was to base the calculations on the market price of production. With such an approach, the question inevitably arises of how to distinguish the component of the contribution of the ecosystem in the market price of the service (agricultural production) from the contribution of the economy (discussed in London Group article "Two Languages or Two Narratives: Comparison of the Selected Market Price and Revealed Preferences Valuation Methods to the Stated Preferences Method"[12]). This question is complex and theoretically unresolved so far. Thus, (at least initially) the supply service of agricultural ecosystems is taken to be proportional to the market value (rent price) of the production.

Stumpage price and net income (resource rent) methods present the alternatives in case of forest ecosystems where costs made are deducted from the service output.

In case of net income method all observed costs are deducted. As we know, the profit (residual value) depends on both the economic situation in the market and the economic policy decisions of the (timber) companies. For example, in some cases the companies could reduce profit to optimize taxes. The influence of the costs on the value of the timber production is one issue but it should not have a direct

[12] Two Languages or Two Narratives: Comparison of the Selected Market Price and Revealed Preferences Valuation Methods to the Stated Preferences Method; UN London Group on Environmental Accounting, 2020; Kaia Oras (Statistics Estonia), Üllas Ehrlich (prof., Tallinn University of Technology), Kätlin Aun; (Statistics Estonia); Grete Luukas (Statistics Estonia), https://drive.google.com/file/d/1Ys-AH4HxYNANqrEJyzxeq73tEyAxJ3j9/view

link to the ecosystem contribution. And how does the financial value of the forest supply service show in practice when the company's profit is negative in some years, i.e. if the company is in loss, is not clear as well.

Looking from the perspective of ecosystem accounting, this alternative suits best with residual value concept (SEEA EA, chapter 9.36)[13] which is also suggested as one approach in case where the market prices (and associated values) are embodied in market transactions. As according to this concept, profit can be seen as the residual value if all manmade costs are subtracted from revenue, residual value concept equals the contribution of the ecosystem with the gained profit. If in case of crop provision service the residual value approach was not justified due to the fact that it reduces ecosystem contribution, then in case of forest accounting the high volatility of the market and economic policy of forest companies are the main reasons why to question the suitability of residual value approach from the viewpoint of valuing ecosystem service of timber provision.

While considering the market price output "output value of the forest activity (less the output of the side activities)" as ecosystem service there is an obvious drawback. Attributing the entire market price of the production to the value equivalent of the provision service of the ecosystem is not recommended, because it does not allow taking into account the contribution of the economic system to the production value (price). The problem is analogous to finding the value of the provision service of agricultural ecosystems based on the price of production. The arguments why the attribution of the entire market price of the production to the value of the ecosystem provision service was not justified are similar for forest and agricultural ecosystems: they do not allow to distinguish the contribution of the ecosystem from the contribution of the economic system, attributing the entire market price of the production to the ecosystem, increasing it unreasonably and unfairly at the expense of the contribution of the economic system.

Thus, among given alternatives it seems that from the ecosystem point of view the least controversial is to describe the monetary value of the timber provisioning service of the forest ecosystem is by applying average stumpage price method due to the subtraction of the direct contribution of economy in this approach.

In case of crop provision, the rent price method was used. Could it be seen also as an alternative to determine the ecosystem contribution for timber? Using the rental price of forest land compared to the rental price of agricultural land as a basis for assessing the provisioning service value of the forest ecosystem is problematic. The price of rent of agricultural land is directly related to the supply service of the agricultural ecosystem, which is agricultural production. The rental price is directly related to the production price. The lessee pays for the potential of the farmland as an agricultural ecosystem, to which the human (economic system) contribution must be added to obtain production. The production cycle in an agricultural ecosystem is short, generally limited to 1-2 years. Thus, the rent price can be used as an indicator of the monetary value of the ecosystem service in the case of agricultural land.

In the case of provisioning ecosystem services of forest, the production cycle is long, generally 50-80 years. The value and price of forest land on the market does not depend so much on the parameters of the land, but on what kind of forest grows on that land and how many years are left until the felling. Forest land without forests can be bought as an investment with the future in mind, but it hardly makes sense economically to rent it for production. Instead of paying low rent for say 60 years in a row, it would

[13] https://seea.un.org/sites/seea.un.org/files/documents/EA/seea_ea_white_cover_final.pdf
Residual value and resource rent methods: The residual value and resource rent methods95 estimate a value for an ecosystem service by taking the gross value of the final marketed good to which the ecosystem service provides an input and then deducting the cost of all other inputs, including labour, produced assets and intermediate inputs (see formula from the SEEA Central Framework below). Depending on the scope of the data (e.g., pertaining to a specific location or to the activities of an industry as a whole), the estimated residual value provides a direct value that can be recorded in the accounts or can be used to derive a price that may be applied in other contexts. The relevant considerations in deriving a price are described in the SEEA Central Framework (annex 5.1).

be economically feasible to invest in forest land. Therefore, it is not practical to use the rent price of forest land, unlike the rent price of agricultural land, as the basis of the monetary equivalent of the value of the forest ecosystem.

By its very nature, agricultural land is a means of production, which, as mentioned above, provides production within 1-2 years. Due to the length of the production cycle, forest land cannot be treated as a means of production in the same way as agricultural land, and the rental market for forestless forest land practically does not exist. Thus, the rent price method, which is preferred by the authors when determining the provision value of agricultural ecosystems, is not suitable for evaluating the provisioning service (timber production) of the forest ecosystem.

The calculation of the monetary value of the timber provisioning service of the forest ecosystem by applying average stumpage price method could be most reasonable among the alternatives because it makes most clear distinction between the contributions of economy and nature without being biased towards either. Output approach seems to overestimate and net income underestimate the ecosystems contribution.

Conclusions and proposals

The paper addressed the parallel methods for the accounting of the provisioning ecosystem services of crop provision (agricultural production) and timber provision. Methods for the feasibility for the isolation of ecosystem contribution in physical and monetary terms were considered as well.

Regarding the valuation in physical terms: comparison shows that different logic is applied for the accounting of crop and wood provisioning services. Crop production ecosystem service is captured on the point of the entrance to economy while in case of timber provisioning the increment taking place in ecosystem is currently considered. Second issue related to the use of increment as a base of calculating ecosystem service is that using increment-based method is not the best method for approximation of timber ecosystem service. False impression may arise that the use of supply services does not have a significant impact on the total value of ecosystem services of a particular forest.

An alternative and better option of ecosystem service definition which is analog to the methodology for the crop provisioning service and also more real economy-based approach, is to account for the removals (second proposed indicator for ecosystem accounting in relevant guidance note). Using removals would be more integrated to the other forest ecosystem services of the same ecosystem.

In order to approximate the ecosystem contribution to the provisioning of the ecosystem services (especially regarding crop production ecosystem service) other alternatives considering the soil contribution etc are also under discussion already and should not be forgotten. These should possibly be considered in future.

Regarding monetary valuation, one aspect is clear: the contribution of ecosystem is precondition that the service can be used but the question is what contribution is captured in economy so that it can be calculated based on market prices. The resource rent calculated gives just 4% of the value of output. It is possible that the contribution of ecosystem is not considered in the market price in case of agricultural production and hence this could not be separated. Considering the above, in case of the crop provision ecosystem service contribution, rent price method was finally preferred/chosen as the one which reveals willingness to pay (in context of expenses) in order to use ecosystem service. Of the existing methods, the rent price is probably the best indicator of the ecosystem service, but we should not create illusions that this is the so-called objective measure of the value of the ecosystem service.

For the timber provision ecosystem service monetary valuation the use of the rent price method however is not realistic as the forest land as a mean of production is in principal usually not rented. Instead stumpage prices based method is suggested. Stumpage prices method separates reasonably

contribution of ecosystem and economy because it reflects better the value of timber as ecosystem provisioning services after the deduction of harvesting costs.

In general, there is no clear framework to calculate the contribution of the ecosystem to the value of the services, therefore similarities and differences when accounting for these two large ecosystem provisioning services were discussed and London Group on environmental accounting is invited to give their opinions and to develop the topics further.

ANNEX 1. Crop provision in physical value

In addition to using the preferred method of using data obtained from MFA (material flow accounts) for physical ecosystem service account, the other two approaches mentioned in the guidance note for crop provision[14] were looked into and data available from agriculture statistics and national geo-spatial data on crop production areas and/or data from national registries of agricultural parcels were evaluated.

The supply of crop is found by using the amount of harvested crops in the MFA (material flow accounts) breakdown, sections 1.1 and 1.2. In MFA, the amount of harvested crops is recorded under characteristics 'Domestic extraction'. It is suggested in the guidance note for crop provision that when compiling the supply side of crop provision, 'Domestic extraction' of all reporting items of MFA sections 'Crops' (1.1), 'Crop residues' (1.2.1) and 'Fodder crops including biomass harvest from grassland' (1.2.2.1) is to be recorded as a supply from ecosystem type 'Cropland'. 'Domestic extraction' of MFA item 'Grazed biomass' (1.2.2.2) is to be reported as a supply from 'Grassland'. However, grassland ecosytem types includes permanent grassland which also contributes to fodder production, therefore it would be more correct to attribute MF.1.2.2.1 Fodder crops (including biomass harvest from grassland) to grasslands than croplands. It is also supported by PM0821 data where production from permanent pastures and meadows is recorded The results in the format of the draft reporting table from the guidance note Annex 2a with added final row "total" can be seen in Table 3.

The use of the crop provision ecosystem service is to be attributed to intermediate consumption by industries (agriculture sector). The results in the format of the draft reporting table from the guidance note Annex 2b with added final row "total" can be seen in Table 4

Table 3. Supply of crop production according to MFA (material flow accounts), thousand tons, 2020

	Settlements and other artificial areas	Cropland	Grassland	Total supply
MF.1.1 Crops (excluding fodder crops)		2115		2115
MF.1.1.1 Cereals		1633		1633
MF.1.1.2 Roots, tubers		94		94
MF.1.1.3 Sugar crops		0		0
MF.1.1.4 Pulses		120		120
MF.1.1.5 Nuts		0		0
MF.1.1.6 Oil-bearing crops		203		203
MF.1.1.7 Vegetables		59		59
MF.1.1.8 Fruits		5		5
MF.1.1.9 Fibres		0		0
MF.1.1.A Other crops (excluding fodder crops) n.e.c.		0		0
MF.1.2 Crop residues (used), fodder crops and grazed biomass		2439		2439
MF.1.2.1 Crop residues (used)		..		..
MF.1.2.1.1 Straw		..		..
MF.1.2.1.2 Other crop residues (sugar and fodder beet leaves, etc.)		..		..
MF.1.2.2 Fodder crops and grazed biomass		804		804
MF.1.2.2.1 Fodder crops (including biomass harvest from grassland)			491	491
MF.1.2.2.2 Grazed biomass			313	313
TOTAL		3749	804	4554

.. - data not published

[14] Eurostat – Unit E2. Doc. Doc. ENV/EA/TF/2023_1/2. Crop provision ecosystem service – guidance note. Version prepared for the Task force on ecosystem accounting after a written consultation by the Environmental accounts working groups (WG EA and MESA) (February 2023)

Table 4. Use of crop production according to MFA (material flow accounts), thousand tons, 2020

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total use
MF.1.1 Crops (excluding fodder crops)	2115					2115
MF.1.1.1 Cereals	1633					1633
MF.1.1.2 Roots, tubers	94					94
MF.1.1.3 Sugar crops	0					0
MF.1.1.4 Pulses	120					120
MF.1.1.5 Nuts	0					0
MF.1.1.6 Oil-bearing crops	203					203
MF.1.1.7 Vegetables	59					59
MF.1.1.8 Fruits	5					5
MF.1.1.9 Fibres	0					0
MF.1.1.A Other crops (excluding fodder crops) n.e.c.	0					0
MF.1.2 Crop residues (used), fodder crops and grazed biomass	2439					2439
MF.1.2.1 Crop residues (used)	..					..
MF.1.2.1.1 Straw	..					..
MF.1.2.1.2 Other crop residues (sugar and fodder beet leaves, etc.)	..					..
MF.1.2.2 Fodder crops and grazed biomass	804					804
MF.1.2.2.1 Fodder crops (including biomass harvest from grassland)	491					491
MF.1.2.2.2 Grazed biomass	313					313
Total	4554					4554

.. - data not published

ANNEX 2. Monetary value of crop provision

It has been discussed which methods could be used to calculate the monetary value of crop provision ecosystem service. In general the rent price method was agreed to be used due to the fact that calculation of other approaches tested (see below which comprise only residual value) would use too many assumptions and probably underestimate the contribution of ecosystem.

Market value of the agricultural production method

However there was no full consensus and according to the opinion of some experts in Estonia and also project team still the simple market value of the agricultural production could reflect in a best manner the ecosystem service of crop production in monetary terms as in this case calculation would reflect the ecosystem contribution in a straightforward manner (data are easily accessible and results are comparable) in a situation where theoretical foundation for the service valuation is still not commonly agreed (Table 5). The value was calculated using data from national accounts and agricultural statistics. Total output of NACE 01 is calculated in national accounts using data from agricultural statistics. In order to distinguish only agricultural production for ecosystem accounting from total Nace 01 value shares from agricultural statistics was used.

Table 5. Market price method, value of the agricultural production, 2020

Transaction	Value, mln EUR
Output	456.8

Rent price method.
Rent is an expenditure user pays to the owner to use the resource. Rent payments can be related to the crop provision supplied by ecosystem as the renter is willing to pay the rent to use the service.

Necessary data for rent price method are rent payments and extent of area under cultivation. Rent price data were available from agricultural statistics but no distinction on land type or county is made. The average rent price of agricultural land in 2020 was 76 €/ha. In order to calculate the value of fodder production service average rent prices were multiplied with the extent of land in hectares. It was possible to calculate monetary value of grasslands as a total value and additional division between semi-natural and permanent grasslands were made using yield data (permanent grasslands have almost 2.5 times higher yield). Input data from agricultural statistics was detailed enough to calculate monetary value separately for temporary grasslands and agricultural land regarding fodder component. The results are given in Table 6. The use of the crop provision ecosystem service is attributed to intermediate consumption by industries (agriculture sector).

Table 6. Monetary value of crop provision service, rent price method, by ecosystem type, 2020, mln EUR

	Rent price, mln EUR
Cropland	52.39
crops from agricultural land	39.07
fodder from agricultural land	3.85
fodder from temporary grasslands	9.47
Grassland	19.34
fodder from semi natural grasslands	5.69
fodder from permanent grasslands	13.64
Total	71.73

Resource rent method of crop provision ecosystem service

Resource rent method was additionally applied for finding the value of crop provision ecosystem service. In order to calculate resource rent value several items have to be taken into account and used in following formula:

Output
Less intermediate consumption
Less compensation of employees
Less other taxes on production
Plus other subsidies on production
Equals Gross operating surplus
Less consumption of fixed capital (depreciation)
Less return to produced assets
less labour of self-employed persons
Equals Resource rent
= Depletion + net return to environmental assets

Resource rent method is used for calculating ecosystem service value by subtracting all costs for capital and labor from the total revenue. The residual value is attributed as the ecosystem contribution.

Data in national accounts are quite aggregated and only total data of NACE 01 – Crop and animal production, hunting and related service activities were available. Using financial data from agricultural statistics it was possible to distinguish separately crop production, animal production and hunting and

related service activities. Distinction of agricultural food from total crop production was made using shares from agricultural statistics.

Return to produced assets and labor of self-employed persons had to be estimated as these were not readily available from national accounts. In order to calculate the return to produced assets 2% (suggested by Statistics Netherlands) of net stock of agriculture activity were calculated. For labor of self-employed persons average salary of agriculture activity and number of self-employed people in agriculture were multiplied.

Production data of food from agricultural lands are available from agricultural statistics. Data are available on a food group level and different prices are used to calculate production value. In order to find the share total production of agricultural food was first calculated. The total included production of wheat, rye, barley, oats, other crops, legumes, potatoes, oilseeds, vegetables and fruits. Physical yield data are collected via agricultural surveys and prices are first obtained from Estonian Institute of Economic Research and are then adjusted with price indexes.

The resource rent value of crop provision service in 2020 was 17.69 million EUR, detailed calculation can be seen in Table 7.

Table 7. Resource rent value of crop provision, mln EUR, 2020

Transaction	Value, mln EUR
Output	456.77
Less intermediate consumption	336.16
Less compensation of employees	77.45
Less other taxes on production	2.64
Plus other subsidies on production	-108.47
Less consumption of fixed capital	68.56
Less return to produced assets	20.48
Less labor of self-employed persons	42.25
Resource rent	17.69

ANNEX 3. Wood provision supply – physical account

Data on increment and removals was obtained from Estonian Environment Agency. As is described in the wood provision guidance note, a distinction is made between forest available for wood supply (FAWS) and forest not available for wood supply (FNAWS) (Table 8). Data on increment or removals from other land available for wood supply (AWS) or other land not available for wood supply (NAWS) is not included in the NA as it only includes forest. All use of wood provision from FAWS is attributed to 'Intermediate consumption by industries'.

The results in the format of the draft reporting tables for supply and use from the guidance note Annex 1 show the supply and use of wood provision service respectively in Table 9 and Table 10.

Table 8. Wood increment and removals (harvested wood) in land available for wood supply (AWS, FAWS- forest available for wood supply) and land not available for wood supply (NAWS, FNAWS- forest not available for wood supply), 1000 m3 overbark, 2020

	Forest and woodland	Total supply
Wood provision - increment in FAWS	11 777.5	11 777.5

Wood provision - increment in FNAWS	2 189.96	2 189.96
Wood provision – increment in other land AWS	n.a	n.a
Removals		
from FAWS	10 547	10 547
Removals from FNAWS	n.a	n.a
Removals from other land NAWS	n.a	n.a

Table 9. Wood provision – supply table (1000 m3 overbark), 2020

	Forest and woodland	Total supply
Wood provision - increment in FAWS *(mandatory)*	11 777.52	11 777.52
Wood provision – increment in other land AWS *(mandatory)*	n.a	n.a
Removals from FNAWS *(voluntary)*	n.a	n.a
Removals from other land NAWS *(voluntary)*	n.a	n.a

Table 10. Wood provision – use table (1000 m3 overbark), 2020

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total use
Wood provision (increment in FAWS) *(mandatory)*	11 777.52					11 777.52
Wood provision – increment in other land AWS *(mandatory)*						
Removals from FNAWS *(voluntary)*						
Removals from other land NAWS *(voluntary)*						

To obtain the increment data on spatial detail, data from the Forest Registry (as of January 2021) was used as primary data source. The increment was found for each forest stand compartment based on a simplified methodology using age, height, normal stand density and site quality class according to the formulas given in Annex 12 "Calculation of the increment of growing stock " in the Regulation of the Minister of the Environment "Forest Survey Guidelines" (RT I, 31.08.2018, 8). In case of forest land, for which data were not available in the register, an average annual increment of growing stock was assigned using the weighted averages of the majority tree species and site type allocations according to the available data in the forest register. Thus, nearly 400 tree species / forest site type groups were formed, the averages of which were generalized to forest areas with incomplete data on the basis of forest site type and main tree species. The result is shown in

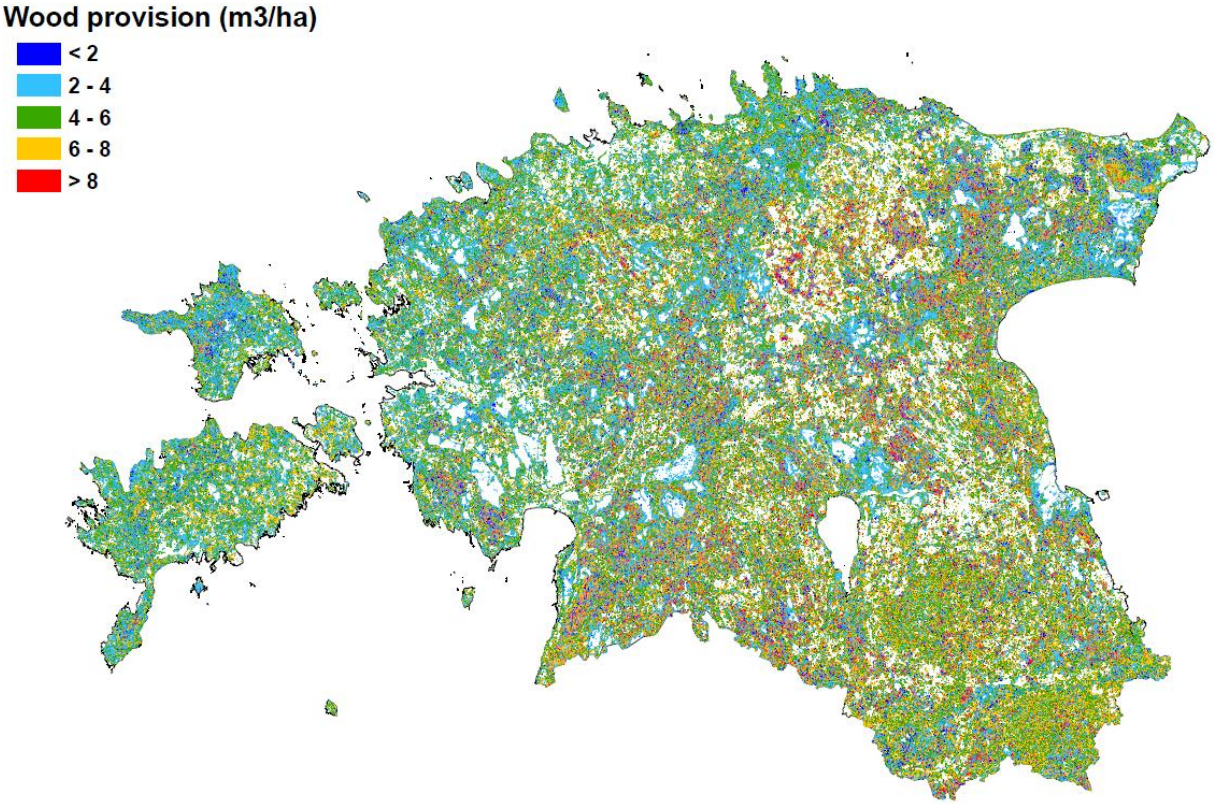

Figure 1. Wood provisioning (based on net increment) areas (forest available for wood supply) and values. The areas coloured from blue to red represent service provisioning areas according to the physical unit value m3/ha). Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

ANNEX 4. Valuation of timber provision and timber assets in European Forest Accounts

Methodologies for the compilation of table A2b on the monetary values of the timber assets

Net Present Value (NPV) is an accepted approach to the valuation of timber resources. Many guidance documents refer for the NPV: SEEA Central Framework, SEEA Ecosystem Accounting, the SNA and also the IEEAF[15] .

This section covers methodology and tables for three alternative approaches for the compilation of timber value:

1. Net present value of expected future revenues. The basis is the average stumpage (€/m^3) process and the predicted cash flows based on the defined long-term felling volumes.
2. Net present value of the future net income (profit) of forest management which is less than the calculations based on stumpage prices above as it deducts the costs incurred. The basis is net income per 1 m^3 of timber (€/m^3) and predictable cash flows. Method is compliant with the principles of the reporting of the value of biological assets which is in book keeping defined by legislation.

[15] https://ec.europa.eu/eurostat/documents/3859598/5859829/KS-BE-02-003-EN.PDF.pdf/5d0687cc-d770-4183-80b5-b684a62a8917?t=1414780453000 Annex 3

3. For the comparison also the value of timber calculated solely with the stumpage prices is given.

SEEA CF definitions for the valuation of the stocks and flows and the explanations in SEEA Central Framework chapter 5.1 were analyzed[16] as starting point, also the national methods applied in national legislation and forest economics were considered.

As also was the case of the forest land valuation the theoretical background and feasible methods for Estonian forest accounts were analyzed and discussed both in bilateral meetings between Statistics Estonia and various experts in a field: professor Paavo Kaimre (Estonian University of Life Sciences), with Carl Obst (who is in charge of the scoping of the EFA handbook) regarding the theoretical background and with representatives of Statistics Slovenia and also on webinars and bilateral discussions with Eurostat representatives of forest accounts.

The results were also presented to relevant experts and stakeholders in Estonia.

In this chapter the methods will be outlined and discussed. National approach for the valuation of the net present value for the biological resources has been suggested by some experts as most relevant. The assumptions pro and cons are discussed and we have also started the discussion on:

1. which revenues and costs to include in the calculation,
2. what assumptions to use in terms of future flows,
3. which discount rate to use.

The linkages to the ecosystem accounts asset and timber provisioning service valuation are discussed as well.

Alternative method 1: Net present value of expected future revenues

The net present value of future sales revenues (Table 11) has been used to calculate the value of the opening and closing stocks. By multiplying the forecasted[17] long-term annual harvesting volume 10.2 million m^3 by the average stumpage price, we get sales revenue that repeats year after year (annuity).

*Table 11. A2 (b) Alternative 1. Timber on wooded land, in million euros, Net present value of expected future revenues Reference year = 2019**

Code	Description	Opening stocks (December 2018)	Net increment	Removals *3	Irretrievable losses	Revaluation (+/-)	Statistical reclassification (+/-)	Balancing item (+/-) *2	Closing stocks (December 2019)
1	Forest	9037.20	319.80	304.72	32.88	7.29	-158.51	-72.38	8795.80
1.1	Forest available for wood supply	9037.20	319.80	304.72	32.88	7.29	-158.51	-72.38	8795.80
1.2	Forest not available for wood supply	0.00	0.00	0	n/a	n/a	0.00	0	0.00
2	Other wooded land	38.04	n/a	n/a	n/a	3.85	n/a	0.0	41.89
2.1	Of which available for wood supply	33.53	n/a	n/a	n/a	3.85	n/a	0.0	37.38
3	Other land with tree cover available for wood supply *	n/a	n/a	20.70	n/a	n/a	n/a	n/a	n/a

*Average stumpage price in 2018 = 26,58 €/m^3; Average stumpage price in 2019 = 25,87€/m^3

The monetary values of the timber flows in reference year (currently 2019) are calculated by multiplying the volume of the timber flow by the stumpage price.

Stumpage price data of different tree species and assortments were used to calculate the weighted stumpage price of one m^3 of removed timber.

[16] https://seea.un.org/sites/seea.un.org/files/seea_cf_final_en.pdf

[17] Valgepea, M., Raudsaar, M., Karu, H., Suursild, E., Pärt, E., Sims, A., Kauer, K., Astover, A., Maasik, M., Vaasa, A., Kaimre, P. 2021. Maakasutuse, maakasutuse muutuse ja metsanduse sektori sidumisvõimekuse analüüs kuni aastani 2050. https://doi.org/10.15159/eds.rep.21.01

For the state forests, the road-side price data are available from the State Forest Management Centre (SFMC) https://www.rmk.ee/puidumuuk-1/puidumuuk. For private forests, the data on buyer's yard prices are available from Private Forest Management Centre (www.eramets.ee/uuringud-ja-statistika/hinnainfo).

Information on distribution of removals into assortments comes from the National Forest Inventory (NFI). Environment Agency has provided this data for Statistics Estonia for compiling National Accounts.

Average logging costs were subtracted from the road-side prices to get stumpage price in state forests. To obtain the stumpage price for private forests, costs of logging and transportation were subtracted from the price of the buyer's yard. Data on average cost of logging and roundwood logistics are available in Yearbook Forest 2020[18] , compiled by the Environment Agency. In 2019, the average stumpage price was 25.87 €/m^3. In 2018, the average stumpage price was 26.58 €/m^3.

Table 12. The net present value of a perpetual annuity (a)

$$NPV = \frac{a}{i}$$

where i is the interest rate.

*With regard to the time preference, discount rates mostly range between 0 and 7% in forest management related calculations. Low interest rates are used in Estonia, usually in the range of 2-4%[19]. In this study, an interest rate of 3% was used to calculate the net present value of future money flows for the Table 13. A2 (b) Timber on wooded land, in million euros, alternative 1. Net present value of expected future revenues Reference year = 2019**

Alternative method 2: Net present value of expected future net income

The discounted net revenue method (of expected future net income) is used in Estonia to calculate the balance sheet value of the biological assets in state forests. The assessment of biological assets is regulated by Appendix 8 of the Minister of Finance's Regulation No. 105 of December 11, 2003, "Instructions for Public Sector Financial Accounting and Reporting". There is no uniform methodology for assessing the value of the biological assets of privately owned forests. Since the volume of growing stock managed by the state forest districts constitutes 50.6% of the total growing stock, it is appropriate to use this methodology for all Estonian forests. Results are displayed in Table 14 A2 (b) Timber on wooded land, in million euros, alternative 2. Net present value of expected future net income Reference year = 2019

Table 14. A2 (b) Alternative 2. Timber on wooded land, in million euros, Net present value of expected future net income Reference year = 2019

Code	Description	Opening stocks (December 2018)	Net increment	Removals *3	Irretrievable losses	Revaluation (+/-)	Statistical reclassification (+/-)	Balancing item (+/-) *2	Closing stocks (December 2019)
1	Forest	5128.10	142.16	135.46	14.62	-1970.79	-70.46	-32.18	3046.75
1.1	Forest available for wood supply	5128.10	142.16	135.46	14.62	-1970.79	-70.46	-32.18	3046.75
1.2	Forest not available for wood supply	0.00	0.00	0	n/a	n/a	0.00	n/a	0.00
2	Other wooded land	16.46	n/a	n/a	n/a	n/a	1.71	0.00	18.17
2.1	Of which available for wood supply	14.90	n/a	n/a	n/a	n/a	1.91	0.00	16.81

[18] Environment Agency. 2020. Yearbook Forest 2020

[19] Kaimre, P. 2002. Economics of forestry. Estonian Agricultural University. 197p

3	Other land with tree cover available for wood supply *	n/a	n/a	9.20	n/a	n/a	n/a	n/a	n/a

*- Net income per m^3 in 2018 = 18,25 €/m^3; Net income per m3 in 2019 = 11,50 €/m^3

The assessment of the value of timber stock is based on the future harvesting volumes, which take into account the steady and eternal forest use. The forecasted average cash flows of forest management are discounted to present value. The fair value of timber stock is found as the difference between the forecasted annual forest management revenues (MR) and forest management costs (MC), divided by the difference between the discount rate (I) and the inflation rate (P).

The formula for calculating the balance sheet value (BSVF) of the state forest is:

$$\mathrm{BSVF} = \frac{\mathrm{MR} - \mathrm{MC}}{\mathrm{I} - \mathrm{P}}$$

As in the previous alternative, the long-term annual harvesting volume of wood is assumed to be 10.2 million m^3 of timber per year.

The discount rate (I) as of 31.12.2019 was 4.85%, the rate of return on equity calculated for SFMC by the State Property Department of the Ministry of Finance. In 2019, the inflation rate (P) in the forestry sector was 1.0%[20] . The inflation rate takes into account the ten-year average inflation rate forecast in the forestry sector.

$\mathrm{BVSF} = \frac{11{,}5*10200000}{0{,}0485-0{,}01}$ =3.048 billion euros

In the first column of the Table 20. A2 (b) Timber on wooded land, in million euros, alternative 2. Net present value of expected future net income Reference year = 2019), the value of timber as of 31.12.2018 is presented. In 2018, the discount rate (I) was 5.86% and the inflation rate (P) in the forestry sector was 2.23%.

The values of the timber flows of the reference year are calculated by multiplying the volume of the physical flow by the net income per one m^3.

To calculate the balance sheet value of biological assets, SFMC data on timber sales revenue and costs of forest management are used. This data are available in annual report for the year 2019[21]. The estimated average forest management income per 1 m^3 of timber for the next 10 years was 54.30 euros, the estimated average cost of forest management per 1 m^3 of timber 42.80 euros. The expected net management income of one m^3 of wood is 11.50 euros.

Values of the biological current and fixed assets (Table 15) in state forest (SFMC) and private forest fluctuate quite a lot. Following table provides an overview. However, lot of small forest owners do not report the value of the biological assets.

Table 15. Values of the biological current and fixed assets, million euro

	Biological current assets in state forest, SFMC*	Biological fixed assets in state forest, SFMC*	Biological current assets of forestry enterprises, excluding SFMC**	Biological fixed assets of forestry enterprises, excluding SFMC**
2017	41	3 200	60	478
2018	49	1 100	70	464
2019	24	640	89	1 015
2020	30	750	65	696
2021	39	910	70	903
2022	59	210	60	478

*- State Forest Management Centre, annual reports 2017-2022

[20] Riigimetsa Majandamise Keskus. 2020. Majandusaasta aruanne 2019
[21] Riigimetsa Majandamise Keskus. 2020. Majandusaasta aruanne 2019

**- Statistics Estonia, financial indicators of the forest sector (EM009: Enterprises' assets, liabilities and equity by economic activity and number of persons employed)

Alternative method 3: The value of timber on wooded land calculated with stumpage prices

The volume of timber stock and timber flows calculated using stumpage prices are presented in Table 16. A2 (b) Timber on wooded land, in million euros, alternative 3. Stumpage, Reference year = 2019*. The values of the timber assets and flows presented in table A2a were multiplied by the average stumpage price calculated for 2019.

*Table 16. A2 (b) Alternative 3. Timber on wooded land, in million euros, Stumpage prices, Reference year = 2019**

Code	Description	Opening stocks (December 2018)	Net increment	Removals *3	Irretrievable losses	Revaluation (+/-)	Statistical reclassification (+/-)	Balancing item (+/-) *2	Closing stocks (December 2019)
1	Forest	11542.80	319.80	304.72	32.88	-308.35	-158.51	-72.38	10985.77
1.1	Forest available for wood supply	11542.80	319.80	304.72	32.88	-308.35	-158.51	-72.38	10985.77
1.2	Forest not available for wood supply	0.00	0.00	0	n/a	n/a	0.00	n/a	0.00
2	Other wooded land	38.04	n/a	n/a	n/a	-1.06	n/a	0.00	40.87
2.1	Of which available for wood supply	33.53	n/a	n/a	n/a	n/a	4.29	0.00	37.82
3	Other land with tree cover available for wood supply *	n/a	n/a	20.70	n/a	n/a	n/a	n/a	n/a

**Average stumpage price in 2018 = 26,58 €/m3

Comparison of the results of timber asset valuation

Two of the timber valuation alternatives presented in this annex (alternative 1 and alternative 2) are quite similar in nature: in both cases the net present value of forecasted future cash flows is calculated. In the first alternative the average stumpage price of timber and the forecasted annual felling volumes are used. In the second case the net income per one cubic meter of timber was used. The net income was obtained when forest management costs were subtracted from the timber management income.

In the first alternative, the 3% interest rate which is pretty common in forestry related economic calculations was used for discounting. In the second alternative, the rate of return on equity calculated for SFMC by the State Property Department and the inflation rate were used. Results for the value of the timber stock differ almost threefold: in the first case, the value of the closing stock of the forest used for wood supply was 8795.80 million euros, while in the second case it was 3046.75 million euros. The difference is caused mainly by the difference between stumpage price and net income per one m^3 of timber.

The present value of the future net income could be the preferred option for estimating the value of the timber stock, because in this case, in addition to the expected wood related income, the actual management costs are also taken into account. Management costs can vary significantly between ownership groups. Therefore, the costs incurred by different forest owners must be specified in the further evaluation.

In addition to the difference in price and net income, the result is to a smaller extent influenced by the interest rate used to calculate the present value.

The value of the timber stock calculated by the average stumpage price is significantly higher than the values obtained by the first two methods. Multiplying the stock volume by the stumpage price gives an overestimated result. Main reason for overestimations are due to the non-availability of wood for harvesting and removal currently even theoretically. In addition, there are many young trees in the forests that cannot be cut yet and thus have no market value at the moment.

Consistency with National Accounts

Comparison of the A tables B subtables timber flow and stocks variables was done to respective categories in National Account. In National Account the monetary value of the net increment of the timber stock is calculated per calendar year by subtracting deadwood from gross increment and removals from net increment. Physical values are multiplied with stumpage prices considering wood species and assortments. NFI data on increment and removals by different assortments and wood species are used as well. In the 2019 NA calculation, the increase of the monetary value of the growth was 15.06 million euros. In the EFA tables, it is 15.08 million euros when using methodology of net present value of future revenues and 6.7 million euros with the methodology of the net present value of future net income. Forest growth value calculated in NA can be calculated subtracting removals from net increment in EFA table A.2b. Since both the national accounts and the first alternative of current work on table A2b use the average stumpage price, the results are also very similar as expected. Since the net income from forest management used in the second method is 2.25 times less than the stumpage price, the difference between net growth and removal is also 2.25 times smaller.

Comparison of the EFA results with Ecosystem Accounts on the bases of timber provision service and asset valuation

Currently Estonian ecosystem accounts have accounted for the supply of the timber as ecosystem service which is not dependent on forest type (available/not available for wood supply, timber from other wooded land). Linking of the forest accounts and ecosystem accounts on the level of the wood provision ecosystem service is still in progress in ecosystem accounting guidelines documents and also in current EFA guidelines. In addition, the monetary valuation principles for the wood provision ecosystem service have not been agreed upon yet and only physical flows are accounted in the scope of the timber provision in the proposal for the amendment of regulation at current stage.

Alternative approach 2 for timber valuation follows SEEA-2012 section 5.378: Resource rent on timber resources can be derived as the gross operating surplus from the harvest of timber resources less the value of the user costs of produced assets used in the harvesting process.

In the development of ecosystem accounts in Estonia[22] both the service value and the value of standing timber (stock) was estimated. First dead wood was subtracted from gross increment. The value of the total net growth was obtained by multiplying the various net increments by their stumpage prices and summing up across all the tree species. This approach for stock valuation is close to the stock valuation of the first alternative but has a slightly different value due to inclusion of the deadwood.

When compiling monetary table Table A2b, the revaluation is applied, which is in accordance with SEEA CF 2012[23] clause 5.374: “most of the changes in the stock relate directly to changes recorded in the physical asset account; but there are also entries relating to the revaluation of timber resources, which are recorded when the prices for timber change during an accounting period.” Timber prices in 2018 and 2019 were remarkably different which led to the need for revaluation.

SEEA-2012 states that not all timber resources are available for harvest because of forest legislation and/or for environmental and economic reasons. It is recommended that the volume of timber resources that cannot be harvested would be separately identified and not form a part of the overall calculations of the value of timber resources. Following the aforementioned principle, FNAWS stock value is estimated as 0 in our analysis.

[22] Statistics Estonia. 2021. Methodological report. Development of the ecosystem accounts.189p
[23] United Nations et al. 2014. System of Environmental Economic Accounting 2012— Central Framework

ANNEX 5. Table B 1 Economic aggregates of the forestry and logging industry (excluding other industries)

Forestry account includes also economic aggregates of forestry and logging industry (NACE A.02) including output of various products and services the industry offers. In this paper the output of wood in the rough was included to show another opportunity to analyze market-based value of wood. Whole table B1 of forestry account is seen in *Table 17* and the values included in this paper are marked with yellow.

Table 17. Table B1 Economic aggregates of the forestry and logging industry, 2019

Code	Description	Million NAC
1	Total output (at basic prices) [P.1]	955.9
1.0	Of which output for own final use [P.12]	9.4
1.1	Goods characteristic of the forestry and logging activity	706.8
1.1.1	Trees, tree plants and forest tree seeds	17.4
1.1.1.1	Live forest tree plants (02.10.11) and tree seeds (02.10.12)	2.3
1.1.1.2	Forest trees (02.10.30) *1	15.1
1.1.2	Wood in the rough (02.20.1)	685.8
1.1.2.1	Logs *2	651.6
1.1.2.2	Fuel wood (02.20.14 and 02.20.15)	34.2
1.1.4	Non-wood products (02.30) *3	3.6
1.2	Services characteristic of the forestry and logging activity *4	131.2
1.3	Other products from connected secondary activities in the local KAU *5	117.9
1.4	Other products (*)	
2	Total intermediate consumption [P.2]	642.7
2.1	Goods input	264.3
2.1.1	Trees, tree plants and forest tree seeds *6	205.5
2.1.2	Energy, lubricants *7	43.4
2.1.3	Fertilisers and soil improvers	15.4
2.1.4	Plant protection products and pesticides *8	
2.2	Services input	139.5
2.2.1	Services characteristic of the forestry and logging activity *4	121.1
2.2.2	Regular maintenance and repair of equipment *9	3.2
2.2.3	Maintenance of buildings (*)	27.1
2.2.4	Financial services (FISIM) [P.119]	-11,8
2.3	Other goods and services used as inputs (*)	238.9
3	Gross value added (at basic prices) [B.1g]	313.2
3.1	Consumption of fixed capital [P.51c]	49.3
3.2	Net value added (at basic prices) [B.1n]	264.0
3.2.1	Other taxes on production [D.29]	7.8
3.2.2	Other subsidies on production [D.39]	-3.8
4	Factor income	252.4
4.1	Compensation of employees [D.1]	126.6
5	Net operating surplus [B.2n] and Mixed income [B.3n]	125.8
5.1	Net property income [D.4] *10	-6.6
5.2	Net entrepreneurial income [B.4n]	119.3

6	**Gross fixed capital formation (excluding deductible VAT) [P.51g]**	**96.0**
Code	Buildings, structures and land improvements	32.0
6.2	Machinery and equipment	60.5
6.3	Plant resources yielding repeat products	0.1
6.4	Other GFCF(*)	3.0
7	**Net fixed capital formation (excluding deductible VAT) [P.51n]**	**46.7**
8	**Changes in inventories [P.52]**	**6.2**
8.1	Work-in-progress on cultivated biological assets [AN.1221]*11	15.1
8.2	Other changes in inventories (*)	-8.8
9	**Capital transfers (net) [D.9]**	11.3
10	**Total labour input** [L] **(in 1000 harmonized AWU) *12**	**6.2**
	Total labour input in 1000 national AWU	6.2
	Number of working hours per year in national AWU	1 800.0