Statistics Estonia

Grant Agreement 881542— 2019-EE-ECOSYSTEMS

Methodological report

Development of the ecosystem accounts

Kaia Oras (Statistics Estonia)
Argo Ronk (Statistics Estonia)
Kätlin Aun (Statistics Estonia)
Grete Luukas (Statistics Estonia)
Üllas Ehrlich (Tallinn Technical University)
Aija Kosk (Tallinn Technical University)
Veiko Adermann (Statistics Estonia)
Egert Indres (Statististics Estonia)

30.06.2021

Thanks

Mr Sjoerd Schenau (*Statistics Netherlands*), Mr Patrick Bogaart (*Statistics Netherlands)*, Madli Linder *(Estonian Environment Agency, ELME Project)*, Merit Otsus (*Ministry of Environment of Estonia*), Aveliina Helm *(University of Tartu),* Ain Kull (*University of Tartu*), Liina Remm (*University of Tartu*), Tambet Kikas (*Agricultural Research Centre*)

Contents

1 Overview of the work done and the introduction to the structure of the report

Current methodological report outlines the work carried out for developing ecosystem accounts in Statistics Estonia in 2020 and in the first half of 2021. Current work was built on obtained experiences of the experimental work carried out in Estonia in 2019 and work done elsewhere as well as methodological guidance provided by UN SEEA E(E)A[1]. Methodological development was assisted by the experts of Statistics Netherlands.

Statistics Estonia:

- worked on classification of ecosystems and development of national ecosystem classification, cross walk between IUCN GET and Estonian ecosystem types, improvement of the extent account and its compilation for the second year.
- focused on the aspect of user relevance of ecosystem accounts by performing discussions with stakeholders and other users, carrying out methodological seminars and writing analytical overviews, doing presentations and developing on-line user interface.
- developed further the monetary valuation of ecosystem services by employing the best and latest knowledge, valued a range of services and compiled ecosystems services supply and use tables.

As 2020 and 2021 were the years of the revision of System of Environmental-Economic Accounting–Experimental Ecosystem Accounting (UN SEEA EA), Statistics Estonia contributed to the revision in relevant areas of ecosystem accounts as was also proposed in grant application. Statistics Estonia has contributed to the revision of UN SEEA EA mainly by:

- testing various methods for monetary valuation of services,
- testing IUCN typology crosswalk,
- trying to develop urban ecosystem thematic account, including trying to define urban area.

Contribution was mainly done by commenting the draft chapters of the UN SEEA EA, presenting the work and viewpoints on UN Expert Forums on Ecosystem Accounting and in bilateral methodological discussions with the experts when revising UN SEEA EA and developing methodologies for ecosystem accounting.

1.1 Carried out work and links to the work done in Statistics Estonia before

Work carried out and described in current methodological report was a further development and the widening of the scope of the work started under the Eurostat grant in 2019 on ecosystem accounting

[1] - System of Environmental-Economic Accounting 2012–Experimental Ecosystem Accounting and Technical Recommendations in support of the System of Environmental-Economic Accounting 2012–Experimental Ecosystem Accounting

"Land account and valuation of grassland ecosystems services" (Grant Agreement 831254)[2]. The methods for the valuation of the services tested in earlier work were developed further and ecosystem services provided by other ecosystems were added to the scope as well, the closing stock of the ecosystem extent account was developed in addition to the existing opening stock.

Ecosystem services account was widened to other ecosystems, compared to the work done in year 2018 where only grasslands were considered. In addition to four ecosystems (forest, grassland, wetland, agricultural ecosystems), urban area was explored as well - an attempt to build a separate thematic satellite account was tested and classification issues of the urban ecosystem types were explored and analysed.

The developed technical solution for compiling ecosystem extent was tested for the compilation of the data for the year 2019 and was improved. In the previous grant only the opening stock of the extent account for year 2018 was produced. By analysing opening and closing extent, the changes in the extent of ecosystem types were detected and analysed. In order to update the ecosystem extent account in the future, the detailed technical work protocol was created. The ecosystems were classified by ecosystem types and owners for the year 2019 and also based on methodology developed last year.

Several methods for monetary valuation of the grassland ecosystem services in Estonia have been tested. Services evaluated in previous grant for grasslands was evaluated for the rest of the ecosystem types (forest, wetlands, agricultural and urban ecosystems) where possible using the same or new monetary valuation methods. Regarding the deliverables, the ecosystem services supply and use table (table 5.1. of the Technical Recommendation[3]), maps and a user interface were compiled.

1.2 New achievements and new areas of ecosystem accounts comprised

The further developed ecosystem services account and the updated ecosystem extent account were the core of the project. First time the supply of ecosystem services covering all terrestrial ecosystem types was done for a range of ecosystem services.

Testing of the classification of ecosystems according to IUCN classification and the application of the valuation concepts of the ecosystem assets were undertaken as new topics.

Urban thematic account was completely new methodological work carried out during this grant when at first the concept for urban area was developed and after that one of the frameworks proposed in UN SEEA EA was applied for the compilation of the urban ecosystem services supply table.

Methods for the evaluation of the services were tested further. In addition to exchange based values the feasibility of the contingent valuation method for the valuing of several ecosystem services was explored and exchange values and welfare values were compared and analysed.

---

[2] "Land account and valuation of grassland ecosystems services" (Grant Agreement 831254). https://www.stat.ee/sites/default/files/2021-06/Methodological%20report_831254_2018_EE_ECOSYSTEMS_revised_version_31_03.pdf

[3] UN (2017) SEEA Experimental Ecosystem Accounting: Technical Recommendations Consultation Draft. New York, USA. https://seea.un.org/sites/seea.un.org/files/technical_recommendations_in_support_of_the_seea_eea_final_white_cover.pdf

An attention was paid on user relevance of the accounts. Interviews were conducted with future users regarding the results and in order to capture their specific needs (Ministry of the Environment, Environmental Board, Ministry of Rural Affairs, Ministry of Finances, etc.) and to select the ecosystem services for monetary valuation. The discussions with experts and stakeholders gave an important input for the the selection of relevant ecosystem services for monetary valuation. The focus was set in a most practical way. Regarding the valuation of ecosystem services and compilation of ecosystem services account, expert consultations, seminars and meetings involving interested parties including experts and Estonian MAES (Mapping and Assessment of Ecosystem Services) team were held as well in order to determine which ecosystem services across the ecosystems are feasible to be evaluated in monetary terms in Estonia. Simultaneously and in the following stages of the project, experts involved in monetary valuations of various ecosystem services from universities but also from one of the more advanced statistical office in the field (Statistics Netherlands) were consulted regarding the development of methodology.

The discussions on the treatment of the results of alternative valuation approaches of ecosystem services is ongoing. Statistics Estonia has used several Market Price and Revealed Preferences methods but also employed alternative methods (Stated Preferences) for the valuation of ecosystem services. The total annual value obtained by Market Price or Revealed Preferences methods and CVM gave the results on different scales. The reasons why the values measured by the Market Price were much higher than by CVM were analysed and discussed.

Compiled accounts were made available (produced and published) and were analysed with the main users, - among others Ministry of Environment and Ministry of Finance. Making the accounts available for the general public would serve also as a tool for getting possible feedback also in future. Results of the work have been presented on several fora (see chapter 12 on communication).

Dedicated section for ecosystem accounting was developed in Statistics Estonia web site thematic area Environment - Biodiversity protection and land use: https://www.stat.ee/en/find-statistics/statistics-theme/environment/biodiversity-protection-and-land-use. Extent account and supply and use table data were made available also in statistical database. In addition both ecosystem extent account and ecosystem services were visualized using ArcGIS Online, where users have a possibility to interactively analyse the compiled accounts on spatial scale. For example to choose the municipality and investigate the provisioning of the ecosystem services in this area or to choose the ecosystem type and follow the distribution and subtypes of this ecosystem type on a maps and the diagrams etc. Next phase of the work would be the testing of the relevance and most important features of the user interface.

The interactive dashboard in ArcGIS Online on Estonian ecosystem accounts is available here: https://experience.arcgis.com/experience/6f4d584477e8427bbb0597b03319f9ea/. It is the first prototype and still under development. As the interface is aimed mainly for experts from national audience, the user language is Estonian.

1.3 Workflows of the project and milestones

Main work flows were:

- Development of ecosystem classification and testing the feasibility of IUCN cross walk - chapters 2 and 3;

- Improvement of the methodology of compiling extent account and compilation of the data for second year - chapter 4;
- Ecosystem services selection, definitions, interviews and seminars in the first phase of the project - chapter 5;
- Researching and carrying out the monetary valuation of ecosystem services by using the best methodology - chapters 6 and 7;
- Compilation of the ecosystems services supply and use tables, analyses from the perspective of the supply of services by ecosystem types - chapter 8;
- Analyses of the treatment of valuation results - chapter 9;
- Spatial allocation of the results of the valuation of ecosystem services - descriptions are under each sub-chapter of chapter 7
- Compilation of the urban thematic account - chapter 10;
- Compilation of asset account - chapter 11,
- Visualisation and communication of the results - chapter 12;
- Analysis of the applicability and use of the provided accounts - chapter 13.

Report outlines each of the workflows in detail in separate chapters as indicated above

Co-operation with the Estonian Environment Agency and partners (Tartu University and University of Life Sciences) who are responsible for nationwide assessment and mapping of ecosystem services [4] was carried out throughout the project and is described under the chapters where the input is relevant. The deliverables from the work by ELME project were of importance and the current project made an attempt to make the best use of the generated data and delivered results (potential supply of the ecosystem services). The deliverables from ELME project in spatial dimensions and in physical units were used as inputs for certain services valuation.

The national methods and data sources for valuation of ecosystem services were determined first hand. During the project we carried out analyses and made use of available experiences of established similar accounts (methods and other related information) and if feasible we applied best methodological approaches.

Four major seminars with users where carried out. These were also main milestones of the project:

1. Kick off meeting with main stakeholders 21.02.2020 (see ANNEX 1 for summary)
2. Methodological seminar and the selection of the services and valuation methods, May 25th 2020
3. Methodological seminars on the criteria for the determining of the of urban area, selection of the services and valuation methods for urban ecosystem services April 19, 2020 and May 7, 2020
4. Methodological seminar of the valuation methods, where compiled accounts were analysed with the main users like Ministry of Environment and Ministry of Finance, November 27, 2020 (see ANNEX 2 for summary)
5. Seminar on the results of ecosystem accounting in Estonia, June 11, 2021. (see ANNEX 6 for summary and recording)

[4] "Establishment of tools for integrating socioeconomic and climate change data into assessing and forecasting biodiversity status, and ensuring data availability" (Estonian acronym – ELME) funded by the European Union Cohesion Fund started in 2019 in Estonia and came to an end in 2020.

1.4 Co-operation with other NSI-s and relevant institutions

2020 and 2021 were extraordinary years in the development of ecosystem accounts due to the massive revision of SEEA EA with which a lot of methodological work and international co-operation activities were carried out.

On the other hand, 2020 and 2021 were extraordinary in the sense of different organizing of the co-operation as due to the COVID 19 pandemic, international travel did not take place. Study visit to the more experienced NSI, which was initially planned with the purpose of discussing methodological issues and sharing of the experiences, did not take place as a physical meeting due to the pandemic. Attending one of the MAIA/KIP INCA workshops with the purpose of gaining the knowledge and co-ordination of the activities was foreseen. The participation in the UN SEEA revision related meeting was foreseen if relevant and feasible as planned work was related to the revision process of the UN SEEA EEA guidelines and several topics would be tested in the proposed grant. All these meetings took place virtually as a series of events. However, organizing the work virtually allowed more meetings to be held and wider participation of our experts on the virtual methodological forums.

Statistics Estonia participated on The Virtual Expert Forum on SEEA Experimental Ecosystem Accounting (SEEA EEA) 2020 which was held online in several sessions between June and September 2020 as follows: Session 1: Ecosystem extent and condition – 23-24 June, session 2: Valuation and accounting treatments – 14-15 July, session 3: Ecosystem services – 24-25 August, session 4: Thematic accounts and indicators - 9-10 November. Proposals regarding methodological aspects were presented via global consultations and discussed in the meetings.

In addition Statistics Estonia contributed the revision of SEEA Experimental Ecosystem Accounting (SEEA EEA) via regular and irregular meetings of London group of environmental accounting in 2020 as the topics which were crosscutting through most of the areas of ecosystem accounts were explored by London Group as well.

The MAIA process was followed and the rich information in MAIA portal was analysed. Statistics Estonia consulted with MAIA partners on the methodological approaches taken in current project and participated in the following MAIA project meetings: Advancing Ecosystem Accounting in Europe (20 April 2021), MAIA Webinar VII: Urban Ecosystem Accounting in the SEEA (13 April 2021), VI: Accounting for Biodiversity in the SEEA (9 March 2021), V: Monetary Accounts in the SEEA (18 February 2021), Ecosystem Extent Accounting (14 January 2021) and Spatial modelling for compiling Ecosystem Services biophysical accounts (10 December 2020).

Co-operation with Estonian scientists was carried out via subcontracting of the respective knowledge in the area of IUCN crosswalks and also on the methods of valuation of specific services, defining of the structure and method of urban thematic accounts, treatment of the valuation results.

Co-operation with Statistics Netherlands experts was carried out in all development areas of ecosystem accounts and was covered by contract. During the grant project period a total of 15 seminars/ discussion meeting were carried out.

Cooperation with local/national stakeholders is also crucial as described above and is ongoing. As the first round of full ecosystem extent and ecosystem services account for one year has now been produced, the more thorough analyses and the specification of the users' needs both internationally and nationally could the done. More precisely, the analysis of the possible outputs of ecosystem accounting in connection with international reporting such as CBD and IPBES could be considered.

Also the co-operation in order to identify most efficient way of producing accounts and publication and communication of the national results has started and will continue in the next phase of the work.

1.5 Further research needs and conclusions

Issues related to the compilation of ecosystem accounts were analysed and will be investigated further. The project results contributed to UN SEEA EEA revision regarding the technical aspects and proposed changes. The revealed strengths and weaknesses of these kind of accounts were discussed UN SEEA EA revision forums. There is still quite a way to go in order to harmonize and improve valuation methods, develop relevant semantics and set the valued figures in a wider context of the policy debate on conservation and maintenance of ecosystem assets and services.

All three areas where Statistics Estonia contributed to the UN SEEA EA revision: testing of the IUCN typology (see chapter 3), urban area and development of the urban ecosystem thematic account(see chapter 9), methods of ecosystem services valuation(see chapter 3) need further effort both on national and international fora.

Methodological questions on the treatment of ecosystems services values and valuation methods was presented to the London Group on Environmental Accounting for discussion. The discussion was followed by more in-depth discussions with the revisers of the UN SEEA EA as several of the issues which we tackled are important from the revision process as well. This work will be developed further.

Final results of the current project will feed as input to the future work in this area. Widening the scope to the ecosystem condition accounts has been suggested by project experts. The continuing of the started work in Statistics Estonia on valuation of services was suggested also by consultants. It has been considered a challenging area and Statistics Estonia's efforts to work through the issues that have been considered important for increasing the understanding from a statistical and accounting perspective.

The definition and framing, development of the methodologies for measurement, having a consistent approach across services would be valuable. Thus it was suggested by the project experts to present to the London Group on environmental accounting (1) how the aggregating of different components of expenditure components of nature education ecosystem service can be performed and (2) how the gross ecosystem product could be compiled to be discussed in autumn 2021.

Final report with the description of activities and methodologies was compiled and reviewed by the project team and will comprise the overview of the methods and main results but also research needs in almost all of the chapters.

Next grant (starting in July 2021) will widen the scope to meet the criteria of upcoming/expected amendment of EU regulation. It would contribute further to the work of developing ecosystem accounts in UN SEEA EA. Condition account is planned to develop as a necessary and integral part of ecosystem accounts. Final results of this work will feed as input to the future planning of this work.

Some of the issues are outlined below:

1. The contribution of ecosystem to services provision. It is not yet agreed how to find the share of the contribution of ecosystem from the total service value. In order to maintain certain coherence among the calculated services in the developed supply and use table and

summary tables of the services, we did not include the calculation results referring to the narrow concept of ecosystem contribution.

2. The issues related to the treatment of valuation results regarding non market services (see chapter 9). The analysis of the contingent valuation study results for the valuing of several ecosystem services provided a new insight and additional source of information on the applicability of the methods as regards to the ecosystem services valuation and ecosystem services accounts from the viewpoint also accounting. Application of CVM methods for valuation of non market services seems currently most relevant in urban areas where demand for several cultural ecosystem services is higher.
3. The issues related to the treatment of intermediate service. Apparently, when evaluating the pollination service with Market Price method, a situation has arisen in which the value of other ecosystem regulatory services was also attributed (either in part or in full) to the only intermediate service valued (for example pollination service. But there are other intermediate services as well and sum of the services should not exceed the services output
4. Principles for the spatial distribution of monetary values of ecosystem services need further efforts.
5. As accounts are now produced and provide rich data, the analysis and further specification of users' needs would be needed. More specifically the analysis of the possible outputs of ecosystem accounting and also in connection with international reporting such as CBD and IPBES reporting need to be done in future
6. Development of an efficient way of producing accounts and publication and communication of the national results
7. Analysing and possibly developing ecosystem condition account
8. Current standards for accounting and statistics should be enhanced to take more adequately into account of the financial equivalents of ecosystem services
9. Crosswalking from IUCN testing results to compiling ecosystem extent still needs to be done in future (grouping of Estonian forest, drained peatlands and seminatural grasslands according to the EFG description is not entirely correct yet).
10. Making ArcGIS map application public enables to get user feedback and continue with additional developments of the dashboard/application – decide what to add, change or delete. In addition to user feedback, other capabilities could potentially be added to the application, such as smaller grids (250x250m for example), 3rd level ecosystem types and its analytics, additional aggregated statistics or improved comparison between counties and municipalities, adding English language, additional services.
11. It should be discussed whether raster or vector maps should be used for extent account and service valuation and what would be the relevant spatial resolution of the maps.

1.6 Conclusions

The tasks taken by Statistics Estonia with the grant application and outlined in grant agreement are fulfilled.

Current project was in line with the general objective of environmental economic accounts to build the bridge between the information about ecosystems and the services they provide with the information already available in national accounts. An attempt to organize the information about ecosystem services in the way information is organized in national accounts and contributed to the integration of economic and environmental information has been done.

Project methodological report is made available on a website in digital format as well. In addition also the recording of the methodological seminar where methodologies and main results were discussed, was made available.

The tested and described methodology could be of the value for other Statistical Institutes, who can build their work on our experiences and applied methods regarding urban thematic accounts or tested IUCN cross walk. Accounts provide an insight to the users on the possible value of the produced ecosystem accounts.

Results were published on statistics Estonia web site in order to be used by those who develop the area further.

1.7 Annexes and deliverables

Current methodological report is one deliverable of the work done (Deliverable D1.1).

The report is supplemented by a set of tables in MS Excel format "Data sets on the main results" which is delivered separately and it contains:

1. Supply and use of ecosystem services (market price and revealed preferences based methods), 2019, €. (Deliverable D1.2).

2. Supply and use of ecosystem services (stated preferences based methods), 2019, €. (Deliverable D1.2).

3. Extent account by ecosystem type and land owners institutional sector and economic activity, 2019, ha. (Deliverable D1.3).

4. Ecosystem extent account (km^2), opening extent for year 2019 and closing extent for year 2020 includes 2 tables: 1 for Estonia (whole EEA) and1 for Pärnu county. (Deliverable D1.3).

5. Deliverable "Visualized output of ecosystem extent account" is accessible on statistics Estonia web page and is described in chapter 12. (Deliverable D1.4).

6. Urban ecosystem services supply table, 2019, thousand € includes 3 tables "Results from exchange value based valuation methods in urban areas, 2019, thousand €", "Results from urban CVM including urban green spaces and forests in urban areas, 2019, thousand €", "Results from CVM results of forest, wetland, grassland in urban areas, 2019, thousand €".

Deliverables D1.2 (Supply and use tables of ecosystem services), D1.3 (Ecosystem extent account) and D1.4 (Visualisation of the results of ecosystem accounts) are also uploaded to the portal as separate Word documents as indicated in grant agreement.

2 Developing national typology for ecosystem classification- Ecosystem Classification for ecosystem accounting in Estonia

The extent map of Estonian ecosystems was compiled using information from different sources, such as information on habitat types (Natura, forest site types), land use and land cover, topographic information etc. We name this data as map units. Crosswalking the map units of the extent map of Estonian ecosystems to UNFCCC/IPCC land use classes (LULUCF) and EUNIS habitat classification were done and extent account was compiled in both LULUCF and EUNIS classifications in previous grant project on the development of the land account and valuation of ecosystem services regarding grassland ecosystem services the development (2020)[5]. However because the map units were different by characteristics, these were difficult to define and classify according to LULUCF and EUNIS frameworks. Also, detail we considered important was lost during the classification. Therefore a more systematic approach for ecosystem classification was needed with the purposes that the classification should not lose its detail on the lowest level and that it should offer a good layout for reporting the results of ecosystem accounting (ecosystem extent and values of ecosystem services).

The creation of a uniform classification of Ecosystem Classification for ecosystem accounting in Estonia began simultaneously with the testing of IUCN Global Ecosystem Typology (GET) which offers a framework for multi-level classification of ecosystem types and combining local ecosystems with the global classification (for more details see chapter0). The work done with identifying ecosystem types from the extent map with the help of experts in the corresponding fields and work undertaken in ELME project[6] to create a crosswalk with IUCN GET was the first input in creating Ecosystem Classification for ecosystem accounting in Estonia and the new classification was built around that.

Based on existing hierarchical habitat classifications and expert opinions, it was decided that a multi-level classification would be the best option to fill the purposes of the new classification. The classification consists of three levels and the overview of the structure of ecosystem types of Ecosystem Classification for ecosystem accounting in Estonia can be seen in Table 1.

As the development of the ecosystem accounts is still ongoing, so is the compiled Ecosystem Classification for ecosystem accounting in Estonia and it can be subject to changes in the future.

The first level represents main ecosystem classes and coincides with IUCN level 2. Based on the classification decisions it should not be compared with main ecosystem classes of other ecosystem/habitat/land use typologies without first analysing whether and how the criteria for classification sub units (ecosystem or habitat types, land use classes, topographic information) differ.

The second level represents a sub-aggregate class of ecosystem types that bridge map units with ecosystem classes. It was chosen as the frame to report results in. It includes 30 different ecosystem types with varying number of types in each ecosystem class depending on the already existing classifications or considering the need for detail when reporting results. E.g in case of forests there exists a three level typology which was incorporated into our classification. The same applies to wetlands and to semi-natural grasslands. In case of ecosystem types belonging under ecosystem

---

[5] Statistics Estonia, 2020. Development of the land account and valuation of ecosystem services regarding grassland ecosystem services (Eurostat Grant Agreement no NUMBER — 831254 — 2018-EE-ECOSYSTEMS) https://www.stat.ee/sites/default/files/2021-06/Methodological%20report_831254_2018_EE_ECOSYSTEMS_revised_version_31_03.pdf

[6] „The nation wide assessment and mapping of ecosystem services“. Project “Establishment of tools for integrating socioeconomic and climate change data into assessing and forecasting biodiversity status, and ensuring data availability” (ELME) http://www.keskkonnaagentuur.ee/elme

classes of coast (1 general type on 2nd level), inland waterbodies (2 general types on 2nd level) and other (1 general type on 2nd level), the generalisation of map units into low number of classes was based on the best fit for reporting ecosystem accounting results, mainly because many of the map units belonging to these types do not supply ecosystem services or the supply is marginal. The group 'Other' includes map unit 'Other' where no ecosystem type or land use class could be identified and also map units from topographic map which could be considered natural ecosystem but were represented with low areas and were difficult to classify. In case of artificial area, the division of level 2 types was mainly done based on the artificiality (green space vs buildings vs mixed areas) and the ability of the map units to supply ecosystem services.

The lowest level in the classification is the third level which contains the total of 126 map units that were identified from extent map. The detailed Ecosystem Classification for ecosystem accounting in Estonia can be seen in ANNEX 4.

Table 1. Overview of the structure of ecosystem types of Ecosystem Classification for ecosystem accounting in Estonia.

Ecosystem class (level 1)	**Ecosystem type (level 2)**	**Number of map units (level 3)**
Forest	Drained peatland forests	3
Forest	Mesotrophic boreal forests	2
Forest	Eutrophic alvar forests and shrublands	3
Forest	Oligotrophic boreal heath forests	2
Forest	Oligo-mesotrophic boreal forests	5
Forest	Oligotrophic paludifying forests	2
Forest	Minerotrophic swamp forests	2
Forest	Eutrophic boreo-nemoral forests	2
Forest	Mixotrophic and ombrotrophic bog forests	2
Forest	Eutrophic paludifying forests	4
Forest	Forest on reclaimed pits	5
Grassland	Cultivated grassland	2
Grassland	Heaths	3
Grassland	Semi-natural grasslands	16
Grassland	Shrubbery	1
Cropland	Horticultural land	1
Cropland	Crops	5
Cropland	Permanent crops	1
Wetland	Fens	5
Wetland	Transition mires	2
Wetland	Peat bogs	6
Wetland	Peat extraction sites	1
Wetland	Abandoned peatlands	1
Artificial area	Green space	3
Artificial area	Buildings and other facilities	7
Artificial area	Other artificial areas	7
Coast	Shores	15
Inland waterbodies	Lakes and ponds	9
Inland waterbodies	Rivers and streams	3
Other	Other	6

3 Developing the crosswalk from national to IUCN RLE ecosystem typology and contribution to the UN SEEA EAA revision

In order to reach a good coverage of the ecosystem accounts the classification guidelines suggested in the revision document on the ecosystem types was to be analysed and if feasible, tested. The applicability of both conceptually and spatially exclusive classifications proposed in the UNSD revision documents and guidelines was analysed. The applicability and the practicability of IUCN RLE (International Union for Conservation of Nature Red List Ecosystems) classifications which is the proposed ecosystem classification in SEEA EA on Estonian national level was analysed.

The preliminary testing of crosswalking the Estonian ecosystem types with the IUCN Global Ecosystem typology (V1.01) was carried out in spring 2020 with the help of several external experts in the field with the purpose to contribute to the development of IUCN RLE GET and UN SEEA EEA revision. The results of the testing are presented in ANNEX 5.

In order to create a crosswalk between Estonian ecosystems and IUCN Global Ecosystem Typology, it was first necessary to create a uniform classification of Estonian ecosystems. The extent map of Estonian ecosystems was compiled using information from different sources, such as information on habitat types, land use and management etc. Thereof ecosystem types were identified from the extent map with the help of experts in the corresponding fields and work undertaken in ELME project[7].

By the time of testing the fit of IUCN GET , the list of Estonian ecosystem types included 80 ecosystem types, mainly from terrestrial and freshwater and their transitional realms (forests, grasslands, heaths, outcrops, agricultural land, wetlands, coasts, artificial land and inland waterbodies). Throughout the project, the Ecosystem Classification for ecosystem accounting in Estonia has been refined and by the time of completion of the project work, the multi-level classification had several differences with the one that was used for testing and consisted of 126 map units which form the lowest level, which aggregate to 30 ecosystem types on the 2nd level, which in turn aggregates to the 1st level containing 8 ecosystem classes. Chapter 2 gives an overview of the final ecosystem classification for ecosystem accounting in Estonia. Therefore the testing results are currently not directly applicable but need further work. However the testing results still give a good overview of the overall fit for the IUCN GET for Estonian ecosystems.

The crosswalk between Estonian ecosystems and the IUCN Global Ecosystem Typology (IUCN GET) was done based on experts' opinion regarding the descriptions of Ecosystem Functional Groups (EFG) in The IUCN Global Ecosystem Typology v1.01[8]. Efforts were made to find the best available fit for each ecosystem type within existing ecosystem functional groups. However, in some cases the description of the existing EFG was not befitting even when we followed the general description of the EFG-s and did not consider minor deviations and individual detailed discrepancies with the EFG descriptions as important as to disregard the fit entirely.

Figure 1 summarises the general fit of the Estonian ecosystem types within the IUCN Global Ecosystem Typology. We found that Ecosystem Functional Groups of IUCN GET offers a uniform fit for Estonian ecosystem types for 40% of the cases (32 cases out of 80). When two or more EFG-s were

[7] „The nation wide assessment and mapping of ecosystem services". Project "Establishment of tools for integrating socioeconomic and climate change data into assessing and forecasting biodiversity status, and ensuring data availability" (ELME) http://www.keskkonnaagentuur.ee/elme

[8] Keith D.A, et al (2020) The IUCN Global Ecosystem Typology v1.01: Descriptive profiles for Biomes and Ecosystem Functional Groups, IUCN CEM, February 2020. https://iucnrle.org/static/media/uploads/references/research-development/keith_etal_iucnglobalecosystemtypology_v1.01.pdf

suitable, approximately for 80% (30 cases out of 37) a preference towards one EFG existed (preferred EFG max>=0.6). In total a preferred EFG can be found for 78% of the Estonian ecosystem types.

For 12 cases IUCN GET did not offer means to fully characterize an ecosystem type (grassland types, heathland types, artificial area). There are 5 cases (~6%) where no dominant EFG is identified, e.g. membership value between two or more candidate EFGs is 0.5/0.5. or 0.4/0.4/0.2.

In total 30 different EFG-s were identified in Estonia.

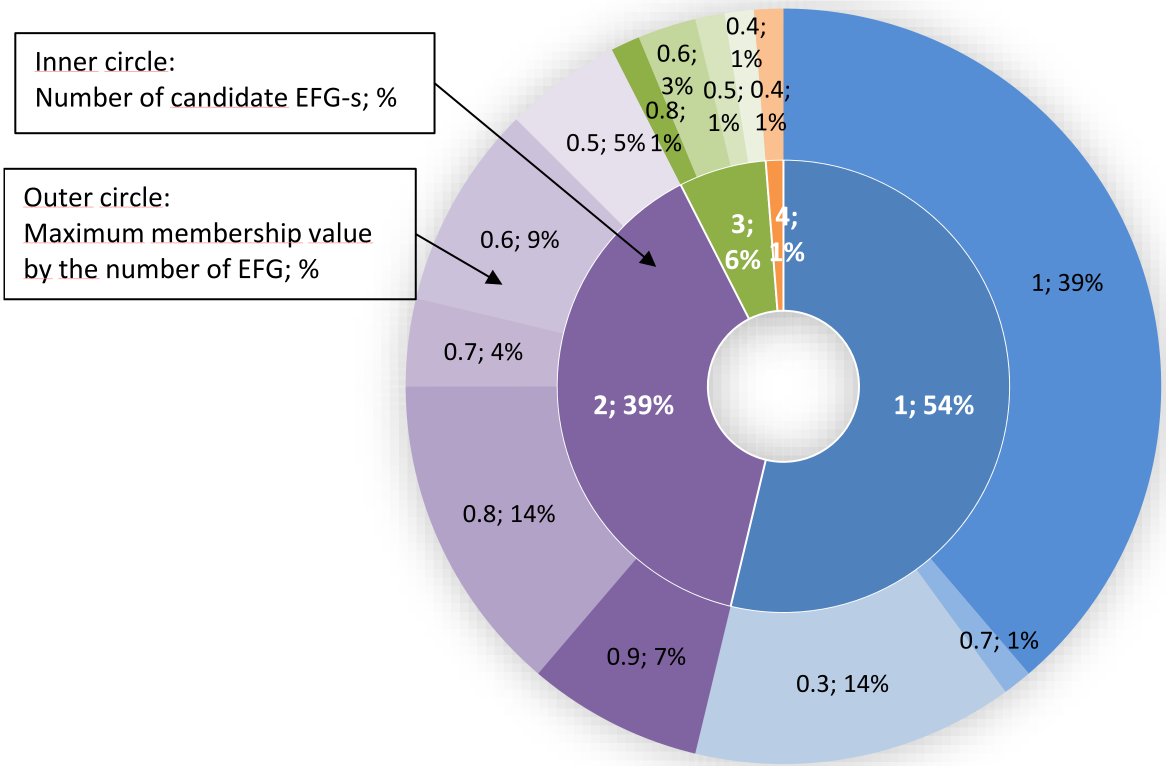

Figure 1. Results from testing the fit of the Ecosystem Functional Groups of IUCN RLE Global Ecosystem Typology with Ecosystem Classification for ecosystem accounting in Estonia. The inner circle shows the number of candidate EFG-s an Estonian ecosystem unit could have and the corresponding percentage. The inner circle is connected with the outer circle in a way that the outer circle shows the distribution of maximum membership values in percentages in accordance to the number of candidate EFG-s in the inner circle.

We brought forward some of the problems while determining the fit and have received good feedback on these. These are as following

- Problem 1: There are difficulties grouping Estonian forest types. The division between boreal and temperate forest types is mainly based on canopy composition in IUCN GET but the classification in Estonian system is based on soil (i.e. site types). It was suggested to maintain classification based on site types for GET level 5-6 classification but to use canopy dominance for GET level (EFG) classification.
- Problem 2: Estonian grasslands are semi-natural. Low-intensity anthropogenic maintenance, such as grazing or mowing is necessary for their existence. Fitting these under EFG T4.5 Temperate grasslands according to the EFG description will not be entirely correct. The

problem coincides with the addition of a new EFG T7.5 Semi-natural pastures and old fields to the typology, under which Estonian semi-natural grasslands and wooded pastures and meadows can be generally well- fitted.

- Problem 3: Many Estonian peatlands have been drained or influenced by draining. These wetlands do not fit the description of TF1.6 Boreal, temperate and montane peat bogs and/or EFG TF1.7 Boreal and temperate fens very well as ecological key drivers have changed because of lowered water table. It was suggested to still fit the drained wetlands under TF1.6 or TF1.7 and describe the influence of drainage with condition.

The IUCN Global Ecosystem Typology is the preferred reference classification for UN System of Environmental-Economic Accounting –Ecosystem Accounting (SEEA EA) for ecosystem accounting and alternative to MAES classification for Module on ecosystem accounts (Regulation (EU) 691/2011) according to discussions by Eurostat. With its standardized, globally consistent, spatially explicit typology and terminology for managing the world’s ecosystems and their services, we consider IUCN GET a good reference classification. Additional strong argument in the favour of the classification is that it foresees structural integration of established national classifications, which would form the lowest level of the hierarchy. However, there is still no clarification how the integration of national classification to the EFG-s will be done based on the testing results. We are especially interested whether one-to-one crosswalk is needed for crosswalking and how to act in these cases when testing results showed no preferred EFG to an ecosystem type.

4 Ecosystem extent account

4.1 Overview of ecosystem extent account compilation

Compilation of ecosystem extent account for year 2020 was based on the experience and knowledge obtained from previous project where land accounts relevant for ecosystem services accounts were developed as fully spatial approach - a GIS based opening extent account for year 2019. Creation of the ecosystem base map is a crucial first step in order to develop ecosystem service accounts as it both gives the opportunity to study ecosystems types' distribution separately as well spatial relationships between ecosystems types. This kind of information is often needed to understand the functioning of the ecosystems and to evaluate certain ecosystem services. Therefore, in the sense of ecosystem services flows it is necessary to ecosystem extent account and hence ecosystem base map to be up to date to reflect latest changes in reality.

Similarly to previous project, the Estonian topographic database served as a basis for the creation ecosystem base map. We updated this basis with additional data layers where more detailed data about ecosystem assets was available. In areas where more detailed information was not available, the Estonian topographic database was only source of information which we could use. Concerning the more detailed data layers, these are both gathered/collected for different purposes and times, which creates inconsistencies in ecosystem boundaries but also making some records outdated. Therefore, it was questionable what the actual state of these older records is. Therefore, similarly in current project we placed a decision tree in order to deal in one hand with data novelty and in other hand with areas where overlaps occurred between two or more detailed data layers.

We preferred and therefore prioritized data layers which were most up to date and likely more precisely mapped (due to local inventories). Different data sources reflect their states based on access date (ANNEX 6). Different detailed data layers were overlaid as follows (starting with highest priority):

1. Agricultural land and semi-natural habitats (support bases)

Data for agricultural land and semi-natural habitats was obtained from Estonian Agricultural Registers and Information Board. As this was generally most up to date dataset we were able to use, this dataset got the highest priority. In this dataset only the lands which are under support bases are actually mapped, therefore it is quite certain that this data is both precisely mapped and to some extent verified. Nevertheless, some overlaps between agricultural land and semi-natural habitats still occurred (as owner of the land can receive support from multiple sources and purposes for the same land), in these cases we treated these overlapped areas as semi-natural habitats in order to avoid double counting.

2. Forest registry of Estonia

This was the largest and most detailed dataset that we were able to use. Data we used is within ten years' time frame. This dataset covers most of the forested areas in Estonia (around 80% are mapped). Nevertheless, there were some overlaps within the dataset which we dealt before merging it to other datasets. In case of overlaps we randomly merged overlapped areas to neighboring polygons within the dataset. For the remaining ca. 20% of forest, based on the soil type, the forest site type was determined or predicted using the national classification (Lõhmus, E. 1984)17. There are over 30 different forest site types and 71 forest soil types according to the national classification. In case when soil type corresponds to more than one forest site type the latter has been predicted based on the probability of its occurrence. This probability has been found by the model (based on the National Forest Inventory, sample size around 23 thousand plots from years 2005 to 2014). Thus, even if the type predicted for a particular area may not be accurate, the result for a larger area (whole country) is correct.

3. Wetlands

Data for wetlands was obtained from Estonian Fund for Nature (ELF). Similarly to forest data, most of the data is within ten years' time frame. This dataset uses Natura 2000 habitat types as classification units and often multiple classes were given for the same area (e.g. transition areas). In order to simplify the original classification, it was therefore decided to use information about the main class/type only. In case of overlaps which were also present, we randomly merged overlapped areas to neighboring polygons within the dataset.

4. Semi-natural habitats

This dataset consist of spatial information about Estonia's semi-natural habitats which are eligible to support and it was obtained from Estonian Environment Agency. Similarly to the last two mentioned datasets, most of the data is within ten years' time frame and uses Natura 2000 habitat types (like wetlands data) as classification units. The reason we decided to use this dataset as a fourth layer was because of, although these are the areas which are designated as eligible to support, these do not actually receive support, meaning these areas are likely not being maintained. It is questionable, what is the actual state of older records. Therefore, we decided that if the area was registered in aforementioned datasets (agricultural land, forest or wetland) then the former information was used. In case of overlaps we randomly merged overlapped areas to neighboring polygons within the dataset.

5. Natura 2000 habitats

This dataset consist spatial information about Natura 2000 habitats in Estonia (around 10% of area is covered by Natura 2000 habitats in Estonia) and it was obtained from Estonian Environment Agency. Unfortunately, most of the data is older than ten years, although this dataset does receive constant updates and corrections. Due to presence of these older records we gave this dataset a lower priority in our decision tree. In case of overlaps we randomly merged overlapped areas to neighboring polygons within the dataset.

6. Meadows

This dataset consist spatial information mainly about Estonia meadows and was obtained from the Estonian Semi-natural Community Conservation Association. This dataset was the oldest we used as all the records are older than ten years. Hence, this dataset consists inaccuracies and is probably outdated. Due to these reasons we gave this dataset the lowest priority in our decision tree. In case of overlaps we randomly merged overlapped areas to neighboring polygons within the dataset.

We did a manual verification on the merged dataset and due to general inaccuracies found in previous project in the spatial data it was decided that some classes: the roads, inland waters, peatlands, quarries, and private yards needed to separately overlay with merged dataset. In case of roads two different types of data was available: 1) polygon type of data (consisting of main roads in Estonia and 2) polyline type of data (consisting of smaller roads and trails). In case of polyline data a 5 meter buffer was created around polylines to convert polyline to polygon type of data to match with other data sources. Additionally, in current project we also delimited more linear features (artificial areas) which we converted to polygons: forest rides (2 meter buffers were created), ditches (average width per width class was used as buffers), power lines (rated power classes were used as buffers) and railroads. Forest rides and powerlines were distinguished only in forests based on the assumption that these areas in forests are treeless hence influencing ecosystem service flows in forest.

Merging different data layers into one layer creates additional relicts due to fact that different ecosystem assets borders do not coincide with each other perfectly. Therefore, similarly to previous project, to simplify the merged dataset, it was first decided to apply "circle method". In other words, if merged dataset polygon was smaller than a circle with radii of 5 meters (area of ~0.008 ha) it was merged to neighboring polygon based on the length of shared border with neighbor polygon. In case, where shared border lengths were equal, we used the area of the neighboring polygons as deciding factor. As the final result was still not satisfactory and had some drawbacks, we also this year dealt ecosystem assets which were relatively "narrow" and at the same time relatively long causing remarkable polygon shape area (analogues to linear features, but with area). Using polygon buffering tool, we decided to test most of the ecosystem assets based on formula: log(asset area+1)+5 as buffer size to capture change in area relative to ecosystem asset original area. If the change was more than 5% of the original ecosystem asset area the buffered boundaries were kept otherwise original boundaries were used. Captured narrow polygons were randomly merged to neighboring polygons within the dataset. For the last step we excluded urban areas as whole (more details in paragraph 10.4) and some assets which by its nature do meet aforementioned criteria in some extent, but should not be in principle merged with neighboring polygons. These were roads, inland waters, peatlands, quarries, private yards, forest rides, ditches, power lines and railroads. After merging and simplification of different data layers and overlying with Estonian topographic database, we were able to get more detailed information for 85% of ecosystem accounting area. For the remaining 15% of the area, Estonian Topographic Database was the only source of information we could use.

The final ecosystem unit base map consisted of ca. 4.4 million polygons covering 126 different mapping units (ANNEX 4). Altogether, area of 43 465 km2 (whole EEA without lakes Võrtsjärv and Peipsi järv) was covered by ecosystem assets (Figure 2). As expected the forest land covered most of the Estonia (54.7%) followed by cropland (19.3%) and grassland (11.9%). Coastal ecosystems have the smallest share (< 0.1%).

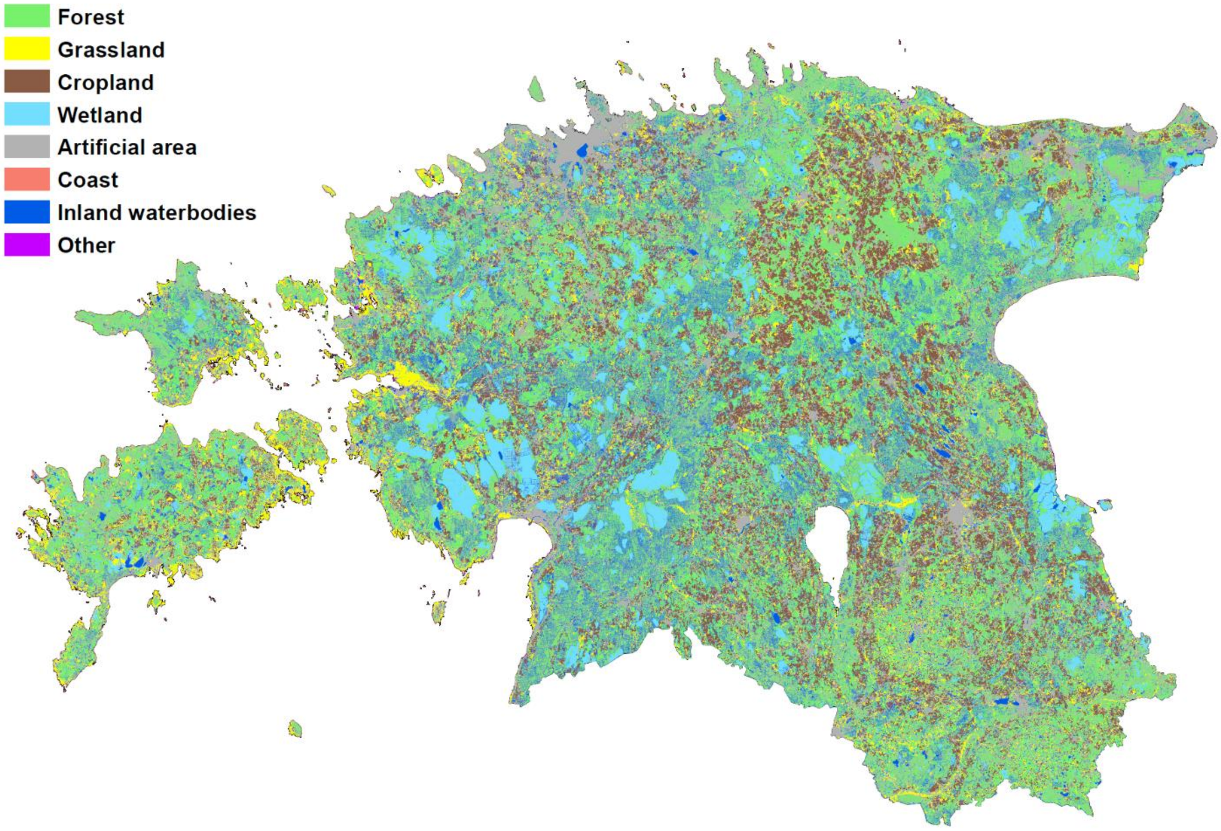

Figure 2. Estonian ecosystem base map aggregated to main ecosystem types

One of the results of current work under this grant was adding an ownership dimension to extent account linking ecosystem units with the owner by the categories in sense of economic activities and institutional sectors. The idea that cadastral parcels would facilitate the linkages to economic units/activities was chosen and tested on a spatially explicit map of ecosystems for Estonia by adding an owner's dimension.

In order to determine the institutional sector and economic activity of the owner of the land various data sources were used. First information from Land Register was analyzed. For example if the citizenship was other than Estonian the institutional sector was classified as Rest of the world. For cadasters where Land Register information about the owner was not available information from statistical profile (SPI) that is compiled and managed in Statistics Estonia was used. SPI contains information about the institutional sector and also economic activity. SPI was also used to determine economic activity for those cadasters whose institutional sector was possible to determine with information from the Land Register. For the cadasters that did not have information from Land Register and SPI information from State Forest Management Centre was used. For some cadasters information from different data sources aligned and was possible to integrate but for some cadasters information differed and in those cases the information from the Land Register, then from SPI was chosen. For cadasters that did not have any information about the owner were classified as Not specified. In the final table State Forest Management Centre was classified under non-financial corporations sector, under NACE A.02. Final extent data classified with NACE and institutional sector categories can be seen in Table 2.

The largest ecosystem type is forest forming 55% from the total extent, second largest is cropland and then comes grassland. It is also seen that the owner of most (55%) of the ecosystems are non-financial corporations. They own also more than half of forest extent (67%), wetlands (82%), coasts (62%) and inland waterbodies (56%). Second largest owner are households (35% of total extent) and they own more than half of grass- and croplands (both 57% of total grasslands and croplands). General government owns ca 8% of total extent and rest of the world owns ca 1% of total extent. Results are presented in Table 3.

The biggest part of corporation sector comes from forestry activity that makes up 81% of corporations total extent value. Forestry activity has also almost half (45%) of total extent and major part of all corporations ecosystem extents except cropland. It is also important to consider that State Forest Management Centre is allocated under non-financial corporations sector under forestry activity. The biggest extent of corporation's cropland is allocated under crop and animal production activity (59 % of corporations total cropland extent). Results are presented in Table 4.

Table 2 Opening extent account, classified according to the closest broad classes of the Ecosystem Classification for ecosystem accounting in Estonia and economic sectors, ha.

	NACE	Forest	Grassland	Cropland	Wetland	Artificial area	Coast	Inland waterbodies	Other	TOTAL	Share, %
Non-financial corporations total		1 599 160	145 258	278 261	228 409	72 467	2 204	49 345	2 239	2 377 343	54.7
..Agriculture, forestry and fishing	A	1 534 291	116 143	217 558	226 155	44 251	2 014	45 428	1 982	2 187 822	50.4
..Crop and animal production, hunting and related service activities	A.01	42 617	37 696	163 368	865	7 847	3	3 104	103	255 603	5.9
..Forestry and logging	A.02	1 491 643	78 408	54 188	225 290	36 375	2 011	42 322	1 877	1 932 115	44.5
..Fishing and aquaculture	A.03	31	38	2	..	29	1	2	2	104	0.0
..Mining and quarrying	B	1 605	482	720	386	1 380	..	123	3	4 700	0.1
..Manufacturing	C	12 083	2 391	3 220	162	4 154	9	493	22	22 535	0.5
..Electricity, gas, steam and air conditioning supply	D	2 415	1 663	866	288	2 114	22	671	15	8 055	0.2
..Water supply; sewerage, waste management and remediation activities	E	345	378	114	16	735	0	274	9	1 871	0.0
..Construction	F	3 053	1 664	1 711	75	1 677	14	153	11	8 358	0.2
..Wholesale and retail trade; repair of motor vehicles and motorcycles	G	10 188	2 110	2 056	243	2 141	8	237	35	17 017	0.4
..Transportation and storage	H	2 426	908	2 446	168	4 961	12	107	21	11 048	0.3
..Accommodation and food service activities	I	2 654	930	706	89	513	10	132	6	5 040	0.1
..Information and communication	J	516	339	364	7	140	0	20	4	1 389	0.0
..Real estate activities	L	22 027	14 049	44 459	630	7 430	82	1 284	90	90 050	2.1
..Professional, scientific and technical activities	M	2 789	1 480	1 827	86	1 121	19	127	9	7 457	0.2
..Administrative and support service activities	N	2 193	1 060	1 070	37	591	2	93	10	5 056	0.1
..Education	P	244	132	116	10	76	3	8	1	591	0.0
..Human health and social work activities	Q	119	33	23	1	100	..	4	1	280	0.0
..Arts, entertainment and recreation	R	450	442	152	11	386	4	59	6	1 511	0.0
..Other service activities	S	332	303	344	9	117	0	25	4	1 134	0.0
..Other corporations		1 431	751	509	35	581	4	108	11	3 429	0.1
Financial corporations		610	295	303	17	189	4	21	2	1 441	0.0
General government		113 482	61 566	66 570	34 286	59 895	480	15 006	745	352 028	8.1
Households		637 350	292 571	473 424	15 052	98 974	731	22 633	1 536	1 542 271	35.5
Non-profit institutions serving households		3 054	1 777	1 564	147	1 626	4	222	10	8 404	0.2
Rest of the world		14 094	7 730	5 528	530	3 377	105	433	96	31 894	0.7
Not specified		9 604	6 035	11 211	306	3 384	14	635	32	31 220	0.7
TOTAL		2 377 353	515 232	836 862	278 746	239 912	3 543	88 294	4 659	4 344 601	100.0
Share, %		54,7	11,9	19,3	6,4	5,5	0,1	2,0	0,1	100	

Table 3. Opening extent account, classified according to the closest broad classes of the Ecosystem Classification for ecosystem accounting in Estonia and institutional sectors, shares in percentages

	Forest	Grassland	Cropland	Wetland	Artificial area	Coast	Inland waterbodies	Other	Share of sector in total
Non-financial corporations total	67%	28%	33%	82%	30%	62%	56%	48%	55%
Financial corporations	0%	0%	0%	0%	0%	0%	0%	0%	0%
General government	5%	12%	8%	12%	25%	14%	17%	16%	8%
Households	27%	57%	57%	5%	41%	21%	26%	33%	35%
Non-profit institutions serving households	0%	0%	0%	0%	1%	0%	0%	0%	0%
Rest of the world	1%	2%	1%	0%	1%	3%	0%	2%	1%
Not specified	0%	1%	1%	0%	1%	0%	1%	1%	1%
Share of ecosystem category in total	55%	12%	19%	6%	6%	0%	2%	0%	100%

Table 4. Distribution of the land use (ecosystem) categories of non-financial corporations by economic activities

	NACE	Forest	Grassland	Cropland	Wetland	Artificial area	Coast	Inland waterbodies	Other	TOTAL	Share from total extent	Share from corporations extent
Non-financial corporations total		1 599 160	145 258	278 261	228 409	72 467	2 204	49 345	2 239	2 377 343	54,7%	
..Crop and animal production, hunting and related service activities	A.01	2,7%	26,0%	58,7%	0,4%	10,8%	0,1%	6,3%	4,6%	255 603	5,9%	10,8%
..Forestry and logging	A.02	93,3%	54,0%	19,5%	98,6%	50,2%	91,2%	85,8%	83,8%	1 932 115	44,5%	81,3%
..Fishing and aquaculture	A.03	0,0%	0,0%	0,0%	..	0,0%	0,0%	0,0%	0,1%	104	0,0%	0,0%
..Mining and quarrying	B	0,1%	0,3%	0,3%	0,2%	1,9%	..	0,2%	0,1%	4 700	0,1%	0,2%
..Manufacturing	C	0,8%	1,6%	1,2%	0,1%	5,7%	0,4%	1,0%	1,0%	22 535	0,5%	0,9%
..Electricity, gas, steam and air conditioning supply	D	0,2%	1,1%	0,3%	0,1%	2,9%	1,0%	1,4%	0,7%	8 055	0,2%	0,3%
..Water supply; sewerage, waste management and remediation activities	E	0,0%	0,3%	0,0%	0,0%	1,0%	0,0%	0,6%	0,4%	1 871	0,0%	0,1%
..Construction	F	0,2%	1,1%	0,6%	0,0%	2,3%	0,6%	0,3%	0,5%	8 358	0,2%	0,4%
..Wholesale and retail trade; repair of motor vehicles and motorcycles	G	0,6%	1,5%	0,7%	0,1%	3,0%	0,4%	0,5%	1,5%	17 017	0,4%	0,7%
..Transportation and storage	H	0,2%	0,6%	0,9%	0,1%	6,8%	0,5%	0,2%	0,9%	11 048	0,3%	0,5%
..Accommodation and food service activities	I	0,2%	0,6%	0,3%	0,0%	0,7%	0,4%	0,3%	0,3%	5 040	0,1%	0,2%
..Information and communication	J	0,0%	0,2%	0,1%	0,0%	0,2%	0,0%	0,0%	0,2%	1 389	0,0%	0,1%
..Real estate activities	L	1,4%	9,7%	16,0%	0,3%	10,3%	3,7%	2,6%	4,0%	90 050	2,1%	3,8%
..Professional, scientific and technical activities	M	0,2%	1,0%	0,7%	0,0%	1,5%	0,8%	0,3%	0,4%	7 457	0,2%	0,3%
..Administrative and support service activities	N	0,1%	0,7%	0,4%	0,0%	0,8%	0,1%	0,2%	0,5%	5 056	0,1%	0,2%
..Education	P	0,0%	0,1%	0,0%	0,0%	0,1%	0,2%	0,0%	0,0%	591	0,0%	0,0%
..Human health and social work activities	Q	0,0%	0,0%	0,0%	0,0%	0,1%	..	0,0%	0,0%	280	0,0%	0,0%
..Arts, entertainment and recreation	R	0,0%	0,3%	0,1%	0,0%	0,5%	0,2%	0,1%	0,3%	1 511	0,0%	0,1%
..Other service activities	S	0,0%	0,2%	0,1%	0,0%	0,2%	0,0%	0,1%	0,2%	1 134	0,0%	0,0%
..Other corporations		0,1%	0,5%	0,2%	0,0%	0,8%	0,2%	0,2%	0,5%	3 429	0,1%	0,1%

4.2 Evaluation of the changes of ecosystem extent account

Opening extent was developed and methodology created in the last project using 2019 as a base year. In current project, the closing extent was created (2020 as a base year) and methodology for compiling base map was further improved. This created situation where methodology for base map compilation for opening and closing extent are slightly different, hence the results. This in turn creates a situation where exploring ecosystem conversions (for a given location, there is a change in ecosystem type) could be problematic as it's almost impossible to pinpoint causes (for example are ecosystem conversions due to used methods or real changes in reality). Ideally one should revise the opening extent using newer methodology for creating the base map but due to time constrains in current project it was decided to do pilot study with the one county in Estonia to explore to ecosystem conversions in more detail. Pärnu County was selected to be used as EAA for pilot study due to its size (largest county in Estonia). Nevertheless, we also present results (see Table 5 and Table 6) for whole Estonia (opening and closing extent) but only with net change as its difficult to pinpoint the causes for conversions (aggregated ecosystem type areas based on vector type data).

For Pärnu County, the first step was to revise ecosystem base map with newer methodology and updating classification which were both developed during this project. In order to determine ecosystem conversions (for a given location) it was needed to use local statistical units. It was decided to use 100 x 100m grid cells. For every grid cell, ecosystem type was determined based on the largest area in that particular cell. These spatial analysis was carried out for both opening and closing extent (Table 7). Although changes were relatively small in area, largest changes occurred in the area of drained peatland forest and oligo-mesotrophic boreal forests which both increased. Eutrophic paludifying forests and peat bogs areas were both largest decreases.

We also created ecosystem type change matrix to illustrate ecosystem conversions in Pärnu County (Table 8). The largest ecosystem conversions between opening and closing extent occurred between cultivated grassland which were converted to crops (18.15 km^2 change). At same time also 15.96 km^2 of crops were converted to cultivated grassland. These changes indicate that changes are all the managed additions typical for agricultural land management scheme. Interestingly, also eutrophic paludifying forests were converted to oligo-mesotrophic boreal forests (9.89 km^2 change) and eutrophic boreo-nemoral forests (9.13 km^2 change). These changes could indicate that these changes are due to reappraisals. Altogether there was 3.3% (179 km^2) of Pärnu county area that experienced some kind of ecosystem conversions. Natural changes in ecosystem do not appear in one year change matrix. As extent account is based on the spatial data in registers the changes reflect the modifications and adjustments in registers. Most of the modifications in registers depend also on the requirements written into the regulations regarding management and hence the changes what could be observe in ecosytems spatial data may not be always related to real changes in ecosystems and in another hand the changes if they take place will appear with certain timelag. Several of the spatial ecosystem data which have been modelled depend on the quality of data in other datasets, which also could be influenced by their own logic. For example there are lot of small conversions from one forest type to another and figuring out the reason behind the changes is tricky as these could be influenced both by reappraisal or the modelling of the forest types based on soil types.

In addition to the changes of one ecosystem type to another, the changes in condition seem to have even bigger importance. For example after the clear cut felling forest ecosystem services change profoundly but the ecosystem type remains the same.

In Estonia in general without human intervention all ecosystems tend to covert to the direction of forest as a climax plant community due to the natural succession in boreal areas. So all the conversion in a direction cropland to forest and grassland to forest could be considered natural by default.

Ecosystem extent account, opening extent for year 2019 and closing extent for year 2020 for Estonia (whole EAA) by main ecosystem types, km^2

Table 5. Ecosystem extent account, opening extent for year 2019 and closing extent for year 2020 for Estonia (whole EAA) by main ecosystem types, km2

	2019			2020
	Opening extent	Net change in extent		Closing extent
Forest	24190.9	-410.8		23780.2
Grassland	5163.6	-8.5		5155.1
Cropland	8457.3	-84.8		8372.5
Wetland	2824.5	-37.3		2787.2
Artificial area	2309.9	95.2		2405.1
Coast	36.3	-0.9		35.4
Inland waterbodies	428.5	454.6		883.2
Other	54.2	-7.6		46.6
Total	43465			43465

Table 6. Ecosystem extent account (km2), opening extent for year 2019 and closing extent for year 2020 for Estonia (whole EAA)

	2019			2020
	Opening extent	Net change in extent		Closing extent
Drained peatland forests	3298.3	-45.5		3252.8
Mesotrophic boreal forests	3959.0	-60.2		3898.8
Eutrophic alvar forests	538.2	-25.5		512.7
Oligotrophic boreal heath forests	205.4	-3.3		202.0
Oligo-mesotrophic boreal forests	4881.1	-43.9		4837.2
Oligotrophic paludifying forests	443.0	-22.4		420.5
Minerotrophic swamp forests	772.7	-33.1		739.6
Eutrophic boreo-nemoral forests	2109.0	-56.3		2052.6
Mixotrophic and ombrotrophic bog forests	1429.6	-10.0		1419.7
Eutrophic paludifying forests	6421.9	-113.8		6308.2
Forest on reclaimed pits	132.7	3.3		136.0
Cultivated grassland	2565.5	31.5		2597.0
Heaths	6.3	-0.9		5.4
Semi-natural grasslands	2442.4	-37.1		2405.3
Shrubbery	149.3	-1.9		147.4
Horticultural land	31.6	3.8		35.4
Crops	8393.2	-89.4		8303.8
Permanent crops	32.5	0.8		33.3
Fens	518.4	-12.1		506.3
Transition mires	425.0	0.5		425.5
Peat bogs	1639.9	-21.8		1618.1
Peat extraction sites	183.4	-1.8		181.6
Abandoned peatlands	57.8	-2.1		55.7
Green space	108.9	-0.2		108.7
Buildings and facilities	782.8	81.2		864.0
Other artificial areas	1418.2	14.2		1432.4
Shores	36.3	-0.9		35.4
Lakes and ponds	316.9	-0.3		316.6
Rivers and streams	111.6	454.9		566.5
Other	54.2	-7.6		46.6
Total	43465			43465

Table 7. Ecosystem extent account (km2), opening extent for year 2019 and closing extent for year 2020 for Pärnu County

	2019					2020
	Opening extent	Additions to extent	Reductions in extent	Net change in extent		Closing extent
Drained peatland forests	327.7	18.0	11.8	6.2		333.9
Mesotrophic boreal forests	162.6	8.4	7.4	1.0		163.6
Eutrophic alvar forests	34.1	1.2	2.1	-1.0		33.1
Oligotrophic boreal heath forests	9.7	0.2	0.5	-0.3		9.4
Oligo-mesotrophic boreal forests	704.6	21.1	14.0	7.2		711.7
Oligotrophic paludifying forests	60.3	2.2	5.1	-2.9		57.4
Minerotrophic swamp forests	78.9	5.2	7.2	-2.0		76.9
Eutrophic boreo-nemoral forests	216.3	14.5	13.9	0.6		216.9
Mixotrophic and ombrotrophic bog forests	163.6	8.2	9.5	-1.3		162.3
Eutrophic paludifying forests	1277.8	30.8	34.9	-4.1		1273.7
Forest on reclaimed pits	4.1	0.2	0.1	0.1		4.2
Cultivated grassland	381.3	21.2	22.8	-1.5		379.7
Heaths	0.2	0.0	0.2	-0.2		0.0
Semi-natural grasslands	308.5	11.7	13.4	-1.7		306.8
Shrubbery	8.9	0.7	0.9	-0.2		8.7
Horticultural land	3.7	0.1	0.1	0.0		3.7
Crops	805.4	22.0	20.7	1.4		806.8
Permanent crops	4.9	0.1	0.2	-0.1		4.8
Fens	59.3	0.8	1.9	-1.0		58.3
Transition mires	55.4	0.4	0.9	-0.5		54.9
Peat bogs	483.8	0.6	4.5	-3.9		479.9
Peat extraction sites	46.5	0.0	0.1	-0.1		46.5
Abandoned peatlands	27.5	0.1	0.0	0.0		27.5
Green space	9.1	0.4	0.3	0.1		9.2
Buildings and facilities	29.9	1.1	0.9	0.2		30.1
Other artificial areas	111.9	7.9	5.3	2.6		114.5
Shores	2.6	0.1	0.1	0.0		2.7
Lakes and ponds	21.4	0.6	0.1	0.5		21.9
Rivers and streams	10.8	0.3	0.2	0.2		10.9
Other	3.0	1.3	0.5	0.7		3.7
Total	5 414					5 414

Table 8. Ecosystem type change matrix to illustrate ecosystem conversions in Pärnu County

Opening extent / Closing extent	Drained peatland forests	Mesotrophic boreal forests	Eutrophic alvar forests	Oligotrophic boreal heath forests	Oligo-mesotrophic boreal forests	Oligotrophic paludifying forests	Minerotrophic swamp forests	Eutrophic boreo-nemoral forests	Mixotrophic and ombrotrophic bog forests	Eutrophic paludifying forests	Forest on reclaimed pits	Cultivated grassland	Semi-natural grasslands	Shrubbery	Horticultural land	Crops	Permanent crops	Fens	Transition mires	Peat bogs	Peat extraction site	Abandoned peatlands	Green space	Buildings and other facilities	Other artificial areas	Shores	Lakes and ponds	Rivers and streams	Other	Opening
Drained peatland forests	0	0.06	0	0.01	1.45	0.05	2.54	0.14	4.4	2.32	0.04	0.04	0.19	0	0	0.08	0	0.04	0.01	0.11	0	0.03	0	0	0.21	0	0.01	0.01	0.01	11.75
Mesotrophic boreal forests	0.1	0	0.16	0	1.71	0	0.01	2.25	0	1.86	0	0.09	0.51	0.08	0	0.16	0	0.01	0	0	0	0	0.05	0.02	0.35	0.02	0	0.01	0	7.39
Eutrophic alvar forests	0	0.94	0	0	0	0	0.01	0.11	0	0.64	0	0.03	0.14	0.05	0	0.02	0	0.03	0	0	0	0	0	0.02	0.15	0	0	0	0	2.14
Oligotrophic boreal heath forests	0.01	0.01	0	0	0.32	0.11	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0.47
Oligo-mesotrophic boreal forests	0.85	1.15	0	0.14	0	1.47	0.04	1.03	0.08	7.43	0	0.21	0.3	0	0	0.3	0	0	0	0.01	0	0	0.01	0.03	0.9	0	0.01	0	0	13.96
Oligotrophic paludifying forests	0.38	0.04	0	0	3.87	0	0	0	0.14	0.46	0	0	0.03	0	0	0.03	0	0	0	0	0	0	0	0	0.18	0	0	0	0	5.13
Minerotrophic swamp forests	4.97	0.1	0.01	0	0.09	0	0	0.04	0.13	1.56	0.07	0	0	0	0	0	0	0.14	0	0.02	0	0	0	0	0.03	0	0.01	0	0	7.17
Eutrophic boreo-nemoral forests	0.12	1.35	0.23	0	2.1	0.01	0.08	0	0	8.67	0	0.11	0.5	0.02	0.01	0.29	0	0.01	0	0	0	0	0	0.01	0.36	0	0	0.03	0.01	13.91
Mixotrophic and ombrotrophic bog forests	7.25	0.01	0	0	0.57	0.29	0.5	0	0	0.37	0	0	0.03	0	0	0	0	0.04	0.13	0.22	0.02	0.01	0	0.02	0.04	0	0	0	0	9.5
Eutrophic paludifying forests	2.36	3.09	0.38	0	9.89	0.27	0.67	9.13	0.13	0	0.01	0.77	3.42	0.18	0	1.38	0.01	0.26	0	0.06	0	0	0	0.08	2.66	0	0.04	0.02	0.05	34.86
Forest on reclaimed pits	0.02	0	0	0	0	0	0	0	0.01	0	0	0	0.01	0	0	0	0	0	0	0.02	0	0.03	0	0	0.01	0	0	0	0	0.1
Cultivated grassland	0.03	0.08	0.02	0	0.11	0	0.01	0.13	0	0.52	0	0	3.12	0	0	18.15	0.01	0.02	0	0	0	0	0	0.05	0.44	0.01	0	0.05	0	22.75
Heaths	0	0.02	0	0	0	0	0	0	0	0.01	0	0	0.18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.21
Semi-natural grasslands	0.16	0.78	0.27	0	0.34	0.01	0.05	1.05	0.01	4.15	0	3.51	0	0.24	0.02	0.86	0	0.23	0	0	0	0	0.05	0.12	1.04	0.03	0.32	0.06	0.06	13.36
Shrubbery	0.06	0.02	0.03	0	0	0	0	0	0.01	0.24	0	0.03	0.23	0	0.01	0.02	0	0	0	0	0	0	0	0	0.2	0	0	0	0	0.85
Horticultural land	0	0	0	0	0	0	0	0	0	0.02	0	0	0.05	0	0	0	0	0	0	0	0	0	0	0.04	0.01	0	0	0	0	0.12
Crops	0.07	0.51	0.02	0	0.39	0	0	0.48	0	1.06	0	15.96	1.17	0.05	0.04	0	0.08	0	0	0	0	0	0.04	0.17	0.6	0	0	0.04	0	20.68
Permanent crops	0	0	0	0	0	0	0	0	0	0.02	0	0.04	0	0	0.01	0.09	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0.17
Fens	0.19	0.03	0	0	0	0	0.68	0	0.06	0.43	0	0.07	0.33	0	0	0	0	0	0.01	0.06	0	0	0	0	0.01	0	0	0	0	1.87
Transition mires	0.11	0	0	0	0.01	0	0.44	0	0.21	0.02	0.01	0	0	0	0.01	0	0	0.03	0	0.04	0	0	0	0	0	0	0	0	0.01	0.89
Peat bogs	1.05	0	0	0	0	0.02	0.12	0	2.99	0	0	0	0.08	0	0	0	0	0	0.21	0	0.01	0	0	0	0	0	0	0	0	4.48
Peat extraction site	0.05	0	0	0	0	0	0	0	0.03	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0.09
Abandoned peatlands	0.03	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.01	0	0	0	0	0	0	0	0	0	0.04
Green space	0	0	0	0	0.02	0.01	0	0	0	0.02	0	0.01	0.03	0.01	0	0	0	0	0	0	0	0	0	0.16	0.03	0	0	0	0	0.29
Buildings and other facilities	0.02	0.03	0.01	0	0.01	0	0	0	0.01	0.11	0	0.03	0.25	0	0.01	0.08	0	0	0	0	0	0	0.11	0	0.2	0	0	0.03	0	0.9
Other artificial areas	0.11	0.18	0.02	0	0.23	0	0.02	0.14	0.01	0.7	0.02	0.32	1	0.03	0	0.54	0	0.02	0	0.01	0	0	0.11	0.36	0	0.02	0.25	0.04	1.13	5.26
Lakes and ponds	0.01	0.01	0	0	0	0	0	0	0.01	0.01	0	0	0.04	0	0	0.01	0	0.01	0	0	0	0	0	0	0.03	0	0	0	0	0.13
Other	0	0	0	0	0	0	0	0	0	0.12	0.01	0	0.03	0	0	0	0	0	0	0	0	0	0	0	0.37	0	0	0	0	0.53
Closing	17.95	8.41	1.15	0.15	21.11	2.24	5.17	14.5	8.23	30.74	0.16	21.22	11.65	0.66	0.11	22.01	0.1	0.84	0.36	0.57	0.03	0.07	0.37	1.08	7.82	0.09	0.64	0.3	1.27	179

5 Selection of the services and consultations with stakeholders

We continued the work started under Eurostat grant in 2019 on ecosystem services accounting "Land account and valuation of grassland ecosystems services" (Grant Agreement 831254)[9] which dealt with identifying and evaluating important ecosystem services for grassland ecosystems. The next logical step and the main purpose in this grant work was to widen the scope to include other ecosystems in Estonian ecosystem accounting area but with the main focus on forest, grassland, wetland, cropland and urban ecosystems and to increase the number of evaluated ecosystem services according to the interest of stakeholders and following the guidelines in international strategic documents (SEEA EA, the module of ecosystem accounts under European environmental economic accounts (Regulation (EU) No 691/2011)).

We applied the same process for identifying services for which monetary valuation is considered important as was already carried out for grasslands in 2019. The process included consulting experts and stakeholders (Ministry of Environment, Ministry of Rural Affairs, Ministry of Finances, Ministry of Economic Affairs and Communications, Estonian Private Forest Centre, ELME team) in the first half of 2020 on the importance of 37 different ecosystem services for monetary valuation in forest, wetland and agricultural ecosystems by first sending out inquiries in written form and then holding a seminar to discuss the results and additional needs (see ANNEX 2 for more information). In the questionnaires we asked the importance for monetary evaluation (rated very important, important and not important) of the ecosystem service in a particular ecosystem class (forest, wetland and agricultural ecosystem), explanation for the rating and additionally available methodology and data.

We received valuable input for the determination of the relevance of monetary valuation of ecosystem services with the questionnaires. To summarize the different opinions and find the overall importance for monetary valuation of an ecosystem service, numerical scores were assigned for the relevance. The relevance was assessed in the scale: A- very important service (numerical score 3), B- important service (numerical score 2), C- service is not important to be valued in monetary terms (numerical score 1). Then an average was calculated for every service in every ecosystem type (forest, wetland and agricultural ecosystems). The results showed that the majority of the services were assessed as very important and therefore included in the primary list of ecosystem services for monetary valuations.

The primary list of selected ecosystem services was further refined by following the three criteria for the prioritization of services from UN SEEA (policy interest, data availability, methodological practicality). With the questionnaires we had obtained the opinions of political interest. As the real extent of data ability and feasibility often becomes clear when already in the phase of carrying out research or valuations, it is difficult to apply it at the very beginning of the process. We based the assumptions regarding the criteria on previous experience gained, however .we did have to make changes in the initial decisions during work process. We also simplified the last criteria in the beginning by checking the correspondence of ecosystem services first to the following: whether the ecosystem service is final or intermediate as final ecosystem services are preferred, also scope of the supplying ecosystems of the service was considered, feasibility and difficulty of the valuation, the economic importance of the service and finally the services which are mentioned in strategic

[9] Statistics Estonia, 2020. Development of the land account and valuation of ecosystem services regarding grassland ecosystem services (Eurostat Grant Agreement no NUMBER — 831254 — 2018-EE-ECOSYSTEMS. https://www.stat.ee/sites/default/files/2021-06/Methodological%20report_831254_2018_EE_ECOSYSTEMS_revised_version_31_03.pdf

documents (SEEA EA, Regulation on European environmental economic accounts) or grant application were given preference.

Similar process was carried out for identifying important services in urban ecosystems. A different questionnaire where 32 different services were listed and asked to be assessed for the importance of monetary valuation was sent out to experts and stakeholders. Then the average importance of the ecosystem service was calculated and additional criteria applied while keeping the focus on the services that are characteristic to urban ecosystems (the scope of the ecosystem supplying area).

In the end, a total of 16 different ecosystem services were chosen and valued with exchange value based methods. 14 different services were assessed with CVM studies on forest and wetland ecosystems, the results of CVM study on grassland ecosystems, which was carried out in 2019, were incorporated in the work. Additionally, CVM on urban ecosystems studied 10 different services. Some specific services of CVM studies were merged or excluded depending on the definitions of the services and their importance of input to economy. The overview of the services included in the monetary valuation with corresponding valuation methods is given in Table 9.

Table 9. Ecosystem services chosen for the monetary valuation with exchange value based methods and inclusion in CVM studies in both natural/semi-natural ecosystems and urban ecosystems.

ECOSYSTEM ACCOUNT					
SERVICE	**Exchange value based valuation method(s)**	**CVM forest**	**CVM wetland**	**CVM grassland**	**CVM urban**
Fodder	Rent price, resource rent			*grassland*	
Medicinal herbs		*forest*	*wetland*	*grassland*	
Herbaceous biomass used for producing energy (bioenergy)	Market price				
Agricultural production (crops)	Rent price				
Wild berries, mushrooms	Market price	*forest*	*wetland*		
Wild game	Market price				
Timber	Stumpage prices				
Peat	Market price				
Forest seed	Market price	*forest*	*wetland*	*grassland*	
Flood protection				*grassland*	
Global climate regulation: C sequestration (storage)	Payment for Ecosystem Services (PES) schemes	*forest*	*wetland*	*grassland*	
Air quality (PM_x)	Benefit transfer (avoided damage costs)	*forest*	*wetland*		
Photosynthesis (oxygen production)		*forest*	*wetland*	*grassland*	
Pollination	Avoided damage costs	*forest*		*grassland*	
Maintenance of soil fertility		*forest*		*grassland*	
Habitat conservation for biological species		*forest*	*wetland*	*grassland*	
Recreation	Valuation by time-use	*forest*	*wetland*	*grassland*	
Recreational hunting	Expenditure-based valuation approach				
Nature education	Expenditure-based valuation approach	*forest*	*wetland*	*grassland*	
Ensuring landscape diversity		*forest*	*wetland*	*grassland*	
URBAN ECOSYSTEM ACCOUNT					
Organic waste which is used for producing compost	Market price				
Water infiltration	Replacement cost				
Global climate regulation: C sequestration (storage)	Payment for Ecosystem Services (PES) schemes				*urban*
Air quality (PMx)	Benefit transfer (avoided damage costs)				*urban*
Photosynthesis (oxygen production)					*urban*
Regulating microclimate (cooling, wind, light mitigation)					*urban*
Noise mitigation					*urban*
Pollination	Avoided damage costs				
Habitat conservation for biological species					*urban*
Recreation	Valuation by time-use				*urban*
Nature education	Expenditure-based valuation approach				*urban*
Aesthetic experience					*urban*
Ensuring urban space diversity					*urban*

6 Methods for the valuation of the services

6.1 Exchange based valuation methods applied for the valuation of ecosystem services

The selection of appropriate monetary valuation methods relied heavily on the experience and results gained during the previous project work. In addition our work on selecting the best valuation methods was put into the perspective of common practices from the compilations of other ecosystem accounts which were observed mainly from attending Virtual Expert Forums on SEEA Experimental Ecosystem Accounting (SEEA EEA) 2020, MAIA meetings. Co-operation with Statistics Netherlands experts was carried out in determining and refining methodologies for ecosystem services valuation.

Table 9. Ecosystem services chosen for the monetary valuation with exchange value based methods and inclusion in CVM studies in both natural/semi-natural ecosystems and urban ecosystems." shows the selected exchange value based valuation method(s). As we continued the work by broadening the scope from the services valued in grassland ecosystems, then for the majority of the services, the methods, if not yet the final methodology, were already chosen based on the data availability and feasibility. As was the case in previous project, the main limiting factor for selecting feasible methods was data availability. Regarding the used data, ELME project[10] results were used first-hand as much as possible for estimating the spatial distribution of the ecosystem services. Research and consultations were carried out in case of new services where valuation methods were still open. The detailed reasoning behind each valuation method is described in subchapters on the valuation of each ecosystem separately in 7. Following paragraphs give an overview of selected valuation methods, which principles can be seen in Table 10.

Provisioning services supply real goods and therefore the physical and monetary flows entering the economy are generally well documented. These services are generally traded in market which makes it easy to value those monetarily using market price methods. In addition to already valued grassland ecosystem services (herbaceous biomass used for producing energy (bioenergy), wild game) the market price method was also used for new provisioning services such as wild berries and mushrooms, peat, forest seed and organic waste which is used for producing compost (valued on urban areas). However, market price method was not always the best method for the valuation of provisioning services, also common practice showed that rent price method was used for agricultural production (crops) in addition to fodder which was previously included in the valuation of grassland ecosystem services. In case of timber, stumpage prices were used. We also found that provisioning services have varying economic importance depending on the demand and use of the goods that ecosystem services supply.

Regulative services climate regulation and pollination were valued previously. Pollination was valued with two alternative methods: benefit transfer and avoided cost method. The latter was selected to continue work with as it gave more detailed results. For climate regulation: carbon sequestration, the valuation method remained the same which was PES scheme. We made an attempt to also value carbon storage using data of PES scheme. Air quality regulation was an added regulative service which was valued with benefit transfer based on a reference study on the average damage cost value. Benefit transfer method offered a good alternative to the methods that use physical flows of ecosystem services as basis of monetary valuation because as of yet air quality regulation service has not been

[10] Projekt ELME – „Elurikkuse sotsiaal-majanduslikult ja kliimamuutustega seostatud keskkonnaseisundi hindamiseks, prognoosiks ja andmete kättesaadavuse tagamiseks vajalikud töövahendid" (projekt nr 2014-2020.8.01.16-0112; kaasrahastajad Euroopa Liidu Ühtekuuluvusfond ja SA Keskkonnainvesteeringute Keskus)

assessed and knowing that combining supply and demand of the regulative services often requires detailed spatial analysis, it could not fit into our work. In urban ecosystems water infiltration was valued using replacement cost method.

All cultural services: recreation, recreational hunting and nature education were included in the previous work. The valuation methods remained the same but were analysed and refined.

Table 10. Summary of valuation techniques. Modified after Table 6.1 of Technical Recommendation [11]

Type	Valuation technique	Description
Market-based	Unit resource rent	Prices determined by deducting costs of labour, produced assets and intermediate inputs from market price of outputs (benefits).
	Production function, cost function and profit function methods	Prices obtained by determining the contribution of the ecosystem to a market based price using an assumed production, cost or profit function.
	Payment for Ecosystem Services (PES) schemes	Prices are obtained from markets for specific regulating services (e.g. in relation to carbon sequestration)
Cost-based	Replacement cost	Prices reflect the estimated cost of replacing a specific ecosystem service using produced assets and associated inputs.
	Damage costs avoided	Prices are estimated in terms of the value of production losses or damages that would occur if the ecosystem services were reduced or lost due to ecosystem changes (e.g. as a result of pollution of waterways).
	Averting behaviour	Prices are estimated based on individual's willingness to pay for improved or avoided health outcomes.
	Restoration cost	Refers to the estimated cost to restore an ecosystem asset to an earlier, benchmark condition. Should be clearly distinguished from the replacement cost method.
Revealed preference	Travel cost	Estimates reflect the price that consumers are willing to pay in relation to visits to recreational sites.
	Hedonic pricing	Prices are estimated by decomposing the value of an asset (e.g. a house block including the dwelling and the land) into its characteristics and pricing each characteristic through regression analysis
Stated preference	Contingent valuation	Prices reflect willingness to pay from either contingent valuation studies or choice modelling.
Benefit transfer	Benefit transfer refers to the process of applying valuation results, functions, data or models derived in one location or context (study site) to estimate economic values of ecosystem services in an alternative context or location (policy site).	

6.2 Contingent valuation method for valuation of ecosystem services and general results

Contingent valuation methodology as an opportunity to assess the monetary equivalent of non-market values based on welfare economics theory. According to the principles of welfare economics, everything that has a positive effect on people's welfare has value. It also valid for ecosystem services, which can be classified according to the nature of expression into supply services, regulatory services and cultural services.

[11] UN (2017) SEEA Experimental Ecosystem Accounting: Technical Recommendations Consultation Draft. New York, USA. https://seea.un.org/sites/seea.un.org/files/technical_recommendations_in_support_of_the_seea_eea_final_white_cover.pdf

However, such a classification is not a good basis for choosing a method of economic evaluation of values. It is important for the choice of the economic assessment method whether or not the ecosystem service product is directly tradable on the market. If the product of the service is a direct market good, the service has a market value and the monetary equivalent of the corresponding ecosystem service can also be assessed on the basis of the market price method.

If the value created by the service is not directly tradable in the market, the corresponding value is a non-market value. Non-market values can be divided into two groups depending on whether or not their use associates with a real financial turnover. If there is a real financial cost of using the service (revealed preference), the revealed preference method (such as the travel cost method) is used.

If no real financial costs are made, people (respondents) are asked to directly assess how much the increase in well-being provided by the service to the individual is financially worthwhile. As a result of a sufficient sample survey, a financial equivalent is found for the service under investigation. The method is called contingent valuation and is very widespread in the world for monetary valuation of non-market values. The advantage of the method is the possibility to directly measure how much the researched value affects the welfare of individuals.

The disadvantage of this method is that the monetary value of the service obtained by the contingent valuation method has no connection with the actual (i.e. „accountable“) turnover. Therefore, it is difficult to place the financial result of the service thus obtained in the existing system of accounting and statistics, which is why the corresponding values are also called non-SNA values.

6.2.1 Methodology

The aim of this work was to evaluate the ecosystem services of three ecosystems: forest, wetland and urban. In order to evaluate the non-market values of services of these ecosystems, 3 independent CVM studies were performed, one for each ecosystem. The sample sizes used for the CVM studies are shown in Table 11. The sample structure was representative of the Estonian adult population.

Table 11. Performed CVM studies and their corresponding sample sizes.

Ecosystem	Number of responses to be considered	The share of positive payment decisions, %	Total willingness to pay, million EUR/year
Forest	660	90	23.9
Bog	400	89	12.3
Urban	720	91	17.3

The questionnaires used in the study were designed according to the requirements for CVM surveys. The questionnaires included a simulated market scenario, a willingness to pay identification question and questions on the respondent’s sociometric data.

In addition, the questionnaire also contained a number of guiding questions, which are not analyzed separately in this report. The full text of the questionnaires is provided in the annexes (see ANNEX 7).

While CVM study typically explores the monetary equivalent of a single non-market value (e.g., an existence value of biological species), the aim in the present study was to explore multiple non-market services in one ecosystem in a single CVM survey. It would probably have been methodologically more correct to carry out CVM study for each non-market ecosystem service separately, but given the labor-intensive nature of such an approach (especially the sample size requirements), this was not possible under this project.

In order to assess several non-market services of one ecosystem in one CVM survey, respondents were asked to rank the given ecosystem services according to their subjective importance in addition to their declaration of willingness to pay. Based on the preferences received, the declared willingness to pay for ecosystem services was divided between the individual services on the list. Willingness to pay for all studied ecosystem services is presented in the tables in the relevant ecosystem subsection.

When allocating the willingness to pay obtained by CVM into the CVM supply and use tables, it should be taken into account that the results of the studies are not transferred to the supply and use tables unambiguously, although the total supply is very close to that identified with the CVM studies. For the use tables, some ecosystem services are aggregated and some are not reflected in the tables.

6.2.2 Relative importance and WTP for forest ecosystem services.

The relative importance of forest ecosystem services according to the respondents and the corresponding WTP are presented in Table 12.
In the survey of non-market values of the forest ecosystem, 660 questionnaires met the requirements. According to the survey, the total willingness to pay of the Estonian adult population for forest ecosystem services was 23.9 million euros per year. The high percentage of respondents with a positive willingness to pay (90%) is worth noting.

Table 12. Relative importance and WTP for forest ecosystem services

Forest ecosystem service	**Relative importance**	**% of total value**	**WTP (thous. EUR)**
Photosynthesis (oxygen production)	1.	13.96	3329.753
Air and water purification	2.	13.71	3271.079
Climate regulation	3.	11.83	2820.943
Habitat supply for biological species	4.	11.64	2777.562
Preserving soil fertility	5.	9.23	2200.465
Ensuring landscape diversity	6.	7.56	1803.242
Enabling pollination and honey collection	7.	7.45	1777.344
Provision of genetic resources and medicinal plants	8.	7.13	1700.029
Provision of berries, mushrooms and other bog products	9.	6.07	1447.123
Providing opportunities for environmental education	10.	5.97	1422.783
Providing recreation and leisure opportunities	11.	5.46	1301.678
TOTAL		**100**	**23852.0**

When ranking ecosystem services on the basis of subjective importance, respondents preferred *Photosynthesis (oxygen production)* (13.96% of the total value, WTP 3.3 million euros). The service *Air and water purification* achieved almost the same result (13.71% of the total value). These two services were followed by *Climate regulation* (11.83% of the total value) and *Habitat supply for biological species* (11.64% of the total value). This sequence clearly shows that, in the case of forests, people consider global environmental regulation services to be paramount. The last three services in the ranking include *Provision of berries*, *mushrooms and other bog products* (6.07% of the total value), and cultural services *Providing opportunities for environmental education* and *Providing recreation and leisure opportunities* (5.97% and 5.46% of the total value respectively).

It is surprising that the service that people are expected to be most exposed to in the forest (*Providing recreation and leisure opportunities*) is at the bottom of the list. It can be concluded that people's subjective welfare is positively influenced more by global life-support services than by direct contact with the forest ecosystem having recreation.

6.2.3 Relative importance and WTP for wetland ecosystem services.

The relative importance of forest ecosystem services according to the respondents and the corresponding WTP are presented in Table 13. The survey is based on 400 questionnaires and the sample structure was representative of the Estonian adult population. Similar to the forest survey, the percentage of positive respondents (89%) was very high,

Table 13. Relative importance and WTP for wetland ecosystem services

Wetland ecosystem service	**Relative Importance**	**% of total value**	**WTP (thous. EUR)**
Maintaining clean water resources	1.	13.57	1665.599
Air and water purification	2.	13.29	1631.006
Habitat supply for biological species	3.	12.90	1583.501
Carbon sequestration	4.	11.30	1387.636
Photosynthesis (oxygen production)	5.	10.71	1315.327
Ensuring landscape diversity	6.	9.42	1156.111
Provision of genetic resources and medicinal plants	7.	7.50	921.072
Provisioning of berries, mushrooms and other bog products	8.	7.28	894.267
Providing opportunities for environmental education	9.	7.18	881.258
Providing recreation and leisure opportunities	10.	6.85	840.725
TOTAL		**100**	**12276.500**

It can be said that the general pattern of wetland ecosystem services ranked by subjective preferences is similar to forest ecosystem services. In the first place is the servic *Maintaining clean water resources* (13.57% of the total value, WTP 3.3 million euros). In second place is *Air and water purification* (13.29% of the total value) and in the third place *Habitat supply for biological species* (12.90). They are followed by services related to global climate regulation *Carbon sequestration* (11.30%) and *Photosynthesis* (10.71%). The last two places are cultural services, *Providing opportunities for environmental education* (7.18% of the total value) and *Providing recreation and leisure opportunities* (6.85%).

In summary, the preferences for wetland ecosystem services are very similar to those for forest ecosystem services. Of the ecosystem services provided by wetlands, people also subjectively regard services related to the quality of the environment as the most important and cultural services as the least important. The relative differences between the highest rated and lowest rated services are also similar to the forest ecosystem services. The main difference between forests and wetlands is the overall willingness to pay for ecosystem services, which is almost twice as high for forests as for wetlands, at 23.9 and 12.3 million euros per year, respectively.

7 Valuation methods and results of the selected ecosystem services

7.1 Agricultural production (crops)

According to CICES v5.1 the ecosystem service of providing agricultural food is described as plant materials (including fungi, algae) grown for nutritional purposes (under code – 1.1.1.1). In this project it is defined as the provision of agricultural crops that is used as food. Agricultural crops are grown and gathered from agricultural lands (temporary grasslands and fodder from agricultural land) and grasslands (semi-natural grasslands and permanent grasslands). Definition of fodder production ecosystem service according to CICES v5.1 can be seen in Table 14.

Table 14. Definition of the ecosystem service of fodder according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes	*1.1.1.1*	*Any crops and fruits grown by humans for food; food crops*	*The ecological contribution to the growth of cultivated, land-based crops…..*	*…that can be harvested and used as raw material for the production of food*	*Standing wheat crop before harvest (Proxy for: ecosystem contribution to growth of harvestable wheat)*	*Harvested crop; Grain in farmer's store; flour, bread*

Food production is one of the provisioning ecosystem services that agricultural lands offer. Agricultural food is a market good and therefore can be calculated using market-based methods and exchange values. The market-based methods - rent prices, and resource rent were tested in order to calculate food production for all Estonia's agricultural lands. Data from agricultural statistics and national accounts were used.

<u>Resource rent</u>

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.

<u>Rent price</u>

Rent is an expenditure user pays to the owner to use the resource. Rent payments can be related to the provision of food service provided 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 agricultural land where food was grown. Rent price data were available from agricultural statistics, as 2019 rent price data are not available yet then rent price of 2018 was used in calculations. Both rent and extent data were available on a county level and therefore it was possible to evaluate the supply of food service with rent price approach for all 15 counties separately. For some counties rent price was not available from agricultural statistics and average rent price value of whole county was then used.

In order to calculate the value of agricultural food production service average rent prices were multiplied with the extent of agricultural land in hectares.

In order to calculate the monetary value of agricultural production ecosystem service resource rent and rent price methods were tested.

Rent is an expenditure user pays to the owner to use the resource. Rent payments can be related to the provision of fodder provided 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, as 2019 rent price data are not available yet then rent price of 2018 was used in calculations. Both rent and extent data were available on a county level and therefore it was possible to evaluate the supply of fodder service with rent price approach for all 15 counties separately. For some counties rent price was not available from agricultural statistics and average rent price value of whole county was then used.

In order to calculate the value of agricultural production service average rent prices were multiplied with the extent of land in hectares.

7.1.1 Results

The resource rent value of agricultural food in 2019 was 38.6 million €, detailed calculation can be seen in Table 15.

Table 15. Resource rent value of agricultural food, 2019, €

Transaction	Value
Output	420 842 606
Less intermediate consumption	277 566 147
Less compensation of employees	68 672 582
Less other taxes on production	5 184 976
Plus other subsidies on production	85 971 482
Less consumption of fixed capital	59 112 003
Less return to produced assets	22 646 512
Less labor of self-employed persons	35 067 251
Resource rent	**38 564 618**

Based on the rent price method agricultural production ecosystem service monetary value was calculated for 15 county. Results are presented in Table 16. Total value of agricultural production service in 2019 was *ca* 32 million € and the largest contribution was from Tartumaa county (total value *ca* 5.2 million €).

Table 16. Monetary value of fodder service by county and ecosystem type, 2019, €

County	Value
Hiiumaa	158 472
Not distributed by county (home gardens)	397 482
Läänemaa	570 414
Saaremaa	673 176
Ida-Virumaa	1 049 474
Valgamaa	1 103 748
Raplamaa	1 585 480
Võrumaa	1 589 922
Pärnumaa	1 674 291
Harjumaa	1 732 576
Põlvamaa	2 015 790
Jõgevamaa	2 809 220
Järvamaa	3 317 930
Lääne-Virumaa	4 135 152
Viljandimaa	4 211 332
Tartumaa	5 248 012
TOTAL	**32 272 471**

The total value was distributed on a county level using price and area differences. For spatial distribution monetary production values from agricultural statistics and areas on map on an agricultural product level were linked (see Figure 3).

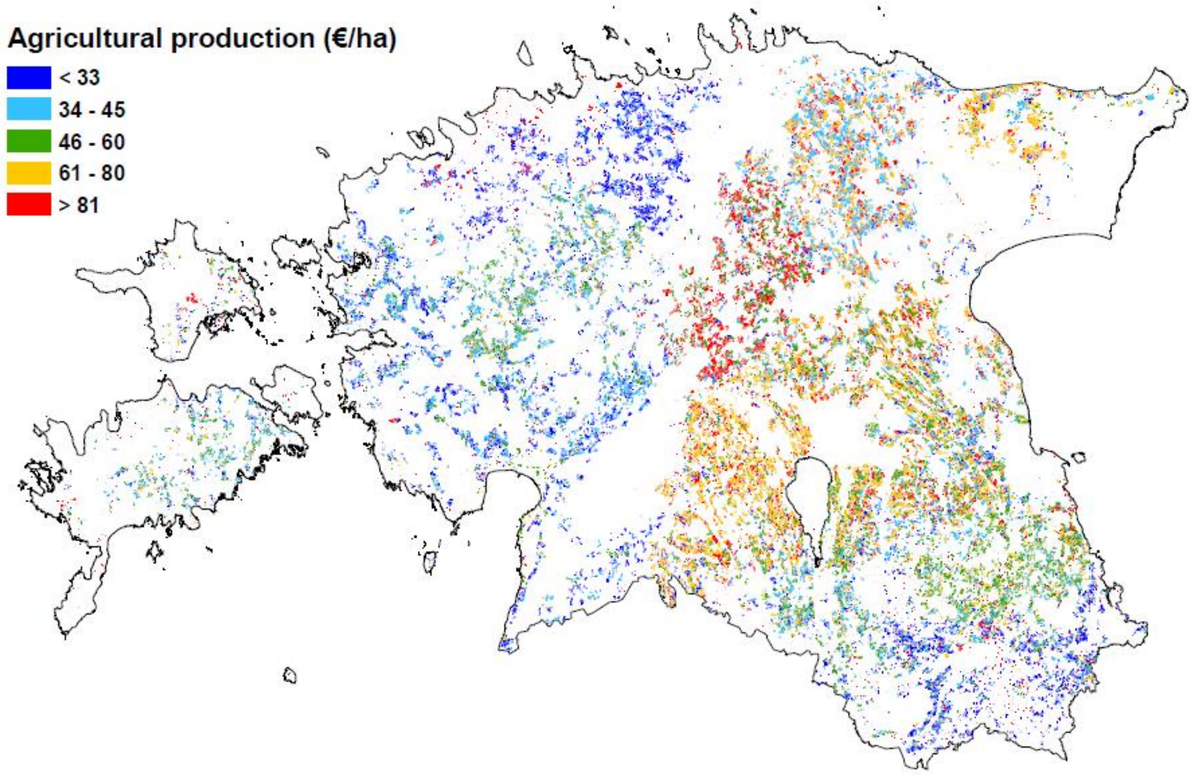

Figure 3. The ecosystem service provisioning areas and values of agricultural production. The areas coloured from blue to red represent service provisioning areas according to the unit value (€/ha) supplied by ecosystem assets that was found by rent price method. Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

7.1.2 Conclusion

Values of agricultural food calculated with resource rent and rent price methods do not differ much. Considering that resource rent method contains values that has to be estimated then the rent price method is more preferred as resource rent value is very dependent on shares and assumptions. Also the rent price method was the preferred method to estimate fodder production from grasslands in previous grant project and as the services are similar their valuation methods should be comparable. Comparability is ensured when using the same calculation method. Rent price method is also used in Statistics Netherlands.

7.2 Fodder

According to CICES v5.1 the ecosystem service of providing fodder is described as plant materials (including fungi, algae) grown for nutritional purposes (under code – 1.1.1.1). In this project it is defined as the provision of fodder that is used as feed for livestock. Fodder is provisioning service that is gathered from agricultural lands (temporary grasslands and fodder from agricultural land) and grasslands (semi-natural grasslands and permanent grasslands). Definition of fodder production ecosystem service according to CICES v5.1 can be seen in Table 17.

Table 17. Definition of the ecosystem service of fodder according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Cultivated terrestrial plants (including fungi, algae) grown for nutritional purposes	*1.1.1.1*	*Any crops and fruits grown by humans for food; food crops*	*The ecological contribution to the growth of cultivated, land-based crops.....*	*…that can be harvested and used as raw material for the production of food*	*Standing wheat crop before harvest (Proxy for: ecosystem contribution to growth of harvestable wheat)*	*Harvested crop; Grain in farmer's store; flour, bread*

In order to calculate the monetary value of fodder production ecosystem service rent price method was used. Rent is an expenditure user pays to the owner to use the resource. Rent payments can be related to the provision of fodder provided 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, as 2019 rent price data are not available yet then rent price of 2018 was used in calculations. Both rent and extent data were available on a county level and therefore it was possible to evaluate the supply of fodder service with rent price approach for all 15 counties separately. For some counties rent price was not available from agricultural statistics and average rent price value of whole county was then used.

In order to calculate the value of fodder production service average rent prices were multiplied with the extent of land in hectares. Rent price difference of agricultural land and grassland were considered.

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 fodder from agricultural land.

7.2.1 Results

Based on the rent price method fodder production ecosystem service monetary value was calculated for 15 counties. Results are presented in Table 18. Total value of fodder production service in 2019 was *ca* 24 million € and the largest contribution was from permanent grasslands (ca 8.7 million €) and from Pärnumaa county (total value *ca* 2.6 million €). But also fodder from temporary grasslands have rather high monetary value (7.8 million €) from the total value. High value from temporary grasslands can be explained with higher rent price compared to rent price for grasslands (country's average rent price for agricultural land was 62 € and for permanent grasslands 50 € in 2018).

Table 18. Monetary value of fodder service by county and ecosystem type, 2019, €

County	Agricultural lands	Temporary grasslands	Semi natural grasslands	Permanent grasslands	TOTAL
Not distributed by county (home gardens)	19 344		36 348	87 152	142 844
Hiiumaa	13 144	82 832	118 549	284 249	498 774
Läänemaa	48 087	128 466	165 171	396 039	737 763
Ida-Virumaa	101 928	252 154	131 689	315 758	801 529
Põlvamaa	182 560	515 620	62 943	150 921	912 044
Valgamaa	96 672	332 709	165 175	396 047	990 603
Jõgevamaa	247 194	451 050	134 207	321 793	1 154 244
Võrumaa	180 144	435 078	189 126	453 474	1 257 822
Harjumaa	166 924	433 144	319 212	765 388	1 684 668
Raplamaa	177 892	500 604	312 358	748 954	1 739 808
Viljandimaa	373 512	833 134	225 451	540 572	1 972 669
Tartumaa	447 139	752 598	252 300	604 950	2 056 987
Saaremaa	74 760	254 520	561 380	1 346 044	2 236 704
Lääne-Virumaa	481 430	844 254	290 888	697 476	2 314 048
Järvamaa	652 960	1 210 132	190 242	456 150	2 509 484
Pärnumaa	180 299	795 844	465 531	1 116 225	2 557 899
TOTAL	**3 443 989**	**7 822 139**	**3 620 568**	**8 681 194**	**23 567 890**

Spatial distribution was made using soil fertility rate and area of ecosystem types on a county level (presented on Figure 2).

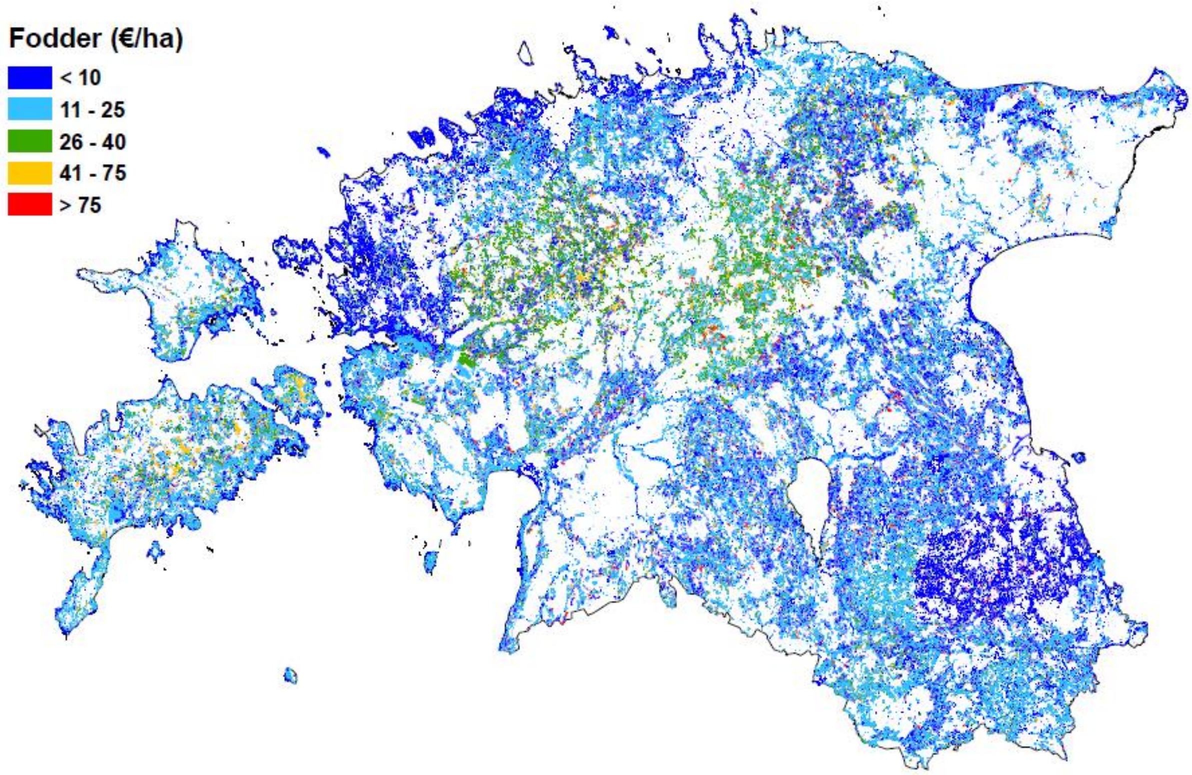

Figure 4. The ecosystem service provisioning areas and values of fodder provisioning. The areas coloured from blue to red represent service provisioning areas according to the unit value (€/ha) supplied by ecosystem assets that was found by rent price method. Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

7.2.2 Conclusion

The rent price method is considered to be good approach to calculate monetary value of fodder production ecosystem service. Input data for calculations are available from agricultural statistics and are collected via annual survey and therefore the calculations can be made regularly. Rent price method is considered to be more reliable compared to resource rent method that was tested in the last project as it uses less assumptions. Rent price method is also used in Statistics Netherlands.

The calculations show that the monetary value of ecosystem provisioning service for fodder was 23.6 million € in 2019. Using yield and input data the total value was distributed: semi-natural grassland, permanent grassland, temporary grassland and fodder from agricultural land.

7.3 Timber

According to CICES v5.1 the ecosystem service of providing timber is described as cultivated terrestrial plants for nutrition, materials or energy (under code 1.1.1.2, Table 19). Here it is defined as the harvest of timber as an input to forestry sector. Ecosystem assets that contribute to the provision of timber are forests.

Table 19. Definition of the ecosystem service of timber according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Fibres and other materials from cultivated plants, fungi, algae and bacteria for direct use or processing (excluding genetic materials)	*1.1.1.2*	*Material from plants, fungi, algae or bacterial that we can use*	*The ecological contribution to the production of plants, fungi, algae or bacterial…*	*…that can be harvested and used as raw material for non-nutritional purposes*	*Harvesta ble surplus of annual tree growth*	*Processed timber (Volume of harvested wood)*

Timber production is one of the ecosystem services that wooded areas offer. It is an important provisioning ecosystem service having the highest value among ecosystem services in Estonia. Timber production shows the monetary value of extracted timber that is an input for economic activities. User of the service is forestry sector.

Harvested timber is also included in national accounts calculations and is a SNA value.

In order to calculate monetary value of timber production service physical harvest amounts by timber owner (State Forest Management Centre or other ownership), assortment and stumpage prices by timber species and assortment were used. As 2019 harvest data are not available yet 2018 data were used in calculations. Data were available for both State Forest Management Centre and other ownership (including also state forests) forests. 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 of harvested timber.

Physical data were available from Environment Agency and intermediate price data were available from State Forest Management Centre. In order to calculate stumpage prices felling costs had to be subtracted from intermediate prices. Felling costs consist average stem volume of harvest (calculated using height and diameter by age and tree species) and average transport distance. Felling costs were available from national accounts and were estimated based on 2017 data.

The value of the timber production ecosystem service was calculated by multiplying the stumpage prices with the amount of wood harvested. Differences between tree species and assortments were considered.

7.3.1 Results

Results of calculations using stumpage price method are seen in Table 20. Value of timber ecosystem service using stumpage price was 338.6 million € in 2018. The biggest value came from spruce. It is also seen that timber contribution to the total value is more than 2 times larger from forests of other ownership. The reason behind it are larger physical harvested timber amounts.

Table 20. Stumpage value of timber production by tree species, 2018, €

Tree species	State Forest Management Centre	Other ownership	Total
Spruce	41 102 423	66 323 163	**107 425 586**
Pine	53 738 305	112 476 082	**166 214 387**

Birch	11 570 540	34 620 270	**46 190 810**
Aspen	3 326 747	4 221 487	**7 548 234**
Alder	1 642 223	3 449 480	**5 091 703**
Gray-alder	470 897	3 653 742	**4 124 639**
Other	369 177	1 637 957	**2 007 135**
Total	**112 220 312**	**226 382 182**	**338 602 493**

Other aspect that was discussed in the grant project was the monetary value of standing timber that is considered under inventories of work- in-progress in national accounts and is part of output value in SNA. Question how the value should be considered in ecosystem accounts aroused.

According to the methodology used in national accounts to obtain the value of standing timber, first, the net growth has to be calculated from timber growth data, and thereafter, multiplied by stumpage prices. The calculations are made for each tree species and timber assortment both for State Forest Management Centre and other owners. First, the total volume lost due to natural death of trees is deducted from timber growth. Therefore, the growth of every tree species is reduced by the share of this approximation from the volume of timber growth.

Thereafter, the remaining timber growth is distributed into timber assortments, using the assortment shares from the felling data, from which the volume of felling is deducted. The result of the calculations is the net growth for every tree species and timber assortment.

The value for the total net growth of standing forest of Estonia is obtained by multiplying the various net growths by their stumpage prices and by summing up across all the tree species and ownerships.

After consulting with Statistics Netherlands it was agreed that standing timber has not been used in economy and therefore also timber ecosystem service has not been provided and hence standing timber e.g. unfinished production (in national) was not added to timber provisioning service.

In order to distribute timber ecosystem value on a map, information from the Forest Register was used. The Forest Register contains spatial information about forest notification with the notation on the permission for cutting. Harvest information was distributed by type of harvest (clearcutting and other), owner (State Forest Management Centre or other ownership) and the main tree species (7 categories). Based on the information 28 separate groups were formed (type of harvest (2), owner (2), tree species (7); 2*2*7=28) to which the timber ecosystem value was distributed. Clear cutting groups values were given two times higher weight than other types of harvest as clearcutting provides larger amount of more expensive timber assortments.

For the distribution by ecosystem types spatially explicit data of felling notices was used.

It is not possible to present the timber production value on the map on detailed spatial distribution level at the moment as spatial information of harvest in private forests is largely confidential. Spatial information of harvest in state forests could be published but then timber ecosystem value would be presented on the map only partially. In order to publish total timber value on map further analyse is needed.

7.4 Herbaceous biomass used for producing energy (bioenergy)

According to CICES v5.1 the ecosystem service of providing biomass for producing energy is described as plant materials used as a source of energy (wild plants under code 1.1.5.3, cultivated plants – 1.1.1.3). Here it is defined as the contribution of biomass by ecosystem assets to the production of energy by energy sector. Ecosystem assets that contribute to the provision of herbaceous biomass that is used as a material for producing energy are semi-natural grasslands and agricultural lands where the material these provide are grass and remaining straw after the harvest of the crops respectively.

Table 21. Definition of the ecosystem service of herbaceous biomass used for producing energy according to CICES v5.1

Class	**Code**	**Simple descriptor**	**Ecological clause**	**Use clause**	**Example Service**	**Example Goods and Benefits**
Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy	*1.1.5.3*	*Materials from wild plants, fungi and algae used for energy*	*Parts of the standing biomass of a non-cultivated plant, fungi, algae or bacteria species…*	*…that can be harvested and used as an energy source*	*Volume of harvested wood*	*Fuel wood*
Cultivated plants (including fungi, algae) grown as a source of energy	*1.1.1.3*	*Plant materials used as a source of energy*	*The ecological contribution to the growth of cultivated crops…..*	*…that can be harvested and used as a source of biomass-based energy*	*Standing crop of Miscanthus at time of harvest*	*Energy production*

We used the market price of harvested grass/straw with the purpose to be used as fuel as it is the best estimation of the value of the ecosystem service. For valuing the service the data about the quantity and purchase prices of fuels recorded in energy statistics were used.

Name of the dataset	**Data type**	**Source**
1251 - Consumption of fuels and energy 2019	Statistics	Statistics Estonia

The companies which used grass/straw as a fuel were determined and the purchase prices they had paid for the fuel were added. Fuel types that were included in the calculations were: crops (under code 1171), straw (1172), rapeseed waste (1174). Prices without VAT were used in calculations to decrease the amount of human input. No further deductions of other human input were made.

7.4.1 Results

Currently only one company, Lihula boiler house, produces heat from biomass harvested from semi-natural grasslands in Estonia, the remaining amount can be attributed to agricultural land.

The results can be seen in Table 22. According to market price, the value of the service of providing biomass for producing energy was 134 thousand € (without VAT) in 2019, which was divided between semi-natural grasslands (46 thousand €) and croplands (88 thousand €).

Table 22. Quantity and ecosystem service value of herbaceous biomass used for producing energy distributed by provisioning ecosystem types 2019.

Provisioning ecosystem	Quantity of harvested biomass used for producing energy (tonnes)	Purchase price without VAT (€)
Semi-natural grasslands	1 079	45 926
Crops	3 443	87 889
TOTAL	**4 522**	**133 815**

The ecosystem service was previously valued for semi-natural grasslands[12], where it was found that according to market price the value of the service of biomass provided by semi-natural grasslands for producing energy was 51 thousand € (without VAT) in 2017. In 2019, the value attributed to semi-natural grasslands was 46 thousand €. The value of the service provided by semi-natural grasslands in both years can be considered similar.

The volume of herbaceous biomass entering the economy as a raw material for energy production is very low, only 0.13 million € according to market price method. The total value of raw material used for energy production is 606 million, which means that the ecosystem service makes up only 0.02% of the material used in the sector. Considering the latter and the potential supply, i.e. the estimation that without alternative uses of biomass and other obstacles like technical issues, 2% of Estonian primary energy consumption could be replaced by bioenergy that comes from semi-natural habitats[13], we found that currently the flow of the ecosystem service of herbaceous biomass used for producing energy has an insignificant role in the energy sector and it adds very little value to the ecosystem services account as a whole.

7.4.2 Conclusion

Worldwide, renewable energy sources in electricity and heat production and the transport sector are on the rise. According to Elering's data, a total of 1970 GWh of electricity was generated from renewable sources in 2019, of which 1162 GWh was produced from biomass and waste. Biomass here means primarily wood waste.

At the moment only Lihula boiler house produces heat from herbaceous biomass by using hay, straw and reed from semi-natural grasslands and crop waste from agriculture. However, it is known that the potential for using herbaceous biomass is significantly higher. According to a study from 2015, Estonia has the potential to produce approximately 450 million Nm3 of biomethane per year, the resource of which would be predominantly herbaceous biomass.[14] Despite of fact that the potential of

[12] Statistics Estonia, 2020. Development of the land account and valuation of ecosystem services regarding grassland ecosystem services (Eurostat Grant Agreement no NUMBER — 831254 — 2018-EE-ECOSYSTEMS) https://www.stat.ee/sites/default/files/2021-06/Methodological%20report_831254_2018_EE_ECOSYSTEMS_revised_version_31_03.pdf

[13] Lepasaar, Helli & Ehrlich, Üllas. (2015). Non-market value of Estonian semi-natural grasslands: a contingent valuation study. Eesti poolloodusliku rohumaa turuväline väärtus: tingliku hindamise uuring. Discussions on Estonian Economic Policy. 23. 10.15157/tpep.v23i2.12494.

[14] Vohu, V. (2015) Eesti biometaani ressursside kasutuselevõtu analüüs http://www.arengufond.ee/wp-content/uploads/2015/10/Eesti_biometaani_ressursside_kasutuselev%C3%B5tu_anal%C3%BC%C3%BCs.pdf

herbaceous biomass is significant it remains untapped, as there is no interest and investments in the use of this energy source.

In order to calculate the monetary value of this ecosystem service, the market price method was used in this study. As herbaceous biomass is used for energy production in Estonia, there is also a market for it. The market price method is very suitable for calculating the monetary value of provisioning services, as the market price most clearly expresses the society's willingness to pay.

Data on the quantity of herbaceous biomass and purchase price are recorded in energy statistics that are a reliable source of raw data for calculations.

The value of herbaceous biomass entering the economy as a raw material for energy production is, according to the study, 0.13 million euros, which is 0.02% of the total price of the material used in the energy sector. As the results show that the use of herbaceous biomass as an energy source is marginal in Estonia, the calculation of its monetary value could be abandoned in this study.

7.5 Wild berries and mushrooms

According to CICES v5.1 the ecosystem service of providing wild berries and mushrooms is described as wild plants used for nutrition (1.1.5.1). Here the ecosystem service is viewed as the provision of wild berries and mushrooms that are used for self-consumption or sold in markets. The service provisioning assets are forest or bog ecosystems.

Table 23. Definition of the ecosystem service of wild berries and mushrooms according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Wild plants (terrestrial and aquatic, including fungi, algae) used for nutrition	*1.1.5.1*	*Food from wild plants*	*Parts of the standing biomass of a non-cultivated plant species…*	*…that can be harvested and used for the production of food*	*Harvestable volume of wild berries or wild mushrooms, Or Benthic macroalgae (e.g. Dulse, Laminaria (Kelp)) and macrophytes (e.g. Salicornia and other saltmarsh plants) harvested in the shallow sublittoral and/or littoral zone*	*Berries as food or for the production of jam*

Gathering various berries and mushrooms has a long tradition in Estonia, which was likely the highest during the Wold War I and Soviet era when wild berries and mushrooms were important for self-consumption and commercial purposes[15]. With changed consumer behaviour and more options, the

[15] Paal, T. 1999. Wild berry and mushrooms resources in Estonia and their exploitation. – Metsanduslikud uurimused XXXI, 131–140. ISSN 1406-9954. http://mi.emu.ee/userfiles/instituudid/mi/MI/FSMU/1999/mets_31-15.pdf

importance of gathering berries and mushrooms has decreased by now. Aside for self-consumption or marketing, people report gathering berries and mushrooms also for leisure activity[16].

Wild berries and mushrooms are marketed goods and there exists a market for the more popular species. Therefore the best and most straightforward method for the valuation of the service would be market price method where used quantity is multiplied with the average market price. However, with the domain losing its importance and since the change of state order in 1990s, the available data and statistics about accurate quantity of overall usage of wild berries and mushrooms has decreased.

The main data source for the quantity of gathered wild berries and mushrooms is Estonian Social Survey 2019 which collects data about household consumption of wild berries and mushrooms (I). Additionally two other data sources were used to find the quantity of gathered wild berries and mushrooms: survey data that is reported in literature (II), potential wild berry and mushroom yields combined with literature data on the share of wild berries or mushrooms which the population uses (III). Overview of the data sources is given in Table 24.

Table 24. Data sources for the ecosystem service of provisioning wild berries and mushrooms. The first column shows the identification number of the approach the data was used for.

	Name of the dataset	Data type	Source
I	Estonian Social Survey 2019. Household consumption. Quantity of consumed wild berries and mushrooms (kg)	Statistics	Statistics Estonia
II	Quantity of gathered wild berries, mushrooms (l)	Literature	Marjade ja seente korjamine elanikkonnas
III	Potential yield of bilberries, cowberries, mushrooms (kg/ha)	Spatial data	ELME project
III	Quantity of gathered wild berries, mushrooms (%)	Literature	Paal, T., 2011. Metsamarjade ja seente varumine
I, II, III	Weekly reports of produce prices on major markets 2019 (kg/ha)	Price data	Maaleht, Toiduainete enam levinud hinnad (€/kg) turgudel, 2019

<u>I approach</u>

Estonian Social Survey[17] is carried out yearly to get information on dwelling and living conditions, health, employment and job search, income, economic well-being, social exclusion, poverty risk, childcare, etc. of the population. As part of the production for self-consumption, data on gathered wild berries and mushrooms is also collected. The results are analysed by household composition. The output is based on the education, social status, sex, age and other important characteristics of household members.

Based on the data, 1231 tons of wild berries and 1632 tons of mushrooms were gathered by the whole population for household consumption in 2019.

<u>II approach</u>

[16] Remm, L., Rünkla, M. and Lõhmus, A. 2018. How Bilberry Pickers Use Estonian Forests: Implications for Sustaining aNon-Timber Value. Baltic Forestry 24(2): 287-295 https://www.balticforestry.mi.lt/bf/PDF_Articles/2018-24%5B2%5D/Baltic%20Forestry%202018.2_287-295.pdf

[17]Sotsiaaluuring 2019 https://www.stat.ee/et/statistika-too/sotsiaaluuring-2019#10-Kattesaadavus-9

During the past two decades several surveys have been carried out among the general public or forest owners with the purpose to understand the values and habits of the population regarding natural environment[18,19] or the importance of the by-products of the forests[20,21,22]. The surveys in some degree also touch upon the use or gathering habits of wild berries and mushrooms.

Survey ordered by RMK and published in 2011 by Turu-Uuringute AS[23] can be considered the most comprehensive and precise regarding the use of wild berries and mushrooms and we used the quantity reported in the survey results as the basis of the valuation of the ecosystem service of provisioning wild berries and mushrooms.

In the survey the percentage of respondents who had gone berry or mushroom gathering in the previous year and their average yield, divided between berries or mushrooms, but without no further distinction, were extrapolated to the whole population. As a result approximately 5 million litres of berries and 8 million litres of mushrooms were gathered.

4 % stated that the main use for the harvest was marketing, the majority of the harvest was household consumption whether to be preserved (freezing, homemade jam etc.) or eaten fresh.

III approach

Information from literature and results of ELME project[24] were used as alternative data sources for the valuation of wild berries and mushrooms with market price method. ELME published raster maps of the potential yearly yield (kg/ha) of bilberries, lingonberries and mushrooms. For each type, the total yield (kg) was calculated by multiplying the potential yearly yield (kg/ha) with the area supplying that yield (ha). It was found that the potential natural yield of bilberries is 53 million kg, for lingonberries it is 42 million kg, for cranberries 58 million kg and for mushrooms 84 million kg. The numbers are presented in Table 29.

According to Paal (2011)[25] about 15–25% of cranberry, 30–50% from bilberry and 40% of lingonberry biological yield is picked yearly. From mushrooms, only a little part of all potential yield is picked, about 1.5%.[26]

The yearly average market price of most common berries and mushrooms were calculated separately based on weekly reports of produce prices on major markets published in the newspaper (Maaleht).

---

[18] Turu-uuringute AS. 2020. Eesti elanike keskkonnateadlikkuse uuring. August 2020. https://www.envir.ee/sites/default/files/ASO/2020_keskkonnateadlikkuse_uuring.pdf

[19] Sepp, K., Lõhmus, A., 2019. 3.1 Kuidas inimesed Eesti looduskeskkonda kasutavad? Inimarengu aruanne 2019/2020. Eesti Koostöö Kogu https://inimareng.ee/eesti-inimarengu-aruanne-20192020.html

[20] Kaldaru H., 2008. Metsa mitmekülgne kasutamine. Elanikkonna, erametsaomanike ja väikeettevõtjate küsitlus, Turu-Uuringute AS. https://www.eramets.ee/static/files/152.Turu-uuringu_aruanne_2008.pdf

[21] Kaldaru, H., 2011. Marjade ja seente korjamine elanikkonnas, Turu-Uuringute AS. https://media.rmk.ee/files/Marjade%20ja%20seenete%20korjamine.pdf

[22] Turu-uuringute AS. 2019. Erametsaomanike küsitlusuuring. Mai-juuni 2019. https://www.eramets.ee/wp-content/uploads/2019/10/Erametsaomanike-uuringu-2019-aruanne.pdf

[23] Kaldaru, H., 2011. Marjade ja seente korjamine elanikkonnas, Turu-Uuringute AS. https://media.rmk.ee/files/Marjade%20ja%20seenete%20korjamine.pdf

[24] Projekt ELME – „Elurikkuse sotsiaal-majanduslikult ja kliimamuutustega seostatud keskkonnaseisundi hindamiseks, prognoosiks ja andmete kättesaadavuse tagamiseks vajalikud töövahendid" (projekt nr 2014-2020.8.01.16-0112; kaasrahastajad Euroopa Liidu Ühtekuuluvusfond ja SA Keskkonnainvesteeringute Keskus)

[25] Paal, T., 2011. Metsamarjade ja seente varumine. Akadeemilise Metsaseltsi Toimetised. XXV. Metsa kõrvalkasutus Eestis. Tartu, lk 67-72

[26] Kalamees, Kuulo; Vaasma, Mall (1980). Eesti seenevarud, nende senine kasutamine ja perspektiivid. Eesti Loodusuurijate Seltsi Aastaraamat (15–31). Eesti Looduseuurijate Selts.

Originally full prices including VAT were reported. To better represent the ecosystem contribution to the service, VAT was excluded (20%) and further calculations were done with these numbers.

For berries, cranberry, bilberry and cranberry prices were included. First the average was found for each type of berry and then it was averaged again. Similar approach was applied for the price of mushrooms where prices on chanterelles, boletes, milkcaps were reported. The detailed breakdown of the berry and mushroom species with prices is presented in Table 25.

Table 25. Yearly average market price of wild berries and mushrooms, 2019, €/kg without VAT.

	Yearly average market price, 2019 (€/kg without VAT)			
Berries	Cranberry	Bilberry	Lingonberry	**Berries total**
	4.5	5	4.2	**4.6**
Mushrooms	Chanterelle	Bolete	Milkcaps	**Mushrooms total**
	8.3	9.2	5.1	**7.5**

7.5.1 Results

<u>I approach</u>

Based on the calculations of I approach which used data from Estonian Social survey, the ecosystem provisioning service value of providing wild berries and mushrooms when used for self-consumption by households is 17.8 million €.

It should be noted that the Estonian Social survey contains information only about self-consumption, the quantities of wild berries or mushrooms gathered for the marketing purposes are excluded. We used the share of 4% that people reported to gather wild berries or mushrooms for the marketing purposes[27] and assumed that the household consumption (96%) and marketed quantity (4%) form the total consumption and equal total ecosystem service value).

Including wild berries and mushrooms for marketing purposes adds 0.7 million € to the service value, giving us a total of approximately 18.6 million €.

Wild berries contribute 5.9 million € and mushrooms over two times more – 12.7 million € to the total value. The breakdown of the components in the ecosystem service valuation of provisioning wild berries and mushrooms is presented in Table 26.

Table 26. Quantity and ecosystem service value of provisioning wild berries and mushrooms in 2019 based on the data from Estonian Social survey in 2019.

	Quantity for household consumption 2019 (kg)	**Average price 2019 (€/kg without VAT)**	**Value of household consumption (€)**	**Value of marketed quantity - 4% in addition to household consumption (€)**	**TOTAL SERVICE VALUE (€)**
Wild berries	1 231 091	4.6	5 663 019	235 959	**5 898 978**
Wild mushrooms	1 622 970	7.5	12 172 272	507 178	**12 679 450**
TOTAL			**17 835 291**	**743 137**	**18 578 428**

[27] Kaldaru, H., 2011. Marjade ja seente korjamine elanikkonnas, Turu-Uuringute AS. https://media.rmk.ee/files/Marjade%20ja%20seenete%20korjamine.pdf

The survey data included administrative data. Considering confidentiality and confidence levels the county level was considered the most appropriate for the distribution of the values. The ecosystem service value for berries and mushrooms was attributed to the counties based on the respective quantities reported in the survey. The data was further converted into spatial data using a map layer of county borders in 2019.[28]

Via GIS analysis the county level data for berries was overlaid by average yield data which was derived from map layers on natural potential yield of cranberry, bilberry, lingonberry which were created by ELME project. Mushrooms were treated similarly, where map layer on average yield of mushrooms created by ELME project was used as an input. Based on GIS analysis, the contribution of different ecosystem types to the service value was found. The results are shown in Table 27 and spatial allocation is given in illustrative maps in Figure 5 and Figure 6 for berries and mushrooms respectively.

Table 27. Ecosystem service value of wild berries and mushrooms by ecosystem types, 2019.

Ecosystem type	**Value of the ecosystem service 2019, €**	
Forest	18 021 334	
…drained peatland forests		1 956 073
…mesotrophic boreal forests		2 922 445
…eutrophic alvar forests		321 799
…oligotrophic boreal heath forests		473 180
…oligo-mesotrophic boreal forests		9 307 571
…oligotrophic paludifying forests		719 474
…minerotrophic swamp forests		102 611
…eutrophic boreo-nemoral forests		292 813
…mixotrophic and ombrotrophic bog forests		984 031
…eutrophic paludifying forests		927 861
…forest on reclaimed pits		13 476
Grassland	5 286	
…heaths		1 218
…semi-natural grasslands		4 067
Wetland	551 808	
…fens		713
…transition mires		201 560
…peat bogs		349 536
Total supply	**18 578 428**	

[28] Maakond 01.01.2019
https://geoportaal.maaamet.ee/docs/haldus_asustus/ajaloolised/maakond_2019.zip?t=20210323111906

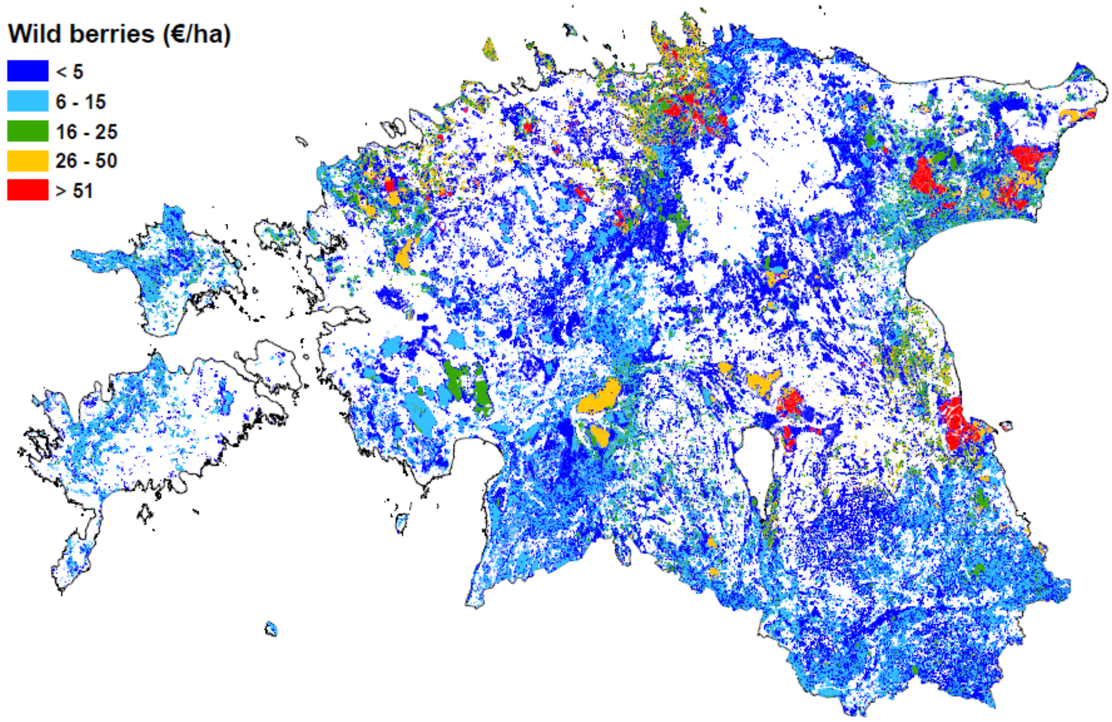

Figure 5. The ecosystem service provisioning areas and values of wild berries provisioning. The areas coloured from blue to red represent service provisioning areas according to the unit value (€/ha) supplied by ecosystem assets that was found by market price method. Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

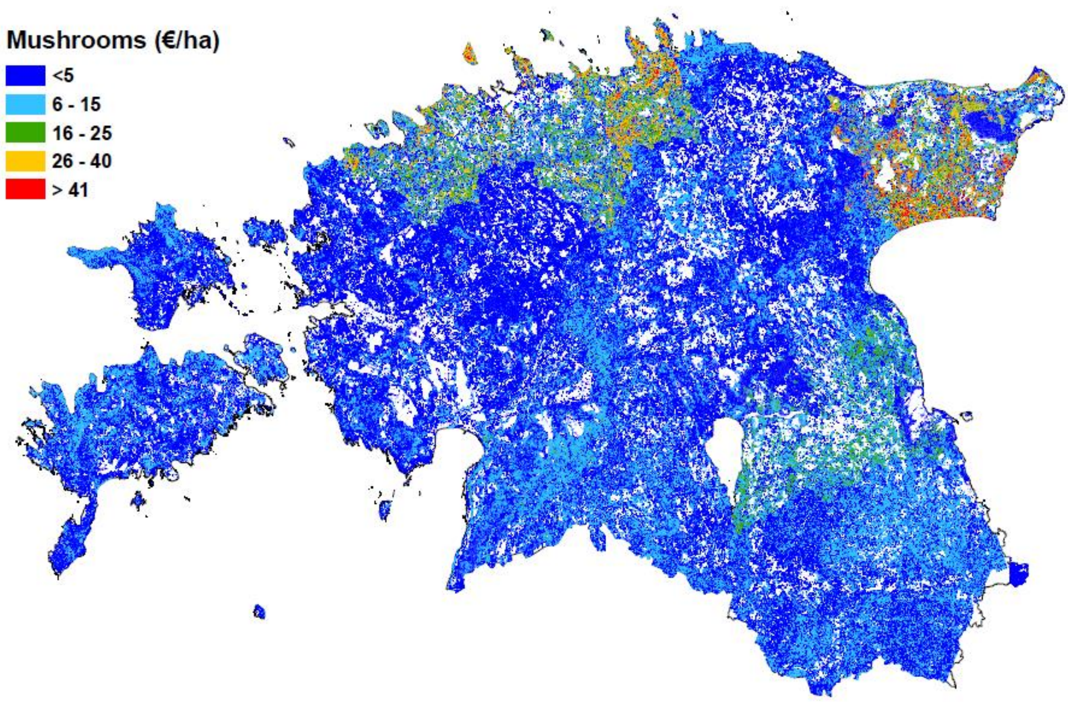

Figure 6. The ecosystem service provisioning areas and values of mushrooms provisioning. The areas coloured from blue to red represent service provisioning areas according to the unit value (€/ha) supplied by ecosystem assets that was found by market price method. Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

II approach

The II approach used data from the survey ordered by RMK and published in 2011 by Turu-Uuringute AS. The survey results on the quantities of berries and mushrooms were in litres, therefore they needed to be converted into kilograms. By multiplying these quantities by price, the ecosystem provisioning service value of providing wild berries and mushrooms was found to be 16.1 million € for wild berries and 20.25 million € for mushrooms. The total value of the ecosystem service of provisioning wild berries and mushrooms was 36.4 million € in 2019. The calculation inputs and results are presented in Table 28.

Table 28. Quantity and ecosystem service value of provisioning wild berries and mushrooms in 2019 based on the data from the survey ordered by RMK and published in 2011 by Turu-Uuringute AS.

	Quantity (l)	**Quantity (kg)**	**Average price 2019 (€/kg without VAT)**	**TOTAL SERVICE VALUE (€)**
Wild berries	5 000 000	3 500 000	4.6	16 100 000
Wild mushrooms	8 000 000	2 700 000	7.5	20 250 000
TOTAL				**36 350 000**

III approach

Based on the calculations of III approach, which used modelled natural potential yield and literature data, the ecosystem provisioning service value of provisioning wild berries and mushrooms was 198 – 277 million €. Wild berries (bilberry, lingonberry, cranberry) contribute the vast majority to the value, 189 to 268 million €, while mushrooms contribute 9.4 million €. The results are presented in Table 29.

Table 29. Potential yield, real yield and ecosystem service value of provisioning wild berries and mushrooms in 2019 based on used modelled natural potential yield and literature data.

	Potential yield (kg)	**Percentage picked (%)**	**Real yield (kg)**	**Average price 2019 (€/kg without VAT)**	**TOTAL SERVICE VALUE (€)**
Bilberry	52 694 583	30 - 50	15 808 375 – 26 347 292	5	79 041 875 – 131 736 458
Lingonberry	42 309 916	40	16 923 966	4.2	71 080 659
Cranberry	57 826 210	15 -25	8 673 932 – 14 456 553	4.5	39 032 692 – 65 054 487
Wild mushrooms	84 258 251	1.5	1 263 874	7.5	9 479 053
TOTAL			42 670 147 – 58 991 684		198 634 279 – 277 350 656

Conclusion on approaches

We considered I approach to give the best estimation for the ecosystem service value as the Estonian Social survey is carried out yearly and the results can be easily interpreted.

The three approaches, especially the third approach, show big differences in results for berries (Table 30). When compared with the first or second approach, which used survey data (2019 and 2011), the values obtained with the third approach are likely strongly overestimated. The overestimation may be derived from separate components of input data or from their combination. Most likely the percentage of picked berries which dates back to 1990s is outdated because the consumption habits of the population has changed and the need for berry picking as a way to diversify dining table is not as high anymore.

Using potential maximum yield can also lead to overestimations. Even when the growing conditions in the ecosystem asset could provide the maximum yield, the final yield per year is also influenced by weather conditions of that year etc., which were not currently taken into account.

The monetary value for mushrooms found by IIII approach does not show a big difference with the results obtained with I or II approaches. On the contrary, it is up to two times less than value obtained by the II approach and approximately ¾ of the value obtained by the first approach.

The second approach gave higher values for both berries and mushrooms when compared to the values obtained by I approach. The differences are about 1.5- 2.7 times.

Table 30. Comparison of the ecosystem service value of provisioning wild berries and mushrooms in 2019 found by three different approaches: I- based on the data from Estonian Social survey , II- based on the data from the survey ordered by RMK and published in 2011 by Turu-uuringute AS, III- based on the modelled natural potential yield and literature data.

	Ecosystem service value of provisioning wild berries and mushrooms in 2019 (million €)		
Approach	**I**	**II**	**III**
Berries	5.90	16.10	189 - 268
Mushrooms	12.68	20.25	9.48
Total	18.58	36.35	199 - 277

Results. Provisioning of wild berries and mushrooms valued by CVM

The service was also valued with CVM, where it was valued for 1.4 mln € in forests and 0.9 mln € in wetlands. For more information, see chapter 6.2.

7.5.2 Conclusion

In Estonia, picking wild berries and mushrooms is an activity with a long tradition. In previous centuries, wild berries and mushrooms provided an important addition to the family table. In this century, picking wild berries and mushrooms is seen more as a holiday in nature and as an opportunity to enrich the dining table with "exclusive, home-made products".

The literature recommends the use of methodologies based on market price surveys to calculate the monetary value of provisioning ecosystem services. The market price method has been used to calculate the monetary value of wild berries and mushrooms.

Estonian Institute of Economic Research publishes weekly a review of market prices of wild berries and mushrooms. These are reliable data and are also used in this study.

It is extremely difficult to find the quantities of harvested wild berries and mushrooms. In fact, it is almost impossible to estimate how many people are picking wild berries and mushrooms as it depends on a great many circumstances. Also it is difficult to estimate the amount of berries / mushrooms collected, as these are generally not weighed and no records are kept of quantities.

Data from three different sources have been used to obtain the quantities of wild berries and mushrooms:

1. Data from expert assessments;
2. Data from household survey;

3. Data that are obtained by multiplying habitat surface and pilot plot harvest results.

The first alternative provided a monetary value of 18 578 428 EUR for the provision of wild berries and mushrooms, the second alternative 36 350 000 EUR and the third alternative 198 634 279 - 277 350 656 EUR. The third alternative overestimates definitely the amount of mushrooms and berries collected from the forests and bogs.

The quantities of wild berries and mushrooms collected by the household survey is estimated as the most reliable source of data. In order to obtain more accurate results, it would be necessary to develop a methodology and conduct a study to assess the quantities of mushrooms and berries harvested from the forests and bogs.

7.6 Wild game

The ecosystem service is providing wild game (hereinafter *game*). The ecosystem service of provisioning of game is closely related to hunting as the first is a prerequisite for the latter. Providing game (in sense of game meat) is considered as a provisioning ecosystem service whereas hunting is considered as a recreational activity under cultural ecosystem services. People are involved in hunting for both purposes and these often overlap. Therefore it is difficult to determine under which category the service of provisioning of game/hunting falls or how to divide it into shares.

In the development of suitable methods to assess the value of the ecosystem service of provisioning of game/hunting we consider two approaches: first, provisioning of game as a provisioning service and secondly hunting as a cultural service which is included in the assessment of recreational ecosystem service. The two approaches characterize two different aspects that the ecosystems provides, and use different data as an input, therefore it is possible to add up the provisioning and recreational value of game/hunting when overlapping part is distinguished.

According to CICES v5.1 the ecosystem service of providing game is described as wild animals (terrestrial and aquatic) used for nutritional purposes. The ecosystem provisioning service of providing game is defined as the provisioning of elements needed for the growth and livelihood of game (food, water and habitat) by ecosystem asset. The economic benefit is the meat from wild game. The beneficiaries and users of the service are meat processing companies that use the game as the input to their production.

Table 31. Definition of the ecosystem service of provisioning game according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service
Wild animals (terrestrial and aquatic) used for nutritional purposes	1.1.6.1	*Food from wild animals*	*Non-domesticated, wild animal species and their outputs…*	*…that can be used as raw material for the production of food*	*Harvestable surplus of cod population, or deer population*

People in Estonia go hunting to obtain game for their own use or sell it to meat processing companies who sell the products made out of it. As game is traded in the market, it gives the reason to use the market prices to value the service. Only some of the big game: elk, red deer, roe deer, wild boar, and brown bear have commercial importance in that approach. Skins of elk and red deer are traded in small quantity. Because of the lack of demand, skins of small game are not traded in the market.

Name of the dataset	Data type	Source
Hunted game 2019/20	Statistics	Estonian Environment Agency
Weight of game's cold body	Literature	Statistics Estonia
Purchase prices of game meat in 2019	Table	Meat processing companies

We considered using the sum of the quantity of hunted big game multiplied by the average quantity of meat obtained from the game species (weight of game carcass) and purchase price of game meat (without value-added tax (VAT)) a good approximation for the value of the ecosystem service of providing game.

$$Service\ value\ of\ providing\ game = \sum_{i=1}^{n} a_i * b_i * c_i + \sum_{i=1}^{n} a_i * d_i$$

where a_i - quantity of hunted game species;
b_i – average weight of the cold body of game species (kg);
c_i - average price of the meat of game species (without VAT) (€/kg);
d_i – price of skin of game species (without VAT) (€/kg);

The statistics for hunted game is available for the hunting year 2019/2020 (from March 2019 to February 2020), we considered it as an input for the year 2019. The statistics include hunted game for each hunting district, the area of hunting district and the number of users (hunters) of hunting districts.

Purchase prices of big game for the current year are available on web sites of meat processing companies. There are two to three categories for prices depending on the quality of the shot and body weight. The first category has the highest quality and is also priced the highest. The average price for each species was found by taking the most common price of the first category which is the category of the highest quality. The average weight of the cold body of the game was found for a project carried out by Statistics Estonia in 2020 and it is based on expert opinion of companies which buy in game and process meat[29].

The value of skins was also added. The purchase prices of skins of elk and red deer were obtained from the webpage of Estonian Hunters' Society[30] which purchases the skins for further reprocessing. For elk, the skins for adult and calf are bought. These are priced differently, so the price for the skin of the elk was found with the average.

7.6.1 Results

[29] Statistics Estonia, 2020. Development of the land account and valuation of ecosystem services regarding grassland ecosystem services (Eurostat Grant Agreement no NUMBER — 831254 — 2018-EE-ECOSYSTEMS) https://www.stat.ee/sites/default/files/2021-06/Methodological%20report_831254_2018_EE_ECOSYSTEMS_revised_version_31_03.pdf

[30] http://www.ejs.ee/

Table 32. Quantity and ecosystem service value of provisioning wild game in 2019.

Game	Hunted game 2018/19	Average weight of cold body (kg)	Average purchase price of meat without VAT (€/kg)	VALUE of game meat (€)	Purchase price of skin (€ per skin)	VALUE of skins (€)	VALUE of the service (€)
Elk	6304	205	3.7	4 781 584	11	69 344	
Red deer	2543	95	2.5	603 963	4	10 172	
European roe deer	31032	22.5	2.4	1 675 728			
Wild boar	4820	109	2.8	1 471 064			
Brown bear	67	150	10	100 500			
TOTAL				**8 632 839**		**79 516**	**8 712 355**

Based on the calculations the ecosystem provisioning service value of providing game is 8.7 million €. The value of the components that make up the total value of providing game can be seen in Table 32. The biggest contributor to the value of the game meat are elk, followed by European roe deer and wild boar.

The ecosystem service was previously valued with the same method. Then it was found that according to the market price method the value of the service was 8.5 million € in 2018. Compared to the value of 8.7 million € in 2019, it can be seen that there are no big changes in the provision and use of the service.

The ecosystem service value for wild game was attributed to the hunting districts based on the quantities of hunted game reported in the statistics, distinct codes (*kr_kood*) were used to bind the values to spatial data. Then by merging the ecosystem unit map and hunting district map, we obtained the share (in area units) of each ecosystem type in the hunting district. Including all natural and vegetated ecosystems (excluding waterbodies and artificial area), we divided the service value per hunting district between ecosystem types according to the area of ecosystem type (*service value per hunting district*area of the ecosystem type/area of all contributing ecosystem types in the hunting district*). The obtained data is presented in Table 33. Due to the used methodology that all ecosystem types are treated to contribute equally to the provision of the service, except for artificial areas and inland waterbodies which were excluded from the analysis, the results are heavily influenced by the total area of ecosystem types.

The illustrative map is presented in Figure 7.

Table 33. Ecosystem service value of provisioning wild game by ecosystem types, 2019.

Ecosystem type	**Value of the ecosystem service 2019, €**	
Forest	5263308	
…drained peatland forests		635 606
…mesotrophic boreal forests		843 050
…eutrophic alvar forests		169 528
…oligotrophic boreal heath forests		54 457
…oligo-mesotrophic boreal forests		1 058 473
…oligotrophic paludifying forests		87 300
…minerotrophic swamp forests		142 888
…eutrophic boreo-nemoral forests		441 683
…mixotrophic and ombrotrophic bog forests		264 617
…eutrophic paludifying forests		1 542 280
…forest on reclaimed pits		23 425
Grassland	1 265 119	
…cultivated grassland		634 912
…heaths		1 160
…semi-natural grasslands		591 984
…shrubbery		37 063
Cropland	1666657	
…horticultural land		6 977
…crops		1 650 505
…permanent crops		9 176
Wetland	495853.3	
…fens		118 187
…transition mires		68 325
…peat bogs		264 024
…peat extraction sites		35 250
…abandoned peatlands		10 067
Coast	9 389	
Other	12 028	
Total supply		**8 712 355**

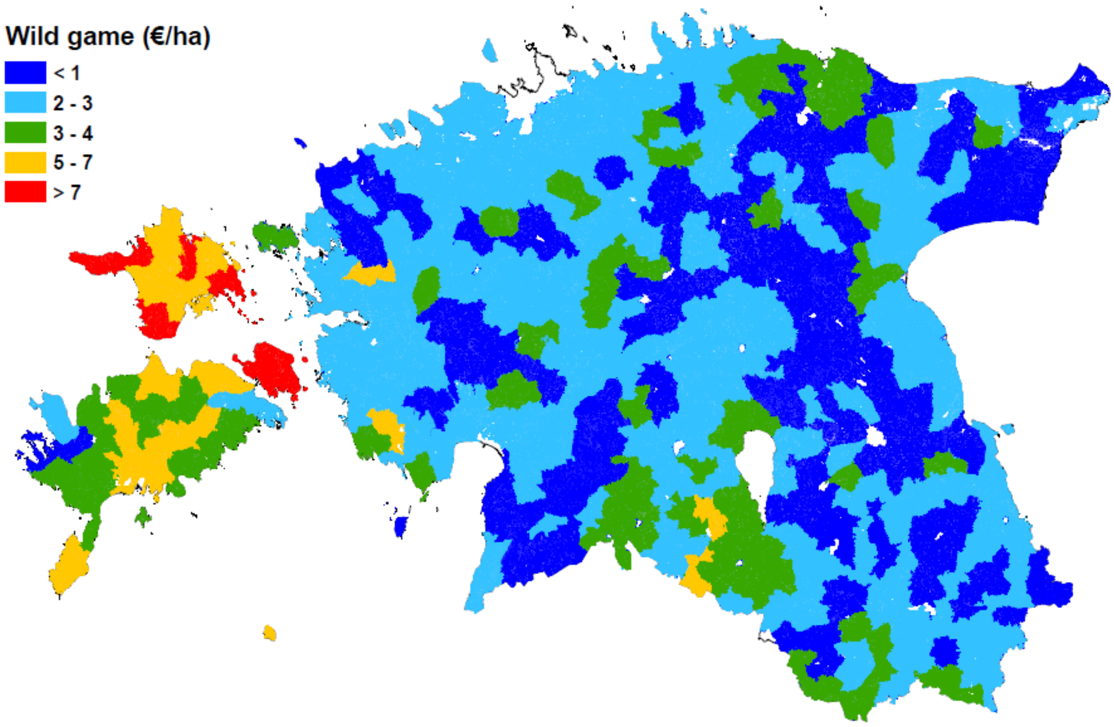

Figure 7. The ecosystem service provisioning areas and values of wild game provisioning. The areas coloured from blue to red represent service provisioning areas according to the unit value (€/ha) supplied by ecosystem assets that was found by market price method. Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

7.6.2 Conclusion

Monetary value of ecosystem provision service "wild animals (terrestrial and aquatic) used for nutritional purposes" is calculated by using market based method. This method is considered to be very suitable for calculating the monetary value of the provisioning service.

The raw data used for the calculations originates from the Estonian Environment Agency and the Statistics Estonia. Average weight of cold body and the market prices of wild game meat has been obtained from meat processing companies. All these data sources are reliable. The fact that wild animal skins currently have no market value is a well-known fact.

The calculations show that the monetary value of ecosystem provisioning service for wild game meat is € 8.7 million. The distribution of this amount by hunting areas is the right decision, as the issue of hunting permits and the number of animals shot are kept on hunting area basis.

A calculation based on the cost of renting a hunting area could also be considered to calculate the monetary value of this service, but the result would probably be significantly less accurate.

7.7 Peat

In Estonia peat is classified as a slowly renewing resource[31], however according to the EU Renewable Energy Directive, peat is a non-renewable natural resource and it is not considered as renewable bioenergy. Considering that there are large peat reserves (205 million tons) in Estonia, peat has always been an important object of economic activity. The main uses of peat are in energy production and horticulture, to a lesser extent environmental technology (slurry binding, oil trapping, odour filters) and medicine (balneotherapy). At the same time the drainage of peatlands and the extraction of peat leads to the reduction in their area and degradation of ecological functions of bog landscapes.

Peat is an organic matter and not mineral substance therefore it would most suitably fall under code 1.1.5.2 or 1.1.5.3 describing the use of materials from wild plants as raw material for non-nutritional purposes or energy resource according to CICES v5.1.

Table 34. Definition of the ecosystem service of provisioning peat according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Fibres and other materials from wild plants for direct use or processing (excluding genetic materials)	*1.1.5.2*	*Materials from wild plants*	*Parts of the standing biomass of a non-cultivated plant species…*	*…that can be harvested and used as raw material for non-nutritional purposes*	*Harvestable volume of reeds Or Macroalgae used for thickening agents, agar and superconductor electrodes*	*Roofing material*
Wild plants (terrestrial and aquatic, including fungi, algae) used as a source of energy	*1.1.5.3*	*Materials from wild plants, fungi and algae used for energy*	*Parts of the standing biomass of a non-cultivated plant, fungi, algae or bacteria species…*	*…that can be harvested and used as an energy source*	*Volume of harvested wood*	*Fuel wood*

Peat is divided into two classes based on its decomposition level, which have different properties and are used for different purposes: well decomposed peat is used mainly in energy production, but increasingly also in agriculture and horticulture. Low composed peat is generally used in gardening and horticulture.

Peat production is strictly regulated by environmental legislation in Estonia. The most essential regulations are Earth's Crust Act and the General Part of the Environmental Code Act. Peat is a natural resource owned by the Estonian government. Peat production areas are mainly located on a government-owned land. The Land Board and the State Forest Management Center are state-owned state agencies that lease production areas to peat mining companies.

[31] https://www.riigiteataja.ee/en/eli/ee/Riigikogu/act/ 520122016001/consolide § 5 (5)

Every peat production enterprise who, on the basis of an environmental permit, has been granted the right to remove natural resources from their natural state, shall pay environmental charges in accordance with the rates established in the Environmental Charges Act.

We can consider the environmental charges as a marginal value of the ecosystem service because it is the marginal expenditure one has to make to use the ecosystem service.

The fee for the right to extract low decomposed peat is fixed in the Environmental Charges Act and in 2019 it was 1.59 €/t. The fee for the right to extract well decomposed peat is variable, the fee is related to the market price of wood chips, just as the fee for the right to extract oil shale is related to the market price of fuel oil. This means that every quarter the Ministry of Economic Affairs and Communications calculates the fee for the right to extract well decomposed peat. The fee for well decomposed peat is determined on the basis of the market price of wood chips in the three months preceding the month of declaration. The average for 2019 is EUR 1.69 / tonne.

Peat as a raw material and products made out of it are market goods and these flows are well documented. The data is collected with the statistical report “Manufactured goods”. Therefore, as a second method for the valuation of the service we used the market price method where mined quantity is multiplied with the average market price.

To find the market price, we used products with CN codes 08921000002 – Peat for heating (milled peat, peat blocks (excl. compressed peat) and 08921000003 – Milled peat, peat blocks for horticulture, production of peat mixtures, litter peat from the report on Manufactured goods. Knowing that the products code CN08921000002 contains mainly heating peat, it can be concluded that it is well decomposed peat. To find the market price of well decomposed peat, we divide the value of peat sold for heating (1 661 799 EUR) by the quantity sold (55 700 tonne). The market price of well decomposed peat is 29.84 EUR/tonne (2019). Similarly, we find the market price for low decomposed peat, considering that product code CN08921000003 contains mainly low decomposed peat. The value of peat sold (43 767 593 EUR) divided by the amount sold (839 700 tonne), we can find that the market price of low decomposed peat is 52.12 EUR/tonne (2019).

Name of the dataset	**Data type**	**Source**
Extraction Charge, low decomposed peat, 2019	Legislation	Environmental Charges Act
Environmental taxes, 2019	Statistics	Statistics Estonia
Quantity of mined peat	Statistics	Maavaravarude koondbilanss 2019, Maa-amet
T067: Manufacturing production by the list of manufacturing products (TTL), 2019	Statistics	Statistics Estonia

7.7.1 Results

Based on extraction charge, the value of the ecosystem service peat provision is 1.3 million € in 2019. The value obtained by calculating the value of ecosystem service based on manufacturing production is 34.9 million € in 2019. The latter is approximately 27 times higher than the previous but it should be noted that manufacturing production comprises data about marketed products and therefore includes mining and producing costs. The breakdown of the components in the ecosystem service valuation of provisioning peat is presented in Table 35.

Table 35. Quantity and ecosystem service value of provisioning peat in 2019.

	Mined quantity 2019 (tonnes)	Extraction charge 2019 (€/t)	VALUE of the ecosystem service based on extraction charge, 2019 (€)	Manufacturing production 2019, (€/t w/o VAT)	VALUE of the ecosystem service based on manufacturing production, 2019 (€)
Well decomposed peat	335 300	1.69	566 657	29.83	10 001 999
Low decomposed peat	477 000	1.59	758 430	52.12	24 861 240
TOTAL	**812 300**		**1 325 087**		**34 863 239**

The ecosystem types contributing to the provisioning of peat are mainly peat extraction sites or abandoned peatlands under wetland class. The illustrative map is presented in Figure 8 where the service values were allocated to service supplying assets based on the physical quantity of mined peat from mining claim areas.

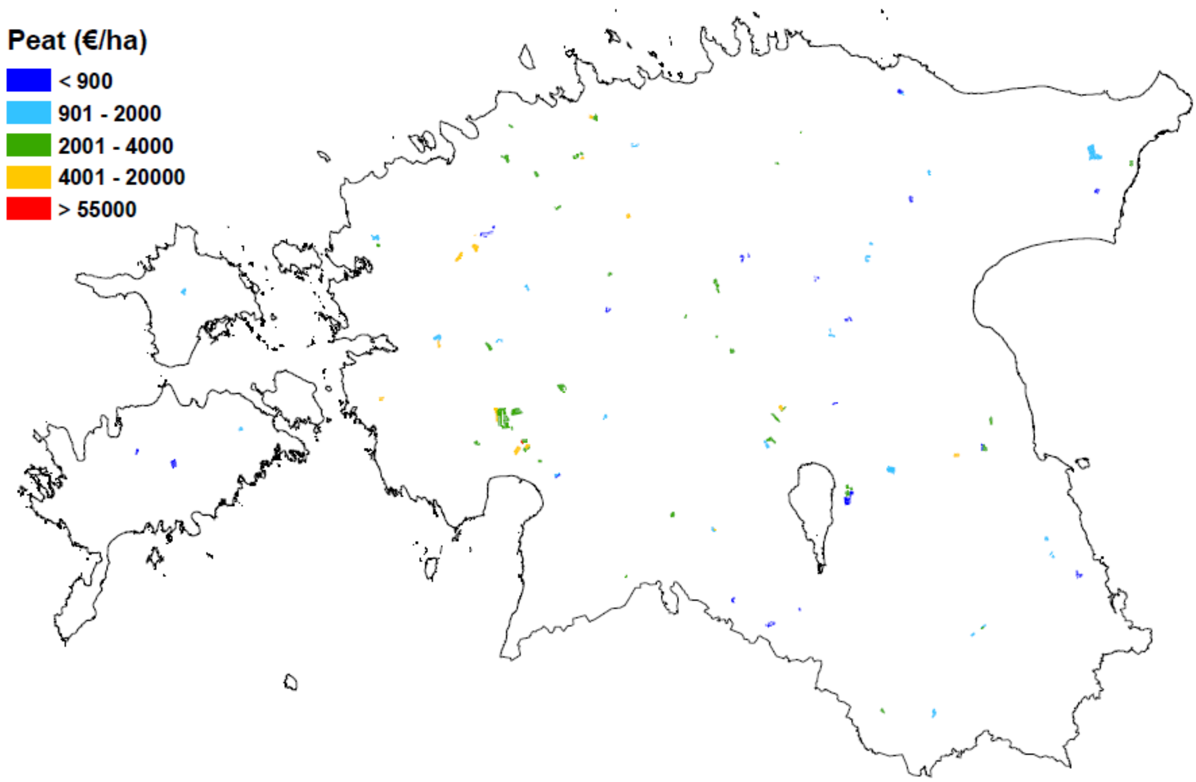

Figure 8. The ecosystem service provisioning areas and values of peat provisioning. The areas coloured from blue to red represent service provisioning areas according to the unit value (€/ha) supplied by ecosystem assets that was found by market price method. Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

7.7.2 Conclusion

Although the CICES classification does not explicitly refer to peat as a provisioning service, the peat mining has a long history in Estonia. Peat has been and continues to be used extensively in energy and agriculture. Recently, it has also been used in other industries, for example cosmetics industry. Peat has been classified under CICES codes 1.1.5.2 or 1.1.5.3, which describe the use of natural plant material as a raw material or energy source.

The monetary value of peat has been calculated using the peat extraction fees stipulated in the Environmental Charges Act (RT I 2005, 67, 512) and specified by a regulation of the Government of the Republic (RT I, 27.03.2020, 20).

The raw data used for the calculations are from reliable sources.

Based on the extraction fees and extracted amount of well-decomposed and low-decomposed peat in 2019, the value of the ecosystem service of peat provision is 1.3 million €.

Monetary value of goods, including ecosystem services, is based on an assessment of society's willingness to pay. However, the fees imposed by law and regulation are in no way related to society's willingness to pay. Thus, the use of fees to calculate the monetary value of peat, as an ecosystem service, does not provide us with information on the monetary value of that service. Table 36 shows the change in the sales price of peat in 2009 - 2019. The sales price of low decomposed peat has increased in 2009 - 2015 and has decreased since 2016, and the sales price of well-decomposed peat has a declining trend in this period.

Table 36. Overview of peat sales prices in 2009 - 2019[32]

Year	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Low decomposed peat. EUR/t	48.78	54.28	56.66	58.11	53.14	61.15	61.94	57.27	51.44	45.57	52.12
Well decomposed peat. EUR/t	35.22	33.83	31.37	33.27	34.28	26.99	30.37	24.01	21.07	31.25	29.83

Taking into account the pressure of society to stop extracting peat and to maintain and restore the bogs, the selling price of peat reflects these trends very clearly. In conclusion, using market prices to calculate the monetary value of peat would reflect society's willingness to pay more accurately than using extraction fees.

Calculating the value of ecosystem service based on manufactured production and sale prices gives the result 34.9 million € in 2019. Based on the principles of environmental economics, this result is a more accurate financial value of the ecosystem service.

7.8 Forest seed

According to CICES v5.1 the provisioning ecosystem service of forest seed provision is described as under code 1.2.1.1 - seeds, spores and other plant materials collected for maintaining or establishing a population. Whereas seed provision of various wild plants is very important for sustaining ecosystem functions, it mainly has commercial importance regarding collection of forest seed used in reforestation. Ecosystem assets that contribute to the service are forests.

[32] https://andmed.stat.ee/et/stat/majandus__toostus__toostustooted__aastastatistika

Table 37. Table 18. Definition of the ecosystem service of provisioning forest seed according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Seeds, spores and other plant materials collected for maintaining or establishing a population	*1.2.1.1*	*Seed collection*	*Seeds and spores and other plant materials…*	*…that can be used to maintain or establish a new population*	*Seeds or spores that we can harvest*	*Wild plant seed for commercial sale*

In Estonia, it is the duty of State Forest Management Centre (SFMC) to provide the state with a sufficient availability of forest seed. Seeds are used for planting forest (mainly pine seed) and producing forest plants (mainly for growing spruce and birch, to a lesser extent also black alder, ash, larch and oak)[33]. While other forestry enterprises also produce forest plants, SFMC is the sole collector and seller of seeds. SMFC collects seeds from designated forest areas or seed orchards.

Name of the dataset	Data type	Source
Forest seed collection, 2019	Statistics	State forest Management Centre
Sale of seeds, prices 2019	Price data	State forest Management Centre

SFMC stores the data about collected quantity of seeds per year and the selling prices.

As forest seed is traded in the market, we used the market price method to value the service in which case the quantity of collected seeds by species was multiplied with their average market price set for the accounting year. The prices for the current year are available on SFMC's webpage. The prices are divided into different classes depending on germination rate. The higher the germination rate (up to 95-100%), the higher the price. According to SMFC, the average germination rate is 90%. Therefore in calculations we used the price class which corresponded to 90% germination rate for different species.

7.8.1 Results

Based on the calculations the ecosystem provisioning service value of providing forest seed is 0.1 million €. The value of the components that make up the total value of providing seeds can be seen in Table 38.

Table 38. Quantity and ecosystem service value of provisioning forest seed in 2019.

Seed type	Quantity 2019 (kg)	Price 2019 (€/kg)	VALUE of the ecosystem service 2019 (€)
Birch (forest)	149	150	22 350
Birch (orchard)	0	-	0
Spruce (forest)	0	210	0
Spruce (orchard)	0	350	0
Pine (forest)	131	320	41 920
Pine (orchard)	118	400	47 200
Black alder (forest)	25	170	4 250

[33] RMK https://www.rmk.ee/for-a/plants-a/sale-of-seeds

TOTAL Seed (forest)	305		68 520
TOTAL Seed (orchard)	118		47 200
TOTAL	**423**		**115 720**

The service is very dependent on the natural supply which is different yearly. Seeds are collected mainly on very fruitful years as these give higher quality seeds and collecting more quantity-wise is also better. Fruitful years occur after every 5 - 8 years for spruce, for pine it is after every 3 - 4 years. Spruce and pine usually make up the majority of the stock and therefore the service value can also vary greatly depending whether it is a fruitful year and seeds are collected or not. When compared to previous years, it can be seen that 2019 was not a particularly fruitful year for pine and spruce.

7.8.2 Conclusion

For calculation of the monetary value of ecosystem provisioning service with CICES code 1.2.1.1. (seeds, spores etc.) market price method was used. The raw data (amount and market price of seeds) have been obtained from the State Forest Management Centre, which is a reliable data source for this task. As the result of calculations, the monetary value of ecosystem provisioning service (tree seed) was 0.1 million euros in 2019.

Seeds are crucial for the existence of trees and forests. However, from a socio-economic point of view, the seed supply service is not relevant, as EUR 0.1 million euros per year is marginal, compared to other ecosystem services. As the importance of seeds is not financially expressed, it should not be calculated annually.

7.9 Medicinal herbs

In Estonia, there is a long tradition of collecting different herbs from the wild and using these for medicinal purposes. Historically, over 120 plant species have been used as herbs in Estonia and the prognosis is that using herbs as tea mixtures and drugs will not be decreasing. ‘Drug’ (Estonian ‘droog’) refers to the natural substances used for medicinal purposes as it is defined in pharmacology.

Herbs are collected from the wild and used by households often as tea mixtures. Products produced from medicinal herbs (pure parts of the herb, tea mixes, extracts, pills etc.) are marketed in apothecaries, stores and markets. When used for marketing purposes, herbs are not only collected from the wild, but are also widely cultivated. For example herbs that are marketed in the largest quantities (flax seeds, chamomile, and caraway) are cultivated in herb fields, but there are also herbs (e.g. Epilobium parviflorum) which are collected from the wild. The market share of the latter may be smaller but it is an indicator that provisioning of medicinal herbs is an important ecosystem service.

The ecosystem service is providing medicinal herbs. It is defined as the provisioning of medicinal herbs by ecosystem assets to the production of herbal goods. The economic benefits are the goods that are produced from medicinal herbs such as herbal tea mixtures, drugs and other herbal pharmaceutical products.

Table 39. Definition of the ecosystem service of climate regulation according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Fibres and other materials from wild plants for direct use or processing (excluding genetic materials)	*1.1.5.2*	*Materials from wild plants*	*Parts of the standing biomass of a non-cultivated plant species…*	*…that can be harvested and used as raw material for non-nutritional purposes*	*Harvestable volume of reeds*	*Materials from wild plants*
					Medicinal resources (IPBES, TEEB)	

The service, provision of genetic and medical resources, was valued with CVM method where its value was found to be 1.7 mln € in forests, 0.9 mln € in wetland and 1.55 mln € in grasslands. The total value of the service according to CVM is 4.2 mln €. For more information, see chapter 6.2.

To find the supply per ecosystem type, the values inside each ecosystem main class (forest, wetland, grassland) were mapped according to the relative occurrence of plant species used as medicinal herbs. The spatial data of the occurrence of plant species used as medicinal herbs were obtained from ELME project[34]. Whereas additional areas offered the service in the input data, the service value was allocated only to those ecosystem classes (forest, wetland, grassland) which were the subject of CVM studies. The results are visualized in Figure 9.

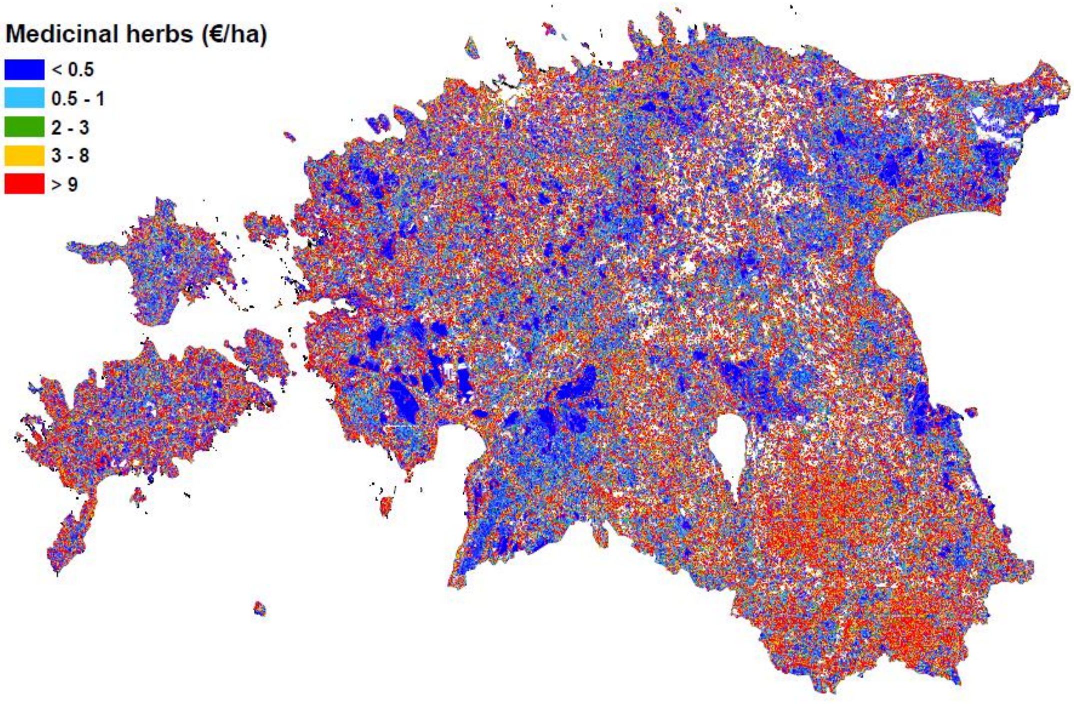

Figure 9. The ecosystem service provisioning areas and values of medicinal herbs provisioning. The areas coloured from blue to red represent service provisioning areas according to the unit value (€/ha) supplied by ecosystem assets that was found by contingent valuation method. Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

[34] Projekt ELME – „Elurikkuse sotsiaal-majanduslikult ja kliimamuutustega seostatud keskkonnaseisundi hindamiseks, prognoosiks ja andmete kättesaadavuse tagamiseks vajalikud töövahendid" (projekt nr 2014-2020.8.01.16-0112; kaasrahastajad Euroopa Liidu Ühtekuuluvusfond ja SA Keskkonnainvesteeringute Keskus)

7.10 Global climate regulation

Carbon sequestration and carbon retention contribute to global climate regulation. Net carbon sequestration is the difference between net primary productivity and soil respiration. The storage of carbon in biomass and in soils is increased or decreased due to the process. Carbon cycle is relatively short-lived and changes in ecosystem processes influence the rate in which carbon is emitted or stored in biomass or soil.

According to CICES v5.1 regulating global climate is defined as regulation of the concentrations of gases in the atmosphere that impact on global climate or oceans. In the current work two separate services are considered under climate regulation ecosystem service: 1) removal of CO_2 from atmosphere by the process of net carbon sequestration; 2) carbon retention in biomass and soil.

The question whether beneficiaries are public sector or households has been discussed by the experts. In our SUT table households are considered as beneficiaries. Net carbon sequestration and storage in biomass and soil of grasslands have been assessed with different methods.

Table 40. Definition of the ecosystem service of climate regulation according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Regulation of chemical composition of atmosphere and oceans	2.2.6.1	*Regulating our global climate*	*Regulation of the concentrations of gases in the atmosphere*	*….that impact on global climate or oceans*	*Sequestration of carbon in tropical peatlands*	*Climate regulation resulting in avoided damage costs* *Or* *Mitigation of impacts of ocean acidification*

Based on available data, we considered payment for ecosystem services (PES) schemes the best technique to assess the monetary value of the service. It is also a fairly straightforward method. European Union (EU) Emissions Trading System was chosen as an appropriate PES scheme and the yearly average European Union Allowance (EUA) price (€/t CO2) was chosen as a unit price. The calculated yearly average EUA price for year 2019 was 24.9 €/t CO_2.

Net CO_2 emissions to atmosphere/removals from atmosphere from land use, land use change and forestry are reported under LULUCF sector of National Inventory Report of greenhouse gas emissions in Estonia. Each land use category includes CO_2 emissions and removals from/by living biomass, dead organic matter (dead wood in case of forest land and additionally litter), mineral and organic soils, and non-CO_2 emissions from biomass burning. Carbon emission factors based on carbon stock changes are described in the report (CRF tables 4.A- 4.F).

Name of the dataset	Data type	Source
Reference values (Emission Factors)	Literature	National Inventory Report 1990-2019[35]
European Union Allowance Price	Spot price	https://icapcarbonaction.com/en/ets-prices
Ecosystem unit map	Spatial data	Statistics Estonia

[35] National Inventory Report 1990-2018. https://unfccc.int/documents/194747, https://www.envir.ee/sites/default/files/Kliima/nir_est_1990-2019_15.03.2021.pdf

7.10.1 Results. Removal of CO2 from atmosphere by the process of net carbon sequestration

We used the data presented in National Inventory Report of greenhouse gas emissions in Estonia 1990-2019 and average EU ETS price in 2019 for finding the value of ecosystem services of carbon sequestration.

Tabel 1. Table. Ecosystem service value based on net CO_2 emissions/removals from LULUCF sector of National Inventory Report of greenhouse gas emissions in Estonia. The signs for removals are negative (–) and for emissions positive (+).

Land use category	Area, kha	Net CO_2 emissions/ removals, kt, 2019	Carbon sequestration ecosystem service value, €, 2019
Forest land	2 446.28	-2 131.52	53 074 786
Cropland	1 003.26	351.73	NA
Grassland	275.41	67.49	NA
Wetlands	28.23	1 242.87	NA
Settlements	347.57	337.60	NA
Other land	37.54	62.13	NA
Harvested wood products	-	-1 014.68	25 265 493
TOTAL			**78 340 280**

The value of carbon sequestration ecosystem service is 78 million € in 2019. Forest land is the only land use category by which CO_2 is removed from the atmosphere, mainly due to the carbon uptake in forest growing stock. The rest of the land use categories emit CO_2 and therefore do not offer the ecosystem service. However, it should be noted that LULUCF only includes managed land and therefore wetlands in natural state, which could be potential service providers as they are known to sequester carbon, are excluded.

It is well- known that among the characteristics of forests, the annual increment of stands has a strong correlation with carbon sequestration and therefore the contribution to the supply by different ecosystems (see Table 41) was obtained by the spatial allocation of carbon sequestration in forests was based on forest increment (see Figure 10).

To obtain the forest 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 total forest growth calculated in the course of the work is not subject to publication, its sole purpose was to be used for the spatial distribution of the carbon capture service. The total value of sequestered CO_2 is based on the National Inventory

Report of greenhouse gas inventory, no calculations were done to assess the carbon content in the biomass of forest increment.

Table 41. Ecosystem service value of carbon sequestration by ecosystem types, 2019.

Ecosystem type	**Value of the ecosystem service 2019, €**	
Forest	78 340 279	
…drained peatland forests		9 239 369
…mesotrophic boreal forests		18 572 782
…eutrophic alvar forests		1 331 609
…oligotrophic boreal heath forests		345 390
…oligo-mesotrophic boreal forests		15 897 009
…oligotrophic paludifying forests		861 700
…minerotrophic swamp forests		1 309 973
…eutrophic boreo-nemoral forests		9 256 013
…mixotrophic and ombrotrophic bog forests		1 711 751
…eutrophic paludifying forests		19 611 327
…forest on reclaimed pits		203 356
Total supply		**78 340 280**

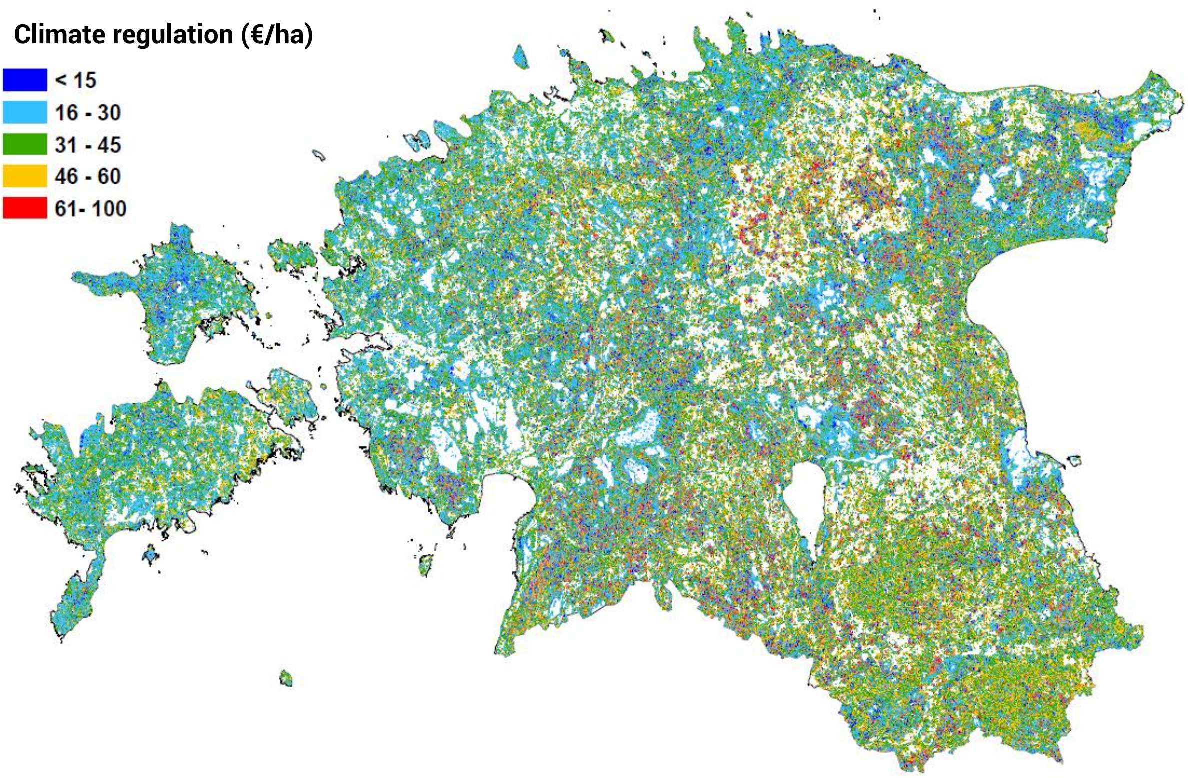

Figure 10. The ecosystem service provisioning areas and values of ecosystem service of climate regulation expressed as carbon sequestration. The areas coloured from blue to red represent service provisioning areas according to the unit value (€/ha) supplied by ecosystem assets that was found by using PES scheme method. Areas coloured white represent ecosystem assets that do not supply the ecosystem service.

7.10.2 Results. Carbon retention

We used the data presented in National Inventory Report of greenhouse gas emissions in Estonia 1990-2019 regarding carbon stocks in biomass and litter and literature data on stocks of organic carbon in Estonian soils with average EU ETS price in 2019 for finding the value of ecosystem services of carbon retention.

In the research by Kõlli et al., the SOC (soil organic carbon) stocks for forest, arable lands, grasslands and for the entire Estonian soil cover were calculated on the basis of the mean SOC stock and distribution area of the respective soil type and it was found that in the Estonian soil cover (42 400 km2), a total of 593.8 ± 36.9 Tg of SOC is retained, with 64.9% (385.3 ± 27.5 Tg) in the epipedon layer (O, H, and A horizons) and 35.1% in the subsoil (B and E horizons) [36].

Total carbon stock in living biomass and dead organic matter in LULUCF land use classes in 2019 according to the National Inventory Report of greenhouse gas emissions in Estonia 1990-2019 is 176 780 t C. The distribution is shown in Table 42. It should be noted that LULUCF only includes managed land and therefore wetlands in natural state, which could be potential service providers as they are known to sequester carbon, are excluded.

Table 42. Total carbon stock (t C) in LULUCF Land Use classes, 2019

LULUCF Land Use class	Total carbon stock (t C)	
	Living biomass (wood)	Dead organic matter
Forest land remaining forest land	168 648	6 454
Grassland remaining grassland	1 661	17

When summing the stocks in soil, in living biomass and in dead organic matter, the total stock is 594 153 559 t C.

EU ETS price 24.9 €/t CO2 was converted to suitable form (€/ t C) by carbon content of carbon dioxide, which resulted in the price of 0.09 €/ t C. Multiplying the total stock with the carbon price, we find that the value of carbon stock is 54 192 028 €.

The found value of the carbon stock is not equal to the ecosystem service value as the latter is defined as yearly flow from a supplier ecosystem to user. To find the ecosystem service value, it was suggested to treat the carbon stock similarly to assets. In the case of assets, the preferred asset lifetime is 100 years for all services (for more detail see chapter 11.1) and when we take the inverse of asset calculation, then the ecosystem service value would be 541 920 € per year in 2019.

7.10.3 Results. Carbon sequestration and storage valued by CVM

The service expressed as carbon sequestration and storage, was also valued with CVM method where its value was found to be 12.9 million €. For more information, see chapter 6.2.

[36] Kõlli, Raimo & Ellermaee, Olav & Köster, Tiia & Lemetti, Illar & Asi, Endla & Kauer, Karin. (2009). Stocks of organic carbon in Estonian soils. Estonian Journal of Earth Sciences. 58. 10.3176/earth.2009.2.01.

7.11 Air quality regulation: air pollutant (fine particles- PM2.5) removal

According to CICES v5.1 air pollutant removal is described as services that fix and store an organic or inorganic substance by a species of plant, animal, bacteria, fungi, or algae. Air pollutant removal by vegetation mitigates the harmful effects of air pollutants and reduces the costs of disposal by other means (see also Table 65). In the case of vegetated areas, both rural and urban areas are covered.

Table 43. Definition of the ecosystem service of air pollutant removal according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Filtration /sequestration/ storage/ accumulation by micro-organisms, algae, plants, and animals	*2.1.1.2*	*Filtering wastes*	*The fixing and storage of an organic or inorganic substance by a species of plant, animal, bacteria, fungi or algae …*	*…that mitigates its harmful effects and reduces the costs of disposal by other means*	*Dust filtration by urban trees, macrophytes, for example salt marsh grass, can trap particles in their roots, sequestering wastes/toxicants in the sediment*	*Reduction in respiratory disease*

Vegetation has the ability to remove air pollutants such as fine particles (PM2.5), nitrogen oxides (NOx), sulfur oxide (SO_2), and volatile organic compounds (VOC). There is clear evidence that exposure to the pollutants listed above has significant effects on health, quality of life, economic activity and the functioning of ecosystems.

In this study, we used the benefit transfer method to calculate the monetary value of PM2.5 removal by vegetation. The benefit transfer method is used to estimate economic value for ecosystem services by transferring available information from studies already completed in another location and/or context.

To calculate the value of the service, data on the amount of PM2.5 emitted and the monetary value used to transfer revenue were collected from the following sources:

Name of the dataset	Data type	Source
Amount of PM2.5 released, in 2019	Statistics	The Estonian Environment Agency[37]
Average damage cost value for air quality assessment calculated in the United Kingdom.	Study materials	ENCA - Services Databook. Version 1.2 July 2020[38]
The ability of vegetation to reduce PM2.5 concentrations	Study material	ENCA - Services Databook. Version 1.2 July 2020[39]
Gross Domestic Product	Statistics	The World Bank[40]
Currency rates		Euroopa Keskpank, 31.12.2019[41]

7.11.1 Results

In 2019, 5 880 tons of PM2.5 were emitted from sources located in the Estonian territory.

Studies in the United Kingdom (UK) have shown that the ability of vegetation to reduce PM2.5 is 10.2%. In urban areas, this percentage is lower (0.44%). The average damage cost value calculated in the UK for estimating PM 2.5 was (in 2017 prices) £ 73,403 / PM2.5 tonnes.

Using GDP per capita, the monetary value of PM2.5 removal calculated in the United Kingdom was recalculated to Estonian prices, resulting in £ 20792.94 / tonne of PM2.5. Using currency exchange rate of the World Bank (31.12.2019) the transferable value is 17 690.63 euros / ton.

In Estonian territory (excluding urban areas) 4 049 982.03 hectares are covered with vegetation. The area of vegetation in urban areas are 29 599.15 hectares.

Vegetation generally removes 10.2% of the emitted PM2.5 but in urban areas the sequestration is 0.44%. From the total amount of PM2.5, 599.76 tons are removed by general vegetation and 25.872 tons by vegetation of urban areas. Knowing the amount of PM2.5 to be removed and the monetary value of one tonne of sequestration, the monetary value of the ecosystem service – PM2.5 removal - was calculated. These values are: ca 10.6 million euros for the vegetation-covered ecosystems (excluding urban areas), and ca 457.7 thousand euros of the urban areas. (See also Table 2.)

[37] Keskkonnaagentuur (2021) Eesti õhusaasteainete heitkogused aastatel 1990 - 2019. www.keskkonnaagentuur.ee

[38] Development ofor Environment, Food and Rural Affairs (July 2020) ENCA - Services Databook. Version 1.2

[39] Ibid

[40] The World Bank. https://data.worldbank.org/indicator/NY.GDP.PCAP.CD?end=2019&locations=GB&start=1960&view=chart

[41] Euroopa Keskpank. https://valuutakursid-euro.ee/kursside-arhiiv/2019-01-04/

Table 44. Calculation of monetary value of ecosystem service of sequestration of PM2.5 from air.

Name and unit of the indicator	Indicator value on vegetation (excluding urban areas), 2019	Indicator value on vegetation in urban areas, 2019
Ability of vegetation to reduce PM2.5, %	10.2	0.44
Total amount of PM2.5 emitted, tons	5880	
Area, ha	4 049 982.03	29 599.15
PM2.5 removed, tons	599.76	25.872
Average damage cost value of PM 2.5, €/ton	17 690.63	
Monetary value of PM2,5 removal, euros	ca 10.6 million	ca 457.7 thousand

The results are distributed in proportion by area to ecosystem types, including urban ecosystems (Table 45).

Table 45. Ecosystem service value of air quality regulation by ecosystem types in 2019.

Ecosystem	Value of air quality regulation, 2019 (€)	
Forest	6 324 619	
Drained peatland forests		858 477
Mesotrophic boreal forests		1 044 576
Eutrophic alvar forests and shrublands		140 931
Oligotrophic boreal heath forests		54 092
Oligo-mesotrophic boreal forests		1 290 227
Oligotrophic paludifying forests		112 977
Minerotrophic swamp forests		195 137
Eutrophic boreo-nemoral forests		545 457
Mixotrophic and ombrotrophic bog forests		373 795
Eutrophic paludifying forests		1 672 823
Forest on reclaimed pits		36 127
Grassland	1 350 552	
Cultivated grassland		680 363
Heaths		1 419
Semi-natural grasslands		630 152
Shrubbery		38 617
Cropland	2 193 437	
Horticultural land		9 273
Crops		2 175 441
Permanent crops		8 722
Wetland	668 016	
Fens		132 638
Transition mires		111 472
Peat bogs		423 906
Artificial area	521 644	
Green space		112 223
Other artificial areas		409 420
Other	9 558	
Other		9 558
TOTAL	11 067 824	

The service was also valued with CVM, where it was valued for 3.27 mln € in forests and 1.63 mln € in wetlands. For more information, see chapter 6.2.

7.11.2 Conclusion

Data of the particulate matter (PM2.5) originate from a report that provides an overview of the country's emissions of pollutants from stationary and diffuse sources. The overview is based on the emission trend chapter of the inventory report submitted to the European Commission, the European Environment Agency and the Secretariat of the Geneva Convention on Long-range Transboundary Air Pollution (CLRTAP). The quantities of PM2.5 emissions by administrative units have not been published, which is why the entire amount emitted in Estonia is evenly distributed throughout Estonia.

The cost transferred comes from a UK report, which is aimed at calculating the monetary value of ecosystem services. Thus, the transfer of income is made from the best possible source.

The literature recommends using the income transfer method to calculate the monetary value of ecosystem services, inter alia, if the aim is to find input values for the preparation of strategic plans. As national statistics are used in the preparation of strategic development plans, the method used is suitable for calculating the monetary value of the PM2.5 removal service.

7.12 Pollination

According to CICES v5.1 pollination is described as the fertilisation of crops by plants or animals that maintains or increases the abundance and/or diversity of other species that people use or enjoy (Table 46).

Pollination is classified as the regulating intermediate ecosystem service and crop pollination is defined here as the increased crop production in insect pollinator-dependent crops. The pollination ecosystem service is supplied by the ecosystems, more precisely, by pollinators who live at the local landscape, to the economic user of the land (i.e. the farmer)[42]. Within the framework of this project economic benefit (as producer price) and rise of welfare (as consumer price) are gained due to pollination which therefore can be seen as a monetary value of pollination.

[42] Hein, L. et al (2019) The economic value of ecosystem services and assets in the Netherlands. Wageningen University and Research.

Table 46. Definition of the ecosystem service of pollination according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Pollination (or 'gamete' dispersal in a marine context)	*2.2.2.1*	*Pollinating our fruit trees and other plants*	*The fertilisation of crops by plants or animals…*	*…that maintains or increases the abundance and/or diversity of other species that people use or enjoy*	*Providing a habitat for native pollinators Or In the context of societal efforts for the restoration of, for example, seagrass beds, it can be considered final since seed dispersal can occur through this service rather than artificially.*	*Contribution to yield of fruit crops*

We used avoided cost method based on spatial modelling proposed by scientists of Wageningen University and Research [43] to value insect pollination.

Avoided damage cost method is one of the cost-based valuation methods. In this method, the prices are estimated in terms of the value of production losses or damage that would occur if the ecosystem services were reduced or lost due to ecosystem changes.[44]

Based on the definition, according to which pollination ecosystem service is the increase in crop production due to the presence of the pollinators, the monetary value of the increase in crop production is taken to describe production losses in avoided damage cost method, which is the estimation of the ecosystem service value.

Name of the dataset	Data type	Source
PM0281: Agricultural land and crops by county, 2019	Statistics	Statistics Estonia
Basic unit prices of agricultural crop products, 2019	Statistics	Statistics Estonia
Habitat suitability for pollinators in Estonia	Table	Kennedy et al. (2013), modified for Estonia
Pollination requirements	Table	Klein et al. (2007), modified for Estonia
Agricultural support and land parcels, 2019	Spatial data	Estonian Agricultural Registers and Information Board (ARIB)
Ecosystem unit map	Spatial data	Statistics Estonia

To apply the avoided cost method, it was first necessary to model the biophysical service flow using spatial data of crops and pollinator habitats. The methodology proposed by scientists of Wageningen

[43] Remme, R., Lof, M., de Jongh, L., Hein L., Schenau, S., de Jong, R., Bogaart, P. (2018) The SEEA EEA biophysical ecosystem service supply-use account for the Netherlands. Wageningen University and Research

[44] UN (2017) SEEA Experimental Ecosystem Accounting: Technical Recommendations Consultation Draft. New York, USA.
https://seea.un.org/sites/seea.un.org/files/technical_recommendations_in_support_of_the_seea_eea_final_white_cover.pdf

University and Research [45] was followed for calculating and modelling of the biophysical value of the pollination service. However, it was needed to make some modifications in the methodology as original calculations in the Netherlands were done using raster data with fixed cell size, but currently Estonian spatial input was in vector format.

Crop field units with their respective grown crop, pollinator habitat units and distances between them were derived through spatial analyses. On all crop field units where a crop which requires pollination is grown and all suitable habitat units within 1750 meter radius (from the middle of crop field unit to the middle of habitat unit) of the crop field unit were chosen to the dataset on which calculations were done. Due to time constrains the spatial data was not transformed from vector to raster, therefore further calculations were done in table form and therefore the precision of the modelling also decreased.

Pollination requirement was linked to the crop field units based on the crop grown there and habitat suitability per ecosystem type was linked to habitat units.

Crops differ in pollination demand. Based on the pollination requirement of the crop, crop field units were assigned a value of pollination requirement on the scale of 0-100. The values for the pollination requirement were derived from Klein et al. (2007) and modified for Estonia with the expert knowledge of entomologist of University of Life sciences, professor Mänd in previous work on ecosystem accounting by Statistics Estonia[46].

Ecosystems are also different in suitability for habitat to pollinators. Data was collected about the suitability of the ecosystem units for the habitat for wild pollinators such as wild bees, bumblebees, butterflies, and hoverflies. Wild pollinators require sufficient resources for nesting (e.g. suitable soil substrate, tree cavities, etc.) and sufficient forage (i.e. pollen and nectar). Based on SEEA EEA report[47], and expert knowledge of entomologist of University of Life sciences, professor Mänd and ecologist of Tallinn University, associated professor Rivis, each ecosystem for the suitability for pollinators habitat on scale 0 – 100 where 100 means most suitable and 0 unsuitable, was assessed in previous work on ecosystem accounting by Statistics Estonia[48].

Using the obtained dataset the relative visitation rate (scale 0-100) in crop field unit c from surrounding habitat units h was calculated [49]

$$v_c = \sum_{h=1}^{H} S_h \frac{e^{-0.00053 d_{hc}}}{\sum e^{-0.00053 d}}$$

where

---

[45] Remme, R., Lof, M., de Jongh, L., Hein L., Schenau, S., de Jong, R., Bogaart, P. (2018) The SEEA EEA biophysical ecosystem service supply-use account for the Netherlands. Wageningen University and Research

[46] Statistics Estonia, 2020. Development of the land account and valuation of ecosystem services regarding grassland ecosystem services (Eurostat Grant Agreement no NUMBER — 831254 — 2018-EE-ECOSYSTEMS). https://www.stat.ee/sites/default/files/2021-06/Methodological%20report_831254_2018_EE_ECOSYSTEMS_revised_version_31_03.pdf

47 Remme, R. et al (2018) The SEEA EEA biophysical ecosystem service supply-use account for the Netherlands. Wageningen University and Research

48 ibid

49 Remme, R., Lof, M., de Jongh, L., Hein L., Schenau, S., de Jong, R., Bogaart, P. (2018) The SEEA EEA biophysical ecosystem service supply-use account for the Netherlands. Wageningen University and Research

S_h represents the relative pollinator abundance (scaled 0 – 100, where 100 marks maximum suitability) in map unit h (based on the suitability for nesting and foraging for pollinators of the habitat in map unit h), habitat suitability.
d_{hc} is the distance between map unit h and the crop in map unit c.
d describes the distance between the crop field unit c and any possible ecosystem around it.
$\Sigma e^{-0.00053d}$ describes the sum of all the distances between the crop field unit c and all possible ecosystems around it.

To use this equation for vector data (polygons) an estimation of the average d was needed, this was obtained based on the average area of crop field. The value of d in our test area was calculated on raster map with the help of Dr. Ir. Marjolein Lof from Wageningen University & Research. For the field with an area of 7.21 ha, which translates into a square cell measured 268x268 m it was calculated how many fields, and at what distances, an ecosystem providing pollination can potentially be connected with. If all natural vegetation within 6 km radius of the crop field is taken into account, the sum of all visitation rates ($\Sigma e^{-0.00053d}$) is 257.5922. The obtained value of d was used in the calculations as a constant. If the crop fields in the local landscape are bigger or smaller than the average size of crop field based on which the d was calculated on, it will result in an under or over estimation of pollinator visitation rate and thereof also the ecosystem service value.

Pollination P_c is a function of the relative visitation rate,

$$P_c = f(v_c)$$

where $P_c = 5v_c$ for v_c between 0 and 20 and 100 for $v_c \geq 20$.

Next potential crop production reduction which is described by crop yield (€) = yield per hectare by county (kg/ha) * average crop basic price (€/kg)*crop field area (ha) in absence of pollination was calculated. Here in the calculations changing from yield (kg) to yield (€) gives the monetary value of the ecosystem service instead of biophysical.

The avoided production reduction represents the use of the pollination service by the crops. Avoided production reduction in the presence of pollinators APR_c is calculated

"Avoided production reduction" = "potential production reduction" * ("pollination")/100

The contribution (supply) of the ecosystems to the avoided production reduction, APRh is calculated:

$$APR_h = \sum_{c=1}^{C} APR_c \frac{\sum_{h=1}^{H} S_h \frac{e^{-0.00053d_{ch}}}{\sum e^{-0.00053d}}}{\sum_{h=1}^{H} S_h}$$

where

APR_c is the avoided production loss in the crop in map unit c,
d_{ch} is the distance between the crop c and the pollinator habitat h.
S_h is relative pollinator abundance in map unit h. Contribution to avoided production loss in crop fields by the ecosystem in map unit h is based on all crop fields that require pollination in a 6 km square around map unit h. This is calculated for all map units that contain an ecosystem that is suitable for pollinators.

7.12.1 Results

The value of pollination ecosystem service was carried out in R by following the modified calculations of the modelling of avoided production reduction in the presence of pollinators. The total value of the pollination service was 31 million €. The ecosystem service value by ecosystem types is shown in Table 47.

The service was also valued with CVM, where it was valued for 1.78 mln € in forests and 1.54 mln € in grasslands. For more information, see chapter 6.2.

Table 47. Ecosystem service value of pollination by ecosystem types, 2019.

Ecosystem	Value of pollination, 2019 (€)	
Forest	13 104 422	
Drained peatland forests		781 050
Mesotrophic boreal forests		5 407 420
Eutrophic alvar forests and shrublands		211 158
Oligotrophic boreal heath forests		26 167
Oligo-mesotrophic boreal forests		788 386
Oligotrophic paludifying forests		87 565
Minerotrophic swamp forests		160 058
Eutrophic boreo-nemoral forests		2 932 172
Mixotrophic and ombrotrophic bog forests		230 926
Eutrophic paludifying forests		2 467 478
Forest on reclaimed pits		12 043
Grassland	10 709 443	
Cultivated grassland		2 598 142
Heaths		574
Semi-natural grasslands		8 026 273
Shrubbery		84 454
Cropland	621 451	
Horticultural land		144 894
Crops		317 126
Permanent crops		159 432
Wetland	6 677 657	
Fens		54 016
Transition mires		6 532
Peat bogs		36 781
Abandoned peatlands		1 847
Artificial area	6 578 481	
Green space		469 185
Buildings and other facilities		11 978
Other artificial areas		6 097 318
Shores	1 056	
Other	14 315	
TOTAL	**31 128 343**	

Spatial distribution of the ecosystem service (Figure 11) was obtained simultaneously with the calculations of the model where a value based on the contribution to the increased crop yield in nearby fields was attributed to each ecosystem asset that was a suitable pollinator habitat.

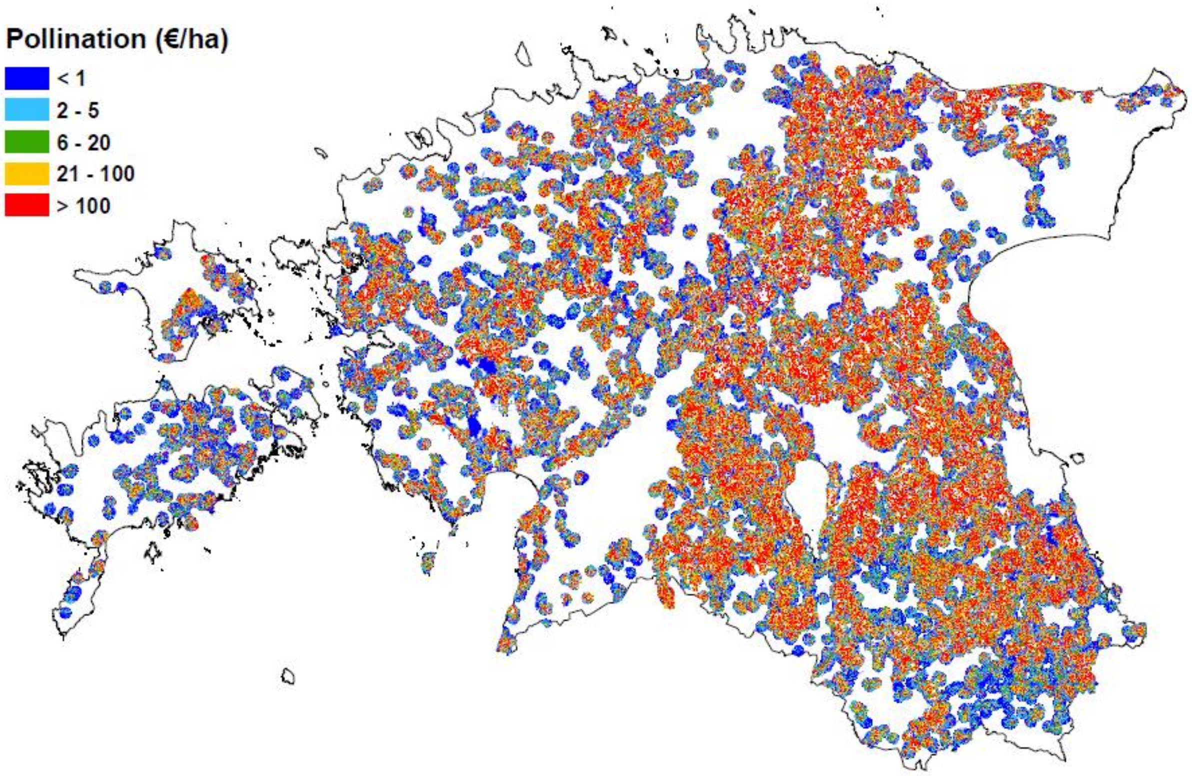

Figure 11. The ecosystem service provisioning areas and values of ecosystem service of pollination. The areas coloured from blue to red represent service provisioning areas according to the unit value (€/ha) supplied by ecosystem assets that was found by applying avoided cost method. Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service in the current scope of the study.

7.13 Monetary valuation of ecosystem services of flood protection and habitat provisioning in Estonia

7.13.1 Flood protection service in Estonia.

Table 48. Definition of the ecosystem service of pollination according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions	*3.1.1.1*	*Pollinating our fruit trees and other plants*	*The biophysical characteristics or qualities of species or ecosystems (settings/ cultural spaces)….*	*…. that are engaged with, used or enjoyed in ways that require physical and cognitive effort*	*Ecological qualities of woodland that make it attractive to hiker; private gardens Or Opportunities for diving, swimming*	*Recreation, fitness; de-stressing or mental health; nature-based recreation*

Floods caused by both the sea and the rivers are topical in Europe and cause a great damages. Europe's big rivers do not flow mostly in natural beds and the land is heavily ditched and agricultural land in the river basins predominates. The ditching of rivers, together with the lack of natural buffers, creates a situation where an exceptionally large body of water cannot flow into grasslands and forests and leaves the riverbed in places with the lowest permeability of the bed, which is often a city or other densely populated area. There is no doubt that in the case of Europe's large rivers, buffer zones (including grasslands) protect (or would protect) against floods. In such a case, it can be argued that the grasslands along the rivers provide a flood protection service.

The question is, however, whether the fact that grasslands in Europe offer flood protection service it is automatically valid for Estonia as well. What would the essence of the "flood prevention service" of Estonian grasslands? In Estonia the largest regular floods are in the Kasari delta, in the upstreams of the river Emajõgi from the Lake Võrtsjärv to the Kärevere bridge and in Soomaa in the basins of the Halliste and Raudna rivers. All of these regularly flooded areas are mostly seminatural grasslands and overgrown areas that were once managed semi-natural grasslands. The total size of the flooded area is to 10 thousand hectares, which can vary greatly from year to year. All of these flooded territories are part of NATURA areas and have been identified as very valuable habitats (bird nesting areas, migratory bird feeding areas, spawning grounds for several fish species, etc.). In addition, they have significant aesthetic and cultural value. (E.g. what would Soomaa be without the fifth season?)

There is no doubt that grasslands provide a valuable "flood service" (i.e. the possibility of being regularly overflooded), which is valuable as a habitat, but also aesthetically and recreationally. Considering that all important flood areas in Estonia do not protect the settlements downstream from the flood site from floods, but rather enable the formation of unique and biologically valuable regularly flooded areas, in the Estonian context we can speak not of a flood protection service but rather of a flood service.

7.13.2 Habitat provisioning service in Estonia

Table 49. Definition of the ecosystem service of pollination according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Maintaining nursery populations and habitats (Including gene pool protection)	*2.2.2.3*	*Providing habitats for wild plants and animals that can be useful to us*	*The presence of ecological conditions (usually habitats) necessary for sustaining populations of species….*	*…that people use or enjoy*	*"Important nursery habitats include estuaries, seagrass, kelp forest, wetlands, soft sediment, hard bottom, shell bottom and water column habitats. Floating seaweed clumps (macroalgae) form rafts under which juvenile fish aggregate e.g. in the North Sea in pelagic habitats"*	*Sustainable populations of useful or iconic species that contribute to a service in another ecosystem.*

Defining the habitat service provided by ecosystems and finding the monetary equivalent to this service is not an easy task. This is due to the fact that ecosystems do not provide a habitat service to humans but to biological species (or, more broadly, biological communities). This is why some methodological manuals suggest to define a habitat service as a so-called intermediate service. Thus, a habitat service would not be a final service and would not be subject to economic valuation. The final service in such a case would be the existence of biological species. The species are directly usable by the economic system and can also be valued monetarily. Such an approach would leave the habitat service out of monetary evaluation.

However, in the contingent valuation studies carried out for the present report, the habitat service was among the services that respondents to the CVM questionnaire were asked to rank according to subjective importance. The results showed that people consider ecosystem habitat service to be very important. This service ranked first in the grassland ecosystem services survey, third in the grassland survey and fourth in the forest ecosystem services survey. Due to the high rating, a significant part of the total willingness to pay and thus the corresponding monetary equivalent has been assigned to the habitat service in the current report.

So the question is, if the habitat service is an intermediate service, why do people value it highly? How does a habitat service for biological species have a positive influence on human welfare? A possible explanation is that the habitat service affects people's welfare through its existence value. People value the existence of habitats for biological species because they perceive habitats as a prerequisite for the existence of species. By its nature, the habitat service is a psycho-social value, which in the higher classification of values (instrumental, aesthetic, moral) it is one of the moral values. When evaluating a habitat service of ecosystems, people also indirectly evaluate the existence of biological species (which is undoubtedly the final service).

The service was valued with CVM, where it was valued for 2.78 mln € in forests, 1.58 mln € in wetlands and 2.61 mln € in grasslands. For more information, see chapter 6.2. However, as the service was assessed in the work of project ELME, we

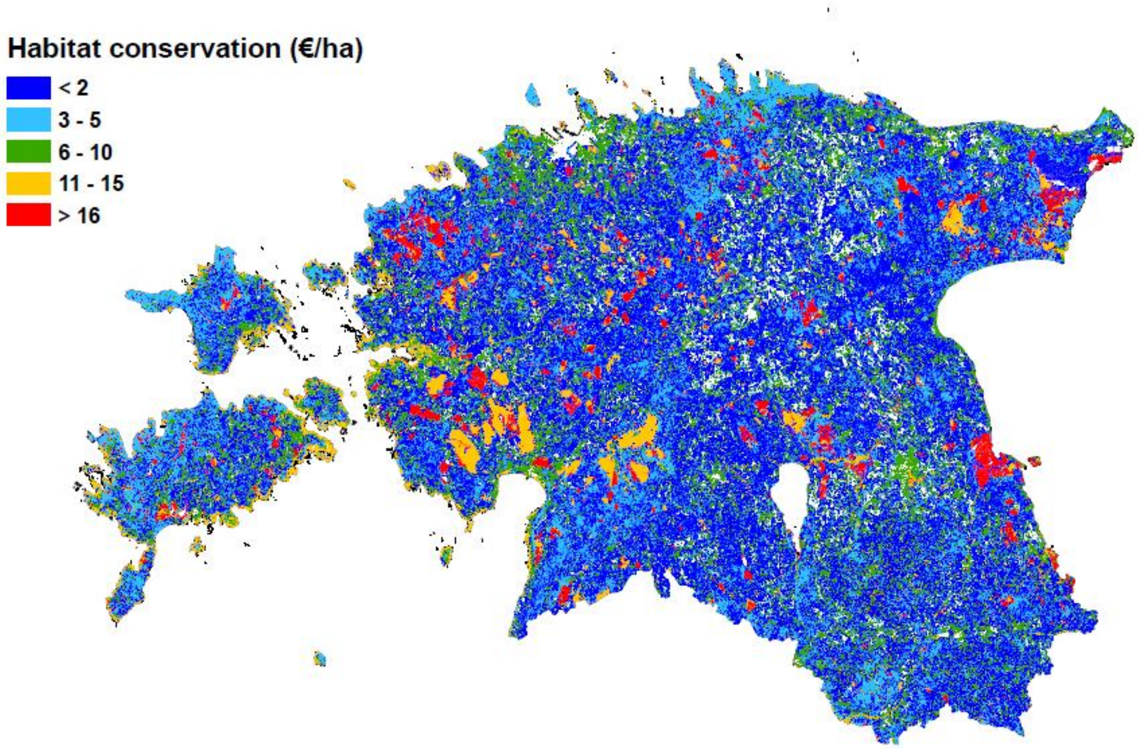

Figure 12. The ecosystem service provisioning areas and values of habitat provisioning. The areas coloured from blue to red represent service provisioning areas according to the unit value (€/ha) supplied by ecosystem assets that was found by contingent valuation method. Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

7.14 Recreation

Ecosystems provide attractive environments for leisure activities. The ecosystem recreational ecosystem service is defined as opportunities for/enabling nature related tourism/recreation. In this report, we discuss recreational ecosystem service from the point of view of the end users – households and non-residents – as beneficiaries and the service is defined as visits for recreational activity to registered recreation areas and trails (State Forest Management Centre, Estonian Health Trails Foundation).

Table 50. Definition of the ecosystem service of pollination according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions	*3.1.1.1*	*Pollinating our fruit trees and other plants*	*The biophysical characteristics or qualities of species or ecosystems (settings/ cultural spaces)….*	*…. that are engaged with, used or enjoyed in ways that require physical and cognitive effort*	*Ecological qualities of woodland that make it attractive to hiker; private gardens Or Opportunities for diving, swimming*	*Recreation, fitness; de-stressing or mental health; nature-based recreation*

The most widely used method for the economic evaluation of ecosystem recreational service is the travel cost method (e.g. Champ et al. 2003), which is based on the individual expenditures of the recreational service users. The limiting factor of using the travel cost method is that the consistent implementation of the method requires a large number of users of the recreational services to be interviewed.

Another possible approach to estimate the ecosystem service value of a recreational service is valuation by time use. This approach is based on the assessment of the monetary value of the time involved in using the service and assessing the monetary value of time for ecosystem service. The use of the time-based method requires data on the number of users of the recreational service, the time spent on using it and monetary value of an hour of leisure time.

Estimations of monetary value of time are most often encountered in cost-benefit analysis of transport projects where time saving is an important factor (Meunier, Quinet, 2014)[50]. Various studies have quantified travel time unit costs and the value of travel time savings, based on analysis of business costs, traveller surveys, and by measuring behavioural responses by travellers faced with a trade-off between time and money. For example, when offered the option of paying extra for a faster trip (Transportation cost…)[51]. However, the use of the monetary value of time is not limited to transport projects, but is also applicable to the evaluation of other time consuming activities and associated values.

When evaluating a recreational ecosystem service, using time value, the monetary value of the leisure (non-working) time must be first determined. While the value of working time is generally related to the individual's income, different approaches are used to determine the value of leisure time. There are two approaches for monetary valuation of leisure time, which are either subjective valuation of people to the value of their leisure time or a fixed percentage of the value of working time which is associated with income.

[50] David Meunier, Emile Quinet. Value of Time estimations in Cost Benefit Analysis: the French experience.. Transportation Research Procedia 8 (2015) 62-71.

[51] Transportation Cost and Benefit Analysis II – Travel Time Costs. Victoria Transport Policy Institute (www.vtpi.org).

For finding the average time value, we used data from the European Union conducted study within the Heatco project analyzing the practice of cost-benefit analysis in 25 EU countries (Heatco 2006)[52]. The corresponding value for Estonia is 4.99 €. The calculations in current study are based on the value of Heacto's recommended time plus one-third due to GDP growth during last ten years. Thus, the monetary value of one hour leisure time used in the following calculations is equal to 6.5 €.

Estonia has an extensive system of hiking and health trails. Considering the population density in Estonia, hiking and exercise and sports tracks (so called health trails) can be divided into two categories: those in densely populated areas (urban) and those in less densely populated areas (nature). In the case of urban health trails, the time taken to get to and from the trail is one hour, plus the time spent on the trail is 0.5 hours. The duration of one visit to trails which are in nature is considerably longer. For nature trails, it takes a total of 3 hours for a visit (1.5 hours at one end) and an average of two hours on the trail.

In case, when the recreational value of ecosystems is calculated only using the time spent in contact with nature (excluding travel time), the average time based monetary value per visit is 3.25 € (0.5 h*6.5 €) for urban trails and 13 € (2 h* 6.5 €) for nature trails.

The majority of Estonian natural recreational sites are managed by State Forest Management Centre (654 places) and Estonian Health Trails Foundation (116 places). All the tracks managed by SFMC are in nature, trails managed by Estonian Health Trails Foundation are located both in nature and urban areas. Many of these trails are equipped with counters that give an indication of the number of visitors.

The value of recreation service was calculated by multiplying the total number of visitors by the time spent on visit (including travel time to visit destination) and average value of leisure time with value of 6.5 €/h.

7.14.1 Results

According to the SFMC estimations, 2.6 million people crossed their managed nature trails in 2019. 0.58 million people visited the trails which are managed by the Estonian Health Trails Foundation in nature areas and 3.3 million people visited the trails in urban areas in 2019.

Table 51. Monetary value of recreational ecosystem service, 2019 €

	Number of visits	**Time spent on visit and transportation (h)**	**Monetary value of leisure time (€/h)**	**VALUE of the service (€)**
SMFC trails in nature areas	2 600 000	5	6.5	84 500 000
Health Trails in nature areas	578 600	5	6.5	18 804 500
Health Trails in urban areas	3 297 500	1.5	6.5	32 150 625
TOTAL				**135 455 125**

52 Heatco. Developing Harmonised European Approaches for Transport Costing and Project Assessment. Deliverable 5 Proposal for Harmonised Guidelines. (2006). [WWW] http://heatco.ier.uni-stuttgart.de/

The time use based recreational value, calculated on the basis of SFMC nature trail visitors is approximately 84.5 million €. The time use based value of recreational service considering trails which are managed by the Estonian Health Trails Foundation is 51 million €.

Adding up the total time spent on the tracks which are managed by the SFMC and the Estonian Health Trails Foundation, we get 135.5 million €. Thus, using the time value 6.5 €/hour, the annual value of the ecosystem recreational service in Estonia is estimated to be 135.5 million €.

The service, nature recreation, was also valued with CVM method where its value was found to be 1.3 mln € in forests, 0.84 mln € in wetland and 1.2 mln € in grasslands. The total value of the service according to CVM is 3.2mln €. For more information, see chapter 6.2.

In order to find the contribution of ecosystem types to the service value, spatial analysis on trails was carried out. Data for recreation areas and trails from the State Forest Management Centre and Health trails from NGO was the same as used in previous grant where it was treated by creating buffers around the object with radii of 500 m to account for the areas/ecosystems that support nature recreation service at the site but do not necessarily intersect with the site/trail directly[53].

In the calculations of the value, three different types of trails/areas were distinguished based on visitation rates and time spent: SMFC trails in nature areas, Health Trails in nature areas and Health Trails in urban areas which obtained different values (see Table 51). These total values were divided among respective objects. The values were further allocated to ecosystem assets based on the total area of ecosystem assets that intersect with the buffered site/trail object. Trails can pass through or neighbour very different map units, therefore some of the linear map units were excluded as service supplying ecosystems, e.g. roads, railroads, powerline and some map units were limited to contribute to the supply of service only in the buffer radius (i.e. 500 m), such as rivers, ditches, forest rides.

Ecosystem service value of recreation by ecosystem types was obtained by summing the individual values of each asset belonging to ecosystem type. The results are presented in Table 52.

The spatial allocation of unit values of assets is shown in Figure 13.

[53] Statistics Estonia, 2020. Development of the land account and valuation of ecosystem services regarding grassland ecosystem services (Eurostat Grant Agreement no NUMBER — 831254 — 2018-EE-ECOSYSTEMS. https://www.stat.ee/sites/default/files/2021-06/Methodological%20report_831254_2018_EE_ECOSYSTEMS_revised_version_31_03.pdf

Table 52. Ecosystem service value of recreation by ecosystem types in 2019.

Ecosystem type	**Value of the ecosystem service 2019, €**	
Forest	65 314 580	
…drained peatland forests		6 966 243
…mesotrophic boreal forests		15 515 061
…eutrophic alvar forests		1 770 913
…oligotrophic boreal heath forests		3 371 911
…oligo-mesotrophic boreal forests		21 128 842
…oligotrophic paludifying forests		952 546
…minerotrophic swamp forests		1 811 023
…eutrophic boreo-nemoral forests		2 870 744
…mixotrophic and ombrotrophic bog forests		4 316 021
…eutrophic paludifying forests		6 412 956
…forest on reclaimed pits		198 321
Grassland	13 478 442	
…cultivated grassland		5 053 793
…heaths		96 840
…semi-natural grasslands		8 049 406
…shrubbery		278 403
Cropland	13 831 846	
…horticultural land		149 953
…crops		13 652 480
…permanent crops		29 414
Wetland	21 786 893	
…fens		2 573 563
…transition mires		1 596 405
…peat bogs		17 387 826
…peat extraction sites		129 989
…abandoned peatlands		99 110
Artificial area	8 962 957	
…green space		1 192 989
…buildings and facilities		1 380 971
…other artificial areas		6 388 996
Coasts	899 189	
Inland waterbodies	11 032 632	
…lakes and ponds		9 538 876
…rivers and streams		1 493 755
Other	148 583	
Total supply		**135 455 125**

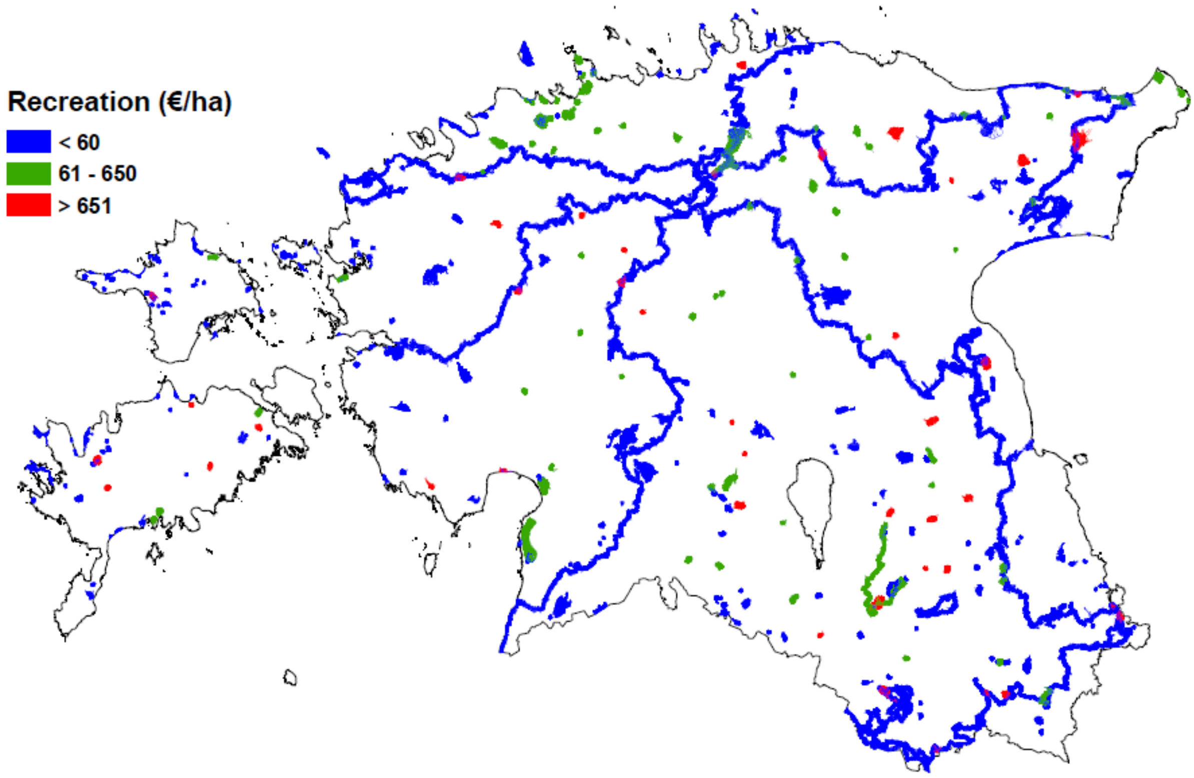

Figure 13. The ecosystem service provisioning areas and values of recreation service. The areas coloured from blue to red represent service provisioning areas according to the unit value (€/ha) supplied by ecosystem assets that was found by valuation of time use. Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service in the current scope of the study.

7.15 Recreational hunting

The cultural ecosystem service of hunting is defined as the physical interaction of the hunter with the natural environment due to the presence of game in the said natural environment. It can be considered as a recreational activity. According to CICES V5.1 it is defined under code 3.1.1.1: The biophysical characteristics or qualities of species or ecosystems (settings/ cultural spaces) that are engaged with, used or enjoyed in ways that require physical and cognitive effort. The beneficiaries and users of the service are households.

Table 53. Definition of the ecosystem service of recreational hunting according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Characteristics of living systems that that enable activities promoting health, recuperation or enjoyment through active or immersive interactions	*3.1.1.1*	*Using the environment for sport and recreation; using nature to help stay fit*	*The biophysical characteristics or qualities of species or ecosystems (settings/ cultural spaces)….*	*…. that are engaged with, used or enjoyed in ways that require physical and cognitive effort*	*Ecological qualities of woodland that make it attractive to hiker; private gardens Or Opportunities for diving, swimming*	*Recreation, fitness; de-stressing or mental health; nature-based recreation*

Hunting is an activity that requires very specific equipment and licences. Therefore we can consider that the expenditure a hunter makes with the purpose to engage in the activity is the expenditure made to use the ecosystem service recreational hunting and we can consider the consumer expenditures as a marginal value of the ecosystem service.

Name of the dataset	Data type	Source
Hunted game 2019/20	Statistics	Estonian Environment Agency
Fee for hunting rights	Literature	Hunting Act
Value and cost of hunting (2020)	Table	Statistics Estonia

Hunting in Estonia is regulated so that every hunter who wishes to hunt needs to have a valid hunting licence and pay a yearly fee for hunting rights. Expenditures to obtain a hunting licence include specific schooling and taking exams, but this is a one-time process and statistics about these are difficult to acquire. A hunter needs to pay a yearly fee for hunting rights which is 10 € per year.

To widen the scope, we included other expenditures a hunter makes. We carried out a short survey among local hunters based on the data of average yearly expenditures of German hunters[54]. The averaged results of the survey are shown in Table 54 with comparisons to the average yearly expenditures of German hunters in 2016 and the latter adapted for Estonian context in 2018 by applying purchasing power standard which data was used previously in the project of ecosystem services evaluation by Statistics Estonia[55].

54 Michl Ebner. The economic value of hunting in the EU. Presentation. 2016

55 Statistics Estonia, 2020. Development of the land account and valuation of ecosystem services regarding grassland ecosystem services (Eurostat Grant Agreement no NUMBER — 831254 — 2018-EE-ECOSYSTEMS) https://www.stat.ee/sites/default/files/2021-06/Methodological%20report_831254_2018_EE_ECOSYSTEMS_revised_version_31_03.pdf

Table 54. Annual average expenditure made for hunting per person broken down by expenditure type. Presented are the results of the average yearly expenditure per hunter derived from the survey carried out among Estonian hunters in 2020, average yearly expenditures of German hunters in 2016 based on literature and the latter adapted for Estonian context in 2018 by applying purchasing power standard

Annual average expenditure (€)	Estonia, survey 2020	Estonia, 2018	Germany, 2016
Lease /possibility to go hunting, incl. fee for hunting rights 10€	130	-	1 570
Car and infrastructure	1 076	396	910
Area facility (e.g. high seats)	142	226	520
Tools (weapons, knives)	288	170	390
Hunting clothes	229	122	280
Game damage / bite protection	20	117	270
Habitat management / biodiversity	56	96	220
Other (dogs, material, etc.)	669	78	180
TOTAL	**2 608**	**1 205**	**4 340**

- According to expert opinion, there is no need to consider lease of a hunting ground as an expenditure for a hunter in Estonia due to differences in hunting systems so it was excluded from the calculations.

7.15.1 Results

In the narrow scope we calculated the value of the service on the basis of yearly hunting fees. This is 0.1 million € per year.

In the wide scope, we calculated the value of the ecosystem service on the basis of annual average expenditure per person. This is approximately 34.7 million € per year. Adding the yearly fee of hunting rights as an expenditure, the value of the recreational hunting service is 35 million €/year.

The ecosystem service was previously valued with the same method but altered data (annual average expenditure per hunter was calculated differently). Then it was found that according to the expenditure cost the value of the service was 16 million € in 2018.

Table 55. Quantity and ecosystem service value of provisioning recreational hunting in 2019.

	Number of users of the hunting district, 2019	**Annual average expenditure per hunter. Estonia, 2019 (€)**	**VALUE of the ecosystem service, 2019 (€)**
Marginal expenditures (fee for hunting rights)	13314	10	133 140
Total expenditures	13435	2608	35 038 480

The ecosystem service value for wild game was attributed to the hunting districts based on the number of hunters using the hunting district reported in the statistics. Then by merging the ecosystem unit map and hunting district map, we obtained the share (in area units) of each ecosystem type in the hunting district. Including all natural and vegetated ecosystems (excluding waterbodies, and artificial area), we divided the service value per hunting district between ecosystem types according to the area of ecosystem type (*service value per hunting district*area of the ecosystem type/area of all contributing ecosystem types in the hunting district*). The obtained data is presented in Table 56.

Table 56. Ecosystem service value of recreational hunting by ecosystem types, 2019.

Ecosystem	Ecosystem area (ha)	Value of recreational hunting, 2019 (€)	Percentage (%)
Forest	2 365 697	20 362 672	58.1
Drained peatland forests	323 802	2 651 138	7.6
Mesotrophic boreal forests	387 718	3 598 404	10.3
Eutrophic alvar forests and shrublands	50 934	607 226	1.7
Oligotrophic boreal heath forests	19 945	159 649	0.5
Oligo-mesotrophic boreal forests	479 951	3 856 884	11.0
Oligotrophic paludifying forests	41 618	308 087	0.9
Menerotrophic swamp forests	73 693	598 344	1.7
Eutrophic boreo-nemoral forests	204 616	1 795 790	5.1
Mixotrophic and ambrotrophic bog forests	141 411	1 084 686	3.1
Eutrophic paludifying forests	628 455	5 594 934	16.0
Reclamationed pits forest site type	13 553	107 530	0.3
Grassland	509 207	5 098 246	14.6
Cultivated grassland	259 132	2 582 512	7.4
Heaths	488	4 933	0.0
Semi-natural grasslands	235 325	2 356 512	6.7
Shrubbery	14 262	154 289	0.4
Cropland	834 945	7 489 089	21.4
Horticultural land	3 361	30 026	0.1
Crops	828 260	7 427 884	21.2
Permanent crops	3 325	31 179	0.1
Wetland	277 651	2 010 900	5.7
Fens	50 274	449 348	1.3
Transition mires	42 470	276 408	0.8
Peat bogs	161 191	1 094 507	3.1
Peat extraction site	18 161	150 771	0.4
Abandoned peatlands	5 556	39 866	0.1
Shores	3 175	32 734	0.1
Other	4 502	44 839	0.1

It can be seen that the highest contributing ecosystem types are forest ecosystems (58.1%), followed by cropland (21.4%), grassland (14.6%), wetland (5.7%), shores and other ecosystem types both contribute only 0.1 %. Due to the used methodology that all ecosystem types are treated to contribute equally to the provision of the service, except for artificial areas and inland waterbodies which were excluded from the analysis, the results are heavily influenced by the total area of ecosystem types.

The ecosystem service value for wild game was attributed to the hunting districts based on the quantities of hunted game reported in the statistics, distinct codes (*kr_kood*) were used to bind the values to spatial data. Then by merging the ecosystem unit map and hunting district map, we obtained the share (in area units) of each ecosystem type in the hunting district. Including all natural and vegetated ecosystems (excluding waterbodies and artificial area), we divided the service value per hunting district between ecosystem types according to the area of ecosystem type (*service value per hunting district*area of the ecosystem type/area of all contributing ecosystem types in the hunting district*).

The illustrative map of the service is presented in Figure 14.

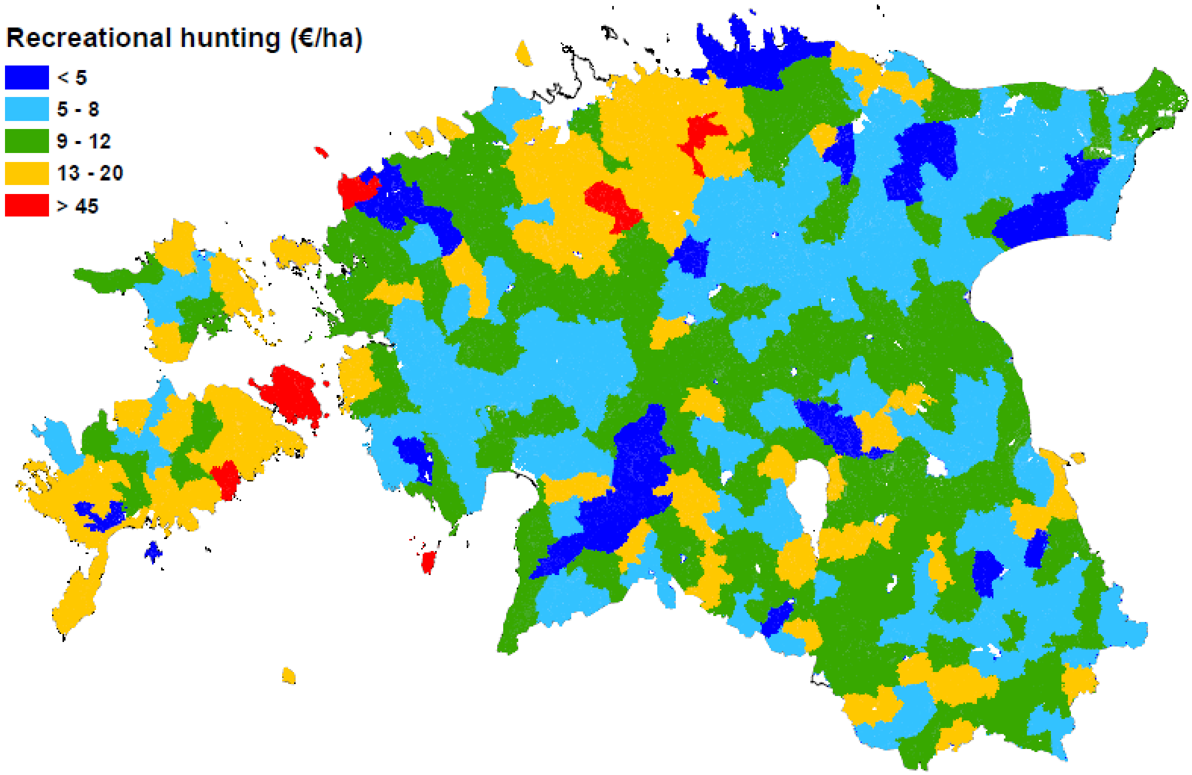

Figure 14. The ecosystem service provisioning areas and values of recreational hunting service. The areas coloured from blue to red represent service provisioning areas according to the unit value (€/ha) supplied by ecosystem assets that was found by expenditure- based method. Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

7.16 Nature education

According to CICES v5.1 the cultural ecosystem service of nature education is described under code 3.1.2.2 - intellectual and representative interactions with natural environment. Based on the CICES classification the project group has agreed on a following definition: "The value of the ecosystem as an educational service provider is expressed by its ability to participate in nature education." The important criteria for the inclusion of the activity as an education service is the direct association of the educational activity with the natural ecosystem. The ecosystem component was restricted to the nature education service provided directly in the ecosystem (i.e. the process of theoretical and practical learning of the relevant nature studies in which the information obtained from the ecosystem is involved). An indirect use, such as visiting a biodiversity/ natural history museum is excluded from the scope.

The agreed scope of nature education service includes institutionally organized nature education, self-learning is not included. The distinction between formal nature education (e.g. during school classes) and informal or private nature education is not made.

Ecosystem assets that contribute to the service are forests, grasslands, croplands, wetlands, artificial areas, coasts, inland waterbodies, and others.

Table 57. Definition of nature education ecosystem service according to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Characteristics of living systems that enable education and training	*3.1.2.2*	*Studying nature*	*The biophysical characteristics or qualities of species or ecosystems (settings/cultural spaces)…..*	*…that are the subject matter for insitu teaching or skill development*	*Site used for voluntary conservation activities*	*Skills or knowledge about environmental management*

Nature education is one of the cultural services ecosystems offer. The same calculation methods were used in this project as in previous grant project. As new survey were not conducted then some of the data was used from previous grant project, data was updated with 2019 data where possible.

Nature education ecosystem service value consists various expenditures that are made to use nature education service. The indicators for the quantification of the ecosystem education services were decided to be "the number of hours spent on nature education", "the number of hours spent in direct contact with the ecosystem", "number of participants in nature programs", "expenditures made for provisioning nature education", "expenditures made for receiving nature education". Detailed overview of the methods are described as follows.

7.16.1 Expenditure transfer approach

Finding the monetary value of ecosystem education services through institutional education spending is based on the assumption that general education is a public service aimed to creating and improving the quantity and quality of human capital. The measure of the value of education is thus an increase in human capital through education, which, however, is difficult to express in monetary terms. Given that the vast majority of education is free of charge to consumers, it can be classified as a non-market public good, whose monetary equivalent can be obtained by using non-market valuation techniques. One such is the incurred expenditure method, which is an indirect method of economic valuation of non-market goods and values. According to this approach, the monetary value of education is considered proportional to the cost to society of providing education. The disadvantage of the method is that the value of education calculated this way is very likely to be lower than the value of human capital created by education. The strength of this method is that it is based on actual costs, which are well described in official statistics.

The method described above can also be used to evaluate the monetary value of both nature education and ecosystem nature education services. Available data allows the total cost of institutional education to be attributed to the ecosystem through its share of hours in contact with the ecosystem. An important assumption for this approach is that the nature program trips should already be included in the official study programs so that time spent in direct contact with the ecosystem would make up one share of the total appointed curriculum of nature subjects in school. Our study does not fill this assumption very well as our data about nature trips was collected as an extracurricular or hobby school activities.

However, this caveat in mind, calculations were still made by applying the method to estimate the nature education service value of Estonian ecosystems by the total cost of hours of being in direct contact with the ecosystem. According to the expenditure transfer approach, the financial equivalent of nature education service value of Estonian ecosystems is approximately 6.62 million EUR per year. It was calculated as follows:

$$Nature\ education\ service\ value = a * b * c$$

where a - average time spent on nature studies directly in ecosystems (h);
b – number of students in nature education programs;
c – cost of one student hour, €. Calculated based on public expenditure on institutional education per year, number of students in institutional education (all levels considered) and average total number of lessons per student per year.

Parameter	**Value**
a - average time spent on nature studies directly in ecosystems (h);	5
b – number of students in nature education programs	116989
c – cost of one student hour (€). Calculated based on public expenditure on institutional education per year, number of students in institutional education (all levels considered) and average total number of lessons per student per year	11.31= =1698200000/(222350*675)

Average time spent (a) and number of students (b) are from previous grant project and were not updated during this grant, cost of one student hour (c) was updated with 2019 data. As general government does not earn surplus then residual value is zero therefore total value was attributed as ecosystem contribution.

7.16.2 Expenditure based approach

Second expenditure based method for valuing nature education as an ecosystem service, considers also (as the method described in previous chapter) that expenditures made to provide nature education service reflect the value that society is ascribing to the service. The expenditures of those providing the nature education service are considered as the value of service. Assumption was made that the sales revenues cover at least the expenditures made.

Also SEEA EEA guidelines regarding the SNA approaches to valuing non-monetary transactions (p 5.4.3) were considered. UN SEEA EEA suggest that if market prices are not observable, valuation according to market price equivalents should provide an approximation to market prices. In such cases, market prices of the same or similar items when such prices exist will provide a good basis for applying the principle of market prices, provided the items are traded currently in sufficient numbers and in similar circumstances. This option is not relevant for educational service of the ecosystems. Where no sufficiently equivalent market exists and reliable surrogate prices cannot be observed, the SNA identifies a second-best procedure for use, namely, the cost of production approach (p 5.45), in which the value of the non-monetary transaction is deemed to be equal to the sum of the costs of producing the good or service, that is, the sum of intermediate consumption, compensation of employees, consumption of fixed capital (depreciation), other taxes (less subsidies) on production, and a net return on capital (2008 SNA, para. 6.125).

Discussions with the experts have revealed that considering the whole expenditure as ecosystem input is questionable, as it would represent the economic input to the production of the service (incidentally, although the ecosystem does 'provide' or supply the services). It has been also decided that it is important to distinguish the costs of the maintenance of nature education areas and providing facilities and the expenditures on service provision (specialized producers without the "real estate"). Following expenditures data (Table 58) are available which reflect in some way the value that society is putting on the educational experience.

Table 58. Expenditures on nature education provision by categories, 2018 and 2019, million EUR*

	Expenditures on nature education service, calculated on the basis of sales revenue and other income	**Current expenditures on educational programs and facilities**	**Value of ecosystem nature education service**
Non-market service providers (owners of nature objects)		0.55	0.55
Non-market service providers (not owning the nature objects)	0.23		0.23
State Forest Management Center, market service provider but providing free nature education service		0.71	0.71
Other market service providers	0.04		0.04
Total	**0.27**	**1.26**	**1.53**

* State Forest Management Center data and market service providers' data are updated with 2019 data, for non-market service providers 2018 data were used

In order to calculate the total value of nature education service current expenditures, sales revenues and other incomes for supporting service providers were aggregated. Overlapping expenditure data was excluded as data taken into calculations was a) the current expenditures of service providers that own/manage nature sites, b) sales revenue and other income of service providers that use but do not own the sites. Total value of ecosystem nature education service was ca 2 million euros if to consider the expenditures of the providers of nature education service.

7.16.3 Travel cost approach

The travel cost model is usually used to value recreational uses of the environment. The model is commonly applied in benefit cost analyses and in natural resource damage assessments where recreation values play a role (Champ, et al 2003)[56]. The travel cost model is a demand based model for expressing a demand for recreational site or sites. Although the demand for a site can be modelled as an aggregate or market demand, the common practice is to estimate demand function on the level of

[56] Champ, P., Boyle, K., Brown, T (eds.). A Primer on Nonmarket Valuation. Kluwer Academic Publishers, 2003

the individual and to calculate site values by adding up individuals` values for the site (Myrick Freeman III, 2003)[57].

Although the travel cost based approach has been developed specifically to measure recreational value, our study attempts to use it to assess the educational value of the ecosystems. This is possible because visiting ecosystems for educational purposes also involves travel costs.

It is important to note that in this work, the estimation of ecosystem education service based on travel costs is not a classic application of the travel cost method. Although actual travel costs are used to determine the monetary value of an ecosystem service, the approach used is not based on individual`s demand and the demand curve constructed on that basis.

According to the methodology, trip cost is the sum of expenses required to make a trip possible. Typical trip cost includes: travel cost, access fees, equipment cost and time cost (Champ, et al 2003).

In order to provide nature education in contact with the ecosystem, students usually travel by bus. The difference from the classical application of the method lies in the fact that the trip is not paid by the students but by the tour organizer, which is either a school or a hobby school (usually method uses individual expenditures). Typically, there are no access fees and equipment costs for any such trips. It is also debatable to use time costs calculations for students because they have no income. Thus, travel expenses for students for educational purposes are the bus rental cost, typically paid by the tour organizer.

In Estonia, the cost of renting a bus suitable for student transportation depends on the duration of rental and not on the distance travelled. The total annual travel cost of providing institutional nature education in Estonia is 2.024 million EUR. It was calculated as follows:

$$Nature\ education\ service\ value = a * b$$

where a - average travel costs for one student (€);
b – number of students in nature education programs.

Parameter	**Value**
a – average travel costs for one student (€). Calculated based on average bus rental price (43,25 €/h), average rental duration (8 h), typical student group size (20)	17.3= =43.25*8/20
b – number of students in nature education programs	116989

The calculations are made based on 2018 data.

7.16.4 Results

As expenditure transfer approach, expenditure based approach and travel cost approach consist different expenditures then it is assumed that these can be summed up to evaluate monetary value of nature education ecosystem service. The value of nature education ecosystem service was 10.17 million EUR in 2019 (Table 69). The calculated value was distributed between ecosystem types using

[57] Freeman. A. M. III. The Measurement of Environmental and Resource values. Theory and Methods. 2nd ed. Washington, DC, 2003.

visitor rates and areas of nature education sites. Final results by ecosystem types are presented in table 53.

Table 59. Monetary value of nature education service, million EUR

Name of the approach for valuing nature education service	Total value
Expenditure transfer approach	6.62
Expenditure based approach	1.53
Travel cost approach	2.02
Total	**10.17**

Table 60. Monetary value of nature education service by ecosystem type, EUR

Ecosystem type	Value of the ecosystem service 2019, €	
Forest	4 276 697	
…drained peatland forests		377 489
…mesotrophic boreal forests		919 428
…eutrophic alvar forests		172 053
…oligotrophic boreal heath forests		301 647
…oligo-mesotrophic boreal forests		1 267 194
…oligotrophic paludifying forests		63 929
…minerotrophic swamp forests		99 626
…eutrophic boreo-nemoral forests		260 822
…mixotrophic and ombrotrophic bog forests		275 393
…eutrophic paludifying forests		534 985
…forest on reclaimed pits		4 133
Grassland	1 116 371	
…cultivated grassland		480 464
…heaths		1 127
…semi-natural grasslands		620 786
…shrubbery		13 994
Cropland	869 168	
…horticultural land		37 824
…crops		830 894
…permanent crops		450
Wetland	931 157	
…fens		108 647
…transition mires		132 327
…peat bogs		681 181
…abandoned peatlands		9 003
Artificial area	2 333 923	
…green space		522 373
…buildings and facilities		620 020
…other artificial areas		1 191 529
Coasts	54 571	
Inland waterbodies	579 776	
…lakes and ponds		476 733
…rivers and streams		103 043
Other	10 257	
Total supply		**10 171 920**

Spatial distribution was made using information about visitors and areas of nature education sites (presented on Figure 15). The detailed process of spatial allocation was similar to that of recreation service, which is described in chapter 7.14.1.

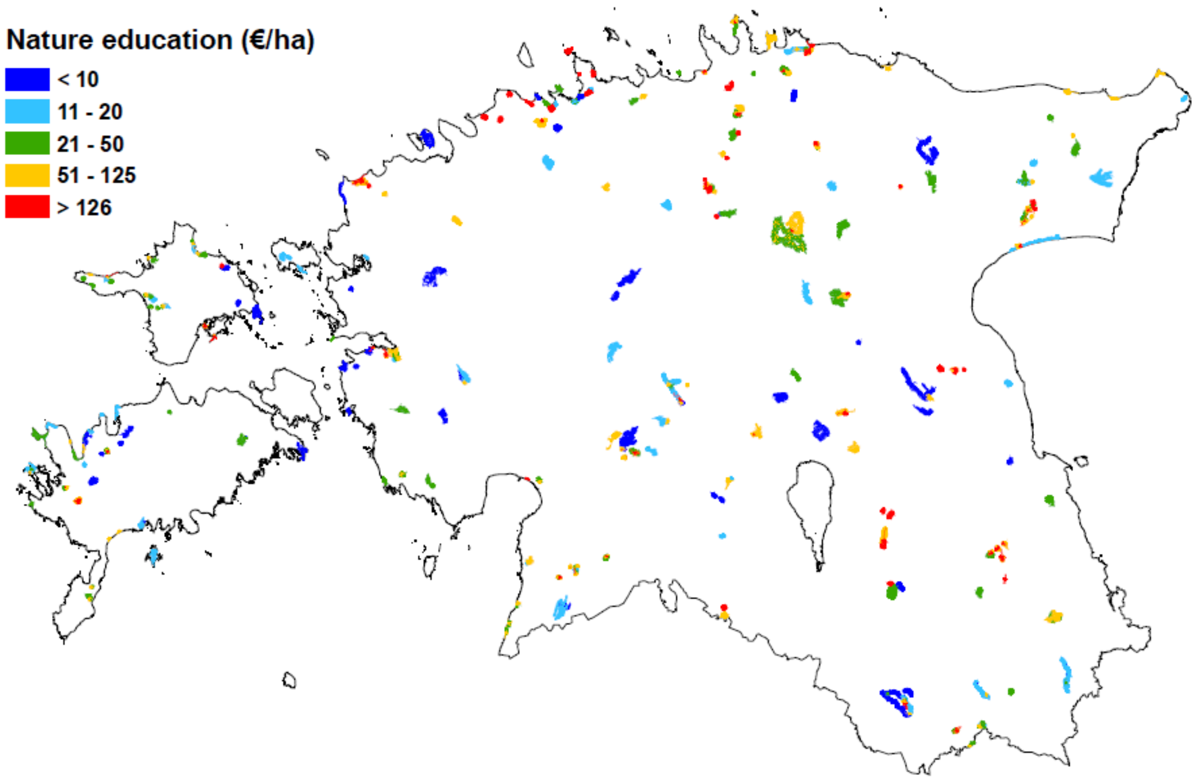

Figure 15. The ecosystem service provisioning areas and values of nature education service. The areas coloured from blue to red represent service provisioning areas according to the unit value (€/ha) supplied by ecosystem assets that was found by expenditure- based method. Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service in the current scope of the study.

7.16.5 Discussion

In the last project nature education ecosystem service value was calculated with same expenditure methods but only the residual values of methods 2 and 3 were considered as ecosystem contributions. After consulting with Dutch experts it was agreed that the methods can be summed up as these consist different expenditures but the full value of all three methods (and not the residual item) should be used to calculate total nature education service value. The reason for this change is that the expenditures made do not expand the output of ecosystem service but rather show how much the users are willing to pay for the service. The residual value concept is rather used for provisioning services, where human made input is important to get the output (in order to get the output one must do expenditures, this is not the case for nature education service).

Suspicion that methods 1 and 2 may overlap in some part still remains but is considered minor as method 2 does not consist data of all nature education suppliers.

In SUT context the use of nature education service is attributed under households as students are the ones using the service.

8 Supply and use tables of ecosystem services

The supply and use tables record the actual flows of ecosystem services supplied by ecosystem assets and used by economic units during an accounting period and the same structure can be used for both physical and monetary terms (SEEA TR 2.27). In this project monetary supply and use tables for Estonia were complied.

Supply and use tables give complete and structured way to present and analyse calculated ecosystem values. The structure of the supply and use tables are similar to tables used in National Acconts and therefore values could easily be compared.

Supply table contains information about ecosystem types and ecosystem services. Different ecosystem types are considered as suppliers and ecosystem services are products that are supplied by ecosystem types. In the supply table can be seen which ecosystem services are provided in which ecosystem asset.

Use table gives information about users of the services by ecosystem services. Users are distributed by institutional sectors and corporations are further broken down by NACE activity. In this grant project use is distributed between corporations, general government and households. Ecosystem services in supply and use tables are the same and total value of supply is equal to use as ecosystem service is provided only if it is used.

Tables and results of exchange value methods and contingent valuation methods are presented in following chapters.

8.1 Supply and use tables based on exchange value methods

Total monetary value of provided ecosystem services calculated with exchange value methods in 2019 was 758 million € and the largest contribution came from timber service (338.6 million €). Recreation (135.5 million €) and global climate regulation service (78.3 million €) had also quite high values. High value of timber ecosystem service contributes to total provisioning service value that makes more than half (60%) of total supplied services value. The largest contribution is made by forest ecosystem forming more than half (73%) of total value. Final results of calculations based on exchange value methods can be seen in Table 61. Table is modified with conditional formatting - the darker blue the cell is, the higher the value.

Comparing with National Accounts it can be calculated that total monetary value of ecosystem services that were considered in this grant project and calculated with exchange value methods amounted to 2.7 % of gross domestic product in 2019.

Table 61. Supply table of ecosystem services based on exchange value methods, thousand €

Ecosystem service	Forest	Grassland	Cropland	Wetland	Artificial area	Coast (SHORES)	Inland waterbodies	Other	Total supply
Fodder		12 302	11 266						23 568
Agricultural production (crops)			32 273						32 273
Herbaceous biomass used for producing energy (bioenergy)		46	88						134
Wild berries and mushrooms	18 021	5		552					18 578
Wild game	5 263	1 265	1 667	496		9		12	8 712
Timber	338 603								338 603
Peat				34 863					34 863
Forest seed	116								116
Provisioning services - total	**361 887**	**13 618**	**45 293**	**35 911**		**9**		**12**	**456 846**
Global climate regulation: carbon sequestration	78 340								78 340
Air quality regulation	6 325	1 351	2 193	668	522			10	11 068
Pollination	13 104	10 709	622	99	6 579	1		14	31 128
Regulating services - total	**97 769**	**12 060**	**2 815**	**767**	**7 100**	**1**		**24**	**120 536**
Recreation	65 315	13 478	13 831	21 787	8 963	899	11 033	149	135 455
Recreational hunting	20 363	5 098	7 489	2 011		33		45	35 039
Nature education	4 277	1 116	869	931	2 334	55	580	10	10 172
Cultural services - total	**89 954**	**19 693**	**22 190**	**24 729**	**11 297**	**987**	**11 612**	**204**	**180 666**
Total	**549 610**	**45 371**	**70 298**	**61 407**	**18 397**	**997**	**11 612**	**240**	**758 048**

Total monetary value of used ecosystem services in 2019 was 758 million € being equal to supplied services value. Final results are presented in Table 62. Table is modified with conditional formatting - the darker blue the cell is, the higher the value.

It is seen that the largest contribution came from timber service and the largest use value is under corporations sector in forestry activity. Households have also quite high value making almost one third (28%) of the total value. Pollination is an intermediate service between ecosystems and therefor it does not have user from institutional sector as it is not directly used but rather used by other ecosystems to provide services.

Global climate regulation: carbon sequestration service use is classified under general government as it represents the collective use of whole society while air quality regulation is rather individual use and classified under households.

Table 62. Use table of ecosystem services based on exchange value methods, thousand €

Ecosystem service	..A Agriculture, forestry and fishing	...A.01 Crop and animal production, hunting	...A.02 Forestry and logging	..B-E Industry	Non-financial corporations - total	General government	Households	Intermediate services	Total use
Fodder	23 568	23 568			23 568				23 568
Agricultural production (crops)	32 272	32 272			32 272				32 272
Herbaceous biomass used for producing energy (bioenergy)				134	134				**134**
Wild berries, mushrooms							18 578		18 578
Wild game	8 712	8 712			8 712				8 712
Timber	338 602		338 602		338 602				338 602
Peat				34 863	34 863				34 863
Forest seed	115		116		116				116
Provisioning services - total	**403 271**	**64 553**	**338 718**	**34 997**	**438 268**		**18 578**		**456 846**
Global climate regulation: carbon sequestration						78 340			78 340
Air quality regulation							11 068		11 068
Pollination								31 128	31 128
Regulating services - total						**78 340**	**11 068**	**31 128**	**120 536**
Recreation							135 455		135 455
Recreational hunting							35 038		35 038
Nature education							10 171		10 171
Cultural services - total							**180 666**		**180 666**
Total	**403 271**	**64 553**	**338 718**	**34 997**	**438 268**	**78 340**	**210 318**	**31 128**	**758 048**

8.2 Supply and use tables based on the contingent valuation method

Total monetary value of provided ecosystem services calculated with contingent valuation method in 2019 was 46 million € and the largest contribution came from global climate regulation: carbon sequestration service (12.9 million €). Habitat conservation service (7 million €) had also quite high value. High value of global climate regulation ecosystem service contributes to total regulation service value that makes major part (70%) of total supplied services value. The largest contribution is made by forest ecosystem forming almost half (48%) of total value. Final results of calculations based on contingent valuation method can be seen in Table 63. Table is modified with conditional formatting - the darker blue cell is the higher the value.

Comparing with National Accounts it can be calculated that total monetary value of ecosystem services considered in this grant project and calculated with contingent valuation method amounted to 0.2 % of gross domestic product in 2019.

Table 63. Supply table of ecosystem services based on contingent valuation method, thousand €

Ecosystem service	Forest	Grassland	Wetland	Total supply
Medicinal herbs	1 700	1 551	921	4 172
Wild berries	1 447		894	2 341
Provisioning services – total	3 147	1 551	1 815	6 513
Global climate regulation: carbon sequestration	6 151	4 014	2 703	12 868
Air quality regulation	3 271		1 631	4 902
Pollination	1 777	1 539		3 316
Maintenance of soil fertility	2 200	1 876		4 076
Habitat conservation	2 778	2 611	1 584	6 972
Regulating services - total	16 177	10 039	5 917	32 134
Recreation	1 301	1 200	841	3 342
Nature education	1 422	1 272	881	3 576
Cultural services – total	2 724	2 471	1 722	6 917
Total	22 049	14 061	9 455	45 564

Total monetary value of used ecosystem services in 2019 was 46 million € being equal to supplied services value. Final results are presented in Table 64. The table is modified with conditional formatting - the darker blue cell is the higher the value.

The largest contribution came from global climate regulation: carbon sequestration service and the largest use value is under general government sector (20 million €). Households have also high value (18 million €) being almost the same with general government consumption. Habitat conservation is classified under consumption of general government as the users are all sectors of society.

Table 64. Use table of ecosystem services based on exchange value methods, thousand €

Ecosystem service	..A Agriculture, forestry and fishing	Non-financial corporations - total	General government	Households	Intermediate services	Total use
Medicinal herbs				4 172		4 172
Wild berries, mushrooms				2 341		2 341
Provisioning services – total				6 513		6 513
Global climate regulation: carbon sequestration			12 868			12 868
Air quality regulation				4 902		4 902
Pollination					3 316	3 316
Maintenance of soil fertility	4 076	4 076				4 076
Habitat conservation			6 972			6 972
Regulating services - total	4 076	4 076	19 839	4 902	3 316	32 134
Recreation				3 342		3 342
Nature education				3 576		3 576
Cultural services – total				6 917		6 917
Total	4 076	4 076	19 839	18 333	3 316	45 564

8.3 Analyses based on supply table: provisioning of the ecosystem services by single ecosystem types, example of forest and agricultural ecosystems

Forest and agricultural ecosystems provide a large part of whole ecosystem provisioning services. These ecosystems are related to the supply of the two most important ecosystem provisioning services of market value, such as timber and agricultural production. Supply tables displayed in chapter 8.2 allow the analyses of the services by the different ecosystems. Service values provided by forest and agricultural ecosystems measured by exchange based methods show that there are in total large differences in service provisioning in these ecosystems in Estonia also on a general level. As a result of a study carried out in the framework of this project, the value of timber provided by the forest ecosystem is about ten times higher than the value of agricultural production provided by cropland (respectively 339 and 32 Million Euros). Comparing the contributions of these two ecosystems, the question arises as to whether the forest ecosystem is really ten times more valuable than cropland as a provider of supply services? In order to find out the differences between the provisioning service values of cropland and forest ecosystems, attention must be paid to the differences in the methodologies used to identify the contributions of ecosystems to the supply of timber and agricultural products. Figure 16Figure 16. Service values provided by forest and agricultural ecosystems measured by exchange based methods, million euros, 2019 Service values provided by forest and agricultural ecosystems measured by exchange based methods, visualizes absolute values of the measured services in these ecosystems in 2019.

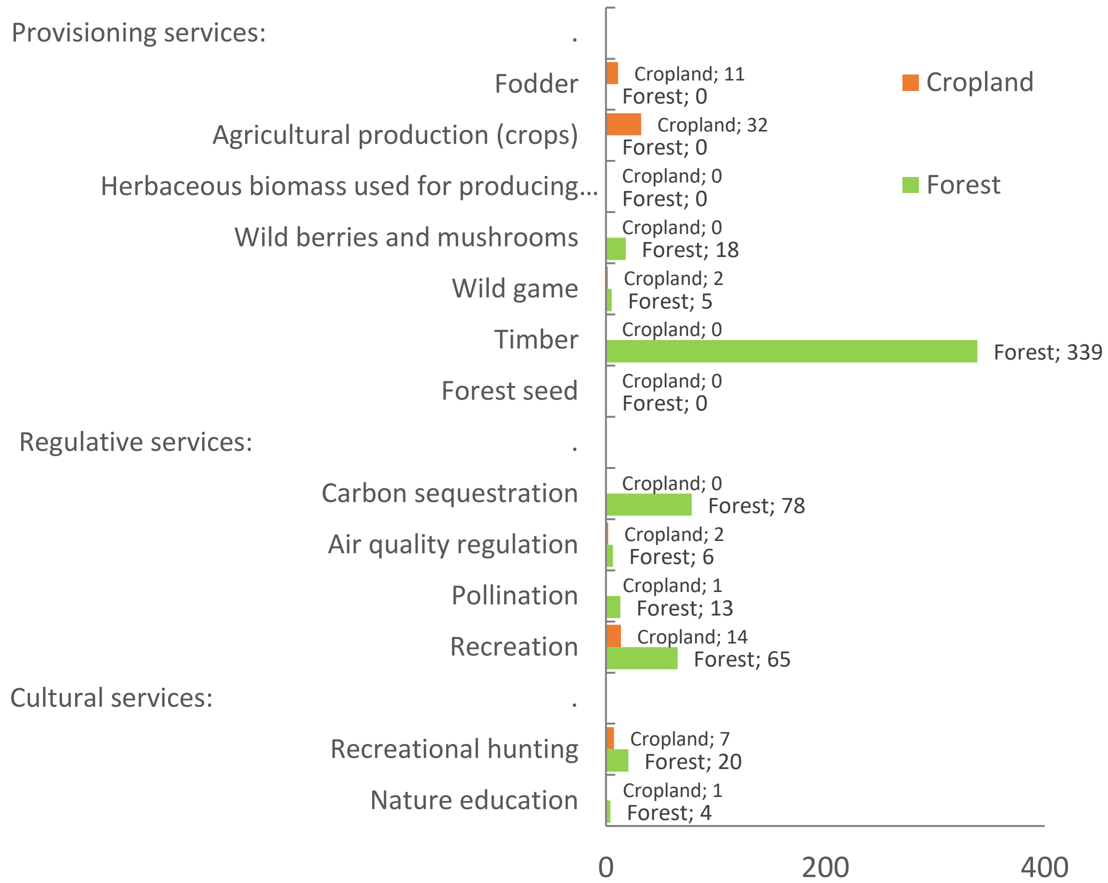

Figure 16. Service values provided by forest and agricultural ecosystems measured by exchange based methods, million euros, 2019

The main supply service for both forest and agricultural ecosystems, respectively timber and agricultural products, has a market price. A similar methodological problem arises for both ecosystems: whether and to what extent the market price of output indicates the contribution of the ecosystem and to what extent it includes the contribution of human and man-made capital. In particular, due to this problem, it may not be accurate to attribute the full market price of the output to the ecosystem provisioning service as the monetary equivalent of the service. Therefore, in the present project, the monetary equivalents of forest and cropland ecosystem provisioning services have been found not directly on the basis of the market price of production but differently. The value of the timber production ecosystem service by forest ecosystem was calculated by multiplying the stumpage prices with the amount of wood harvested. Differences between wood species and assortments were considered.

The use of different assessment methodologies to find the monetary value of forest and agricultural ecosystems is fully justified, as the role of ecosystems in the production of these ecosystems is very different. The forest ecosystem produces timber as a natural ecosystem without human intervention. There is no doubt that there is a need to spend on forest management and timber extraction from the forest, but there is no doubt that the contribution of the ecosystem to timber production is crucial. Therefore, the share of timber services among forest ecosystem service values is also very high.

The cropland ecosystem, the value of which was measured using the rental price method, differs from the forest ecosystem surely in the share of human capital in the price of production. Without the participation of human capital and man-made capital at all stages of agricultural production, the agricultural ecosystem would not produce any output at all. Therefore, it can be assumed that the price of agricultural production includes and reflects, in particular, the contribution of human capital and man-made capital to agricultural production and its automatic transfer to the ecosystem is not justified. This is why the rental price method has been used to evaluate the field ecosystem provisional service, which is expected to better reflect the size of the ecosystem's contribution to the final output than the market price of the agricultural production.

Critical and systematic look on ecosystem contribution is needed if to try to valuate and compare the supply of all ecosystem services by ecosystems types.

8.4 Supply of the ecosystem services by single ecosystem type, comparison of the results, contingent valuation and exchange based methods, example of forest ecosystem

Compiled supply and use tables also allow to compare the service values calculated both by exchange based and CVM methods. Figure 17 displays both supplies of the valued services for forest ecosystem.

In addition to the high values of the provisioning service measured by exchange based method (discussed in chapter 8.3) regulatory and cultural ecosystem services provided by the forest are also higher. This is also to be expected, as, unlike to other ecosystems, net forest carbon sequestration is positive. The forest is also the most preferred ecosystem for recreational use.

In addition to exchange based methods, the monetary equivalent of the values of regulatory and cultural services of the forest ecosystem was also evaluated using the CVM method. Although the total willingness to pay Estonian population for forest ecosystem services was the highest compared to other studied ecosystems(22 million of 46 million), the value of currently measured individual services(22 million) of forest ecosystem is still much lower than estimated using methods based on exchange value(339 millions). The difference between the value found by the CVM method and the values found on the basis of the exchange value is particularly large for carbon sequestration (6.1 versus 78.3 million) and recreational service(1.3 versus 65.3 million). The value of the timber production service was not evaluated using CVM method.

One possible explanation for this is that while the CVM directly measures the increase in welfare due to the use of an ecosystem service, the market price of a carbon pollution unit is not directly related to changes in individual welfare. If it can be assumed that the value of the service found using CVM is underestimated due to the specific use of CVM methodology in current work, then the value of carbon sequestration found by the pollution unit price is overestimated. This means that each method measures different things.

The low value of the recreational service found with the CVM can be explained by the fact that the recreational service was the penultimate by its ranking among the services which was asked to rank in CVM survey. This gave to the recreational service relatively small share from the total willingness to pay. There is probably a difference between what people declare in a CVM survey and what they actually spend on. Although people value regulating services of the ecosystem related to the global environmental quality, they cannot buy them for money in a real market situation.

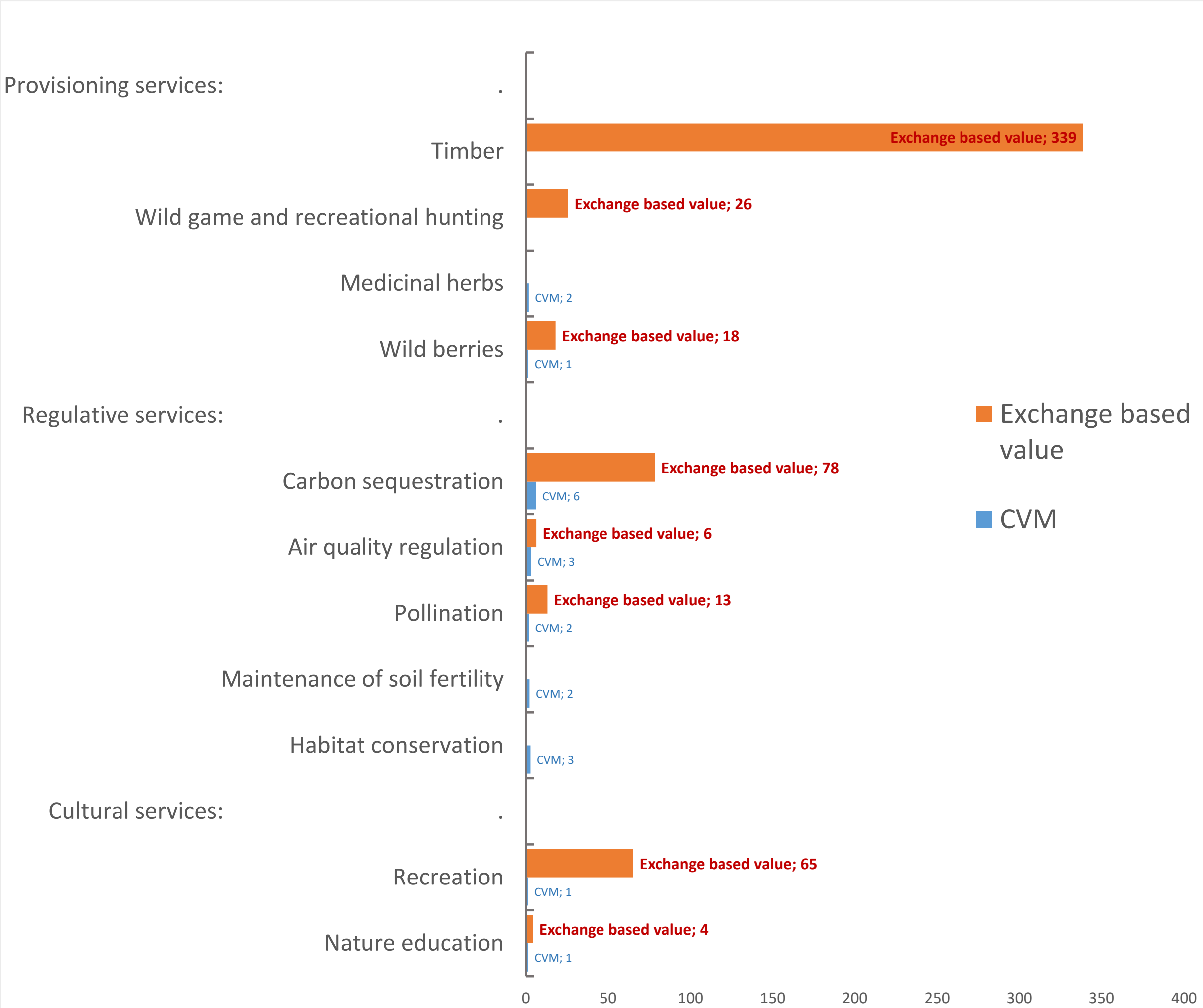

Figure 17. Supply and use table of the service values provided by forest ecosystems measured by different methods, million euros

If an individual is willing to spend a certain amount of money on forest ecosystem services, for example, he or she declares this in CVM and at the same time rates the services truthfully from the point of view of his or her welfare. However, in the actual market situation, a person cannot actually pay for many services (such as regulatory services) and spends the amount of money reserved for ecosystem services (and the time reserved for their use) where possible - for example, by consuming a recreational service. This is a possible reason why the monetary equivalent of the recreational service, found on the basis of actual use, is much higher than that identified by the CVM.

Respondents to the CVM questionnaires may not have adequate knowledge for the several of the ecosystem services. The CVM methods for the several of the ecosystem services need probably also further advancement and probably the choice experiment methods could give the results more up to scale.

In addition to previously described explanations on low values derived by CVM method, the relatively low values could be explained due to the facts that:

1. CVM method is typically used to find out the willingness to pay of individuals for non-market goods (especially for environmental goods, but not only).

2. If the results of the CVM on the willingness to pay of individuals are to be extrapolated to a larger number of individuals and thereby derived the value of the environmental good under evaluation (for example, Estonian forest oxygen production), an important aspect must be taken into account: the monetary value of a territorial unit (such as a hectare) depends on (a) the total willingness to pay for the environmental good under study, and (b) the total area of the ecosystem.

Example 1) let the individual willingness to pay for the service under study be determined by CVM 1 eur / year. If this willingness to pay is extrapolated to 1 million people, the willingness of the country's population to pay for the service (and also the demand for the service) is 1 million euros per year. Assume that the area of the studied ecosystem is 20,000 km2. In this case, 1 km2 offers a service of 10 000 00 euro /20 000 = 50 euro/km2.

Example 2) let the individual willingness to pay for the service under study be determined by CVM 1 eur/year. If this willingness to pay is extrapolated to 10 million people, the willingness of the country's population to pay for the service (and also the demand for the service) is 10 million euros a year. Assume that the area of the studied ecosystem is 10,000 km2. In this case, 1 km2 offers a service of 10,000,000 euro/10,000 ha = 1,000 euro /km2.

These two examples clearly demonstrate that the value of one and the same service per unit area of the same ecosystem depends strongly on both the number of people whose welfare is affected by the service and the size of the territory that provides the service. In the examples above, the value of the same service measured by the CVM differs 20 (!) times. It also explains why the value of ecosystem services as identified using CVM may be lower in less populated countries compared to more densely populated countries.

8.5 Supply of the ecosystem services by single ecosystem type, example of forest ecosystem, lifecycle approach

Forest ecosystem services differ from other ecosystem services in an important respect: timber, the main provisioning service of the forest ecosystem, is either competitive or exclusive of other regulating and cultural services provided by the forest ecosystem, depending on the final felling method (either clear-cutting or some other type of felling). The forest ecosystem cannot simultaneously provide timber and other non-market ecosystem services specific to the forest. If the aim is to evaluate forest ecosystem services in a complex way, taking into account both the provisioning service (timber + secondary use, e.g. berries and mushrooms) and the regulating and cultural services, it would not be appropriate to ignore this fact. Therefore, it would be necessary to analyse how the provisioning service (timber) and other services for which the supply service is either competitive or exclusive influence each other over time period.

Growing forest as an ecosystem provides virtually all of the regulatory and cultural ecosystem services, which are in the list of services in the context of this project. The flow of services provided is continuous and relatively easy to follow over a selected period of time, such as a year (e.g. carbon sequestration, water and air purification, habitat service for species, recreational provision, aesthetic experience, etc.). The reduction of all these regulatory and cultural services to the certain time period also does not create a problem of accounting for turnover, as they are not based on the (actual) turnover described by the accounting and are not (currently) accounted for in national accounts. Obviously, regulatory and cultural services do not participate in the formation of the market price of forest land to the same extent as timber provision service. The argument for the formation of the market price of forest land without forest (in the sense of the land cadastre) is probably the potential of timber production rather than the regulatory and cultural services offered (in the future, as the forest has grown again).

The most important forest ecosystem provisioning service, wood, is constantly growing, but it becomes an SNA value and enters the national accounts periodically, after felling and becoming "timber". The data describing both timber growth and felling are adequately organized, considering the great economic importance of timber. Data on felling volumes, stump prices, harvesting costs (felling costs) as well as transport prices are available, as is the total value of timber production by tree species. Although the accuracy of the data on managed and protected forests is (probably) somewhat different, the available data allow a satisfactory description of the monetary value of the forest ecosystem provisioning service entering to the national accounts. However, this may not be satisfactory if the aim is to attribute value of provisioning service to each forest cadastral unit (or forest allocation) and thus make the provisioning service (and its monetary equivalent) comparable to other forest ecosystem services over a period of one year, considering the aforementioned competitiveness or exclusion of other services in relation to the provisioning service. In a simplified way, the life cycle of a (commercial) forest can be described as follows (starting with the planting / emergence of the forest):

1) Trees are starting to grow, net growth is constantly increasing, the volume of regulatory and cultural services provided is growing, the price of forest land is growing (more or less) in proportion to net growth of wood.

2) The forest reaches (in the sense of forest management) felling maturity and is harvested. At this stage, the non-SNA value of the forest ecosystem becomes the SNA value and it enters to the national accounts. At this stage, it is also possible to attribute to the forest ecosystem the monetary value of the supply service, i.e. the contribution to the price of timber, taking into account felling and transport costs. At the same time, there is a very significant change in the amount and value of the regulatory and cultural services provided by the forest ecosystem - they either decrease sharply or disappear completely for some time (depending on the final felling method). The value of the SNA enters the national economy, but it is not a pure victory in terms of overall welfare, because at the same time other important ecosystem (non-provisioning) services are declining or disappearing, and therefore the welfare from the timber is declining. The felling of valuable forests (recreational forests, community forests, etc.), which are an argument of the welfare of many people, will certainly lead to a decline in overall welfare, i.e. the additional welfare which is formed from timber of wood will not compensate the loss of forest ecosystem.

In view of the above, keeping records of ecosystem services related to forest land at isolated intervals (e.g. years) may not be transparent in a true description of the ecosystem services provided during the forest life cycle. As an opportunity to overcome the periodicity of forest provisioning value changes to SNA and the competitiveness / exclusion of different ecosystem services, a life cycle assessment of forest ecosystem services from clear cut forest area to final felling as a result of which timber enters the economy as SNA value. The different ecosystem values created during the forest life cycle and the corresponding monetary equivalents (as far as we can find them), is divided equally over the years of the forest life cycle, assigning an equal monetary value to each year. While this approach does not accurately describe the actual value of the services provided by the forest (or forest land) ecosystem in each of the years considered, it does indicate the total value of the services provided by the forest ecosystem, taking into account competitiveness and exclusion. This approach also eliminates the need to take into account the monetary value of growing timber and annual net growth.

It seems that the use of the estimations of the annual calculation of the forest provisioning service based on market based approach is limited from the viewpoint of the planning purposes as it ignores the exclusive nature of the timber provisioning ecosystem service to other ecosystem services: if timber is provided other services may not exist anymore. In case of asset valuations these aspects would be magnified even more. The approach used is national accounts may reflect the real forest value better than the stumpage price method currently agreed upon for the valuation of the service.

9 Analyses and treatment of valuations

The discussion on the treatment of the results of alternative ecosystem services valuation approaches is ongoing. Statistics Estonia has used first hand Market Price (Market Price and Revealed Preferences) methods and in addition also alternative methods (Stated Preferences) for the valuation of ecosystem services. We were wondering if the discussion could support the SEEA EA revision (for example on how the service values could be added up or different methods combined for the calculation of the gross ecosystem product).

Variety of methods were used to assess the monetary value of ecosystem services. These include direct Market Price method; different indirect market price evaluation methods (Revealed Preferences) including those which were developed during this study under conditions of limited availability of source data and in the circumstances of no agreed valuation methodologies; and contingent valuation method (Stated Preferences). Selected methods for ecosystem services are displayed in Table 9.

Many of the ecosystem services have no direct exchange value and therefore the monetary equivalent could not be obtained from the market. For example, among ecosystem services there are services related to walking in the forest (recreational value of the ecosystem), knowledge of the existence of biological species (psycho-social value) or enjoying the landscape view (aesthetic value). The question arises whether these values without direct output having market price are in principle comparable to market values and what unites them. Our goal in this work was to cover different types of values.

Statistics Estonia worked together with Tallinn Technical University (who are in lead of environmental economics in Estonia) and found a common ground that all ecosystem services that increase welfare of individuals have value despite their participation in the market. However, the valuation methods differ.

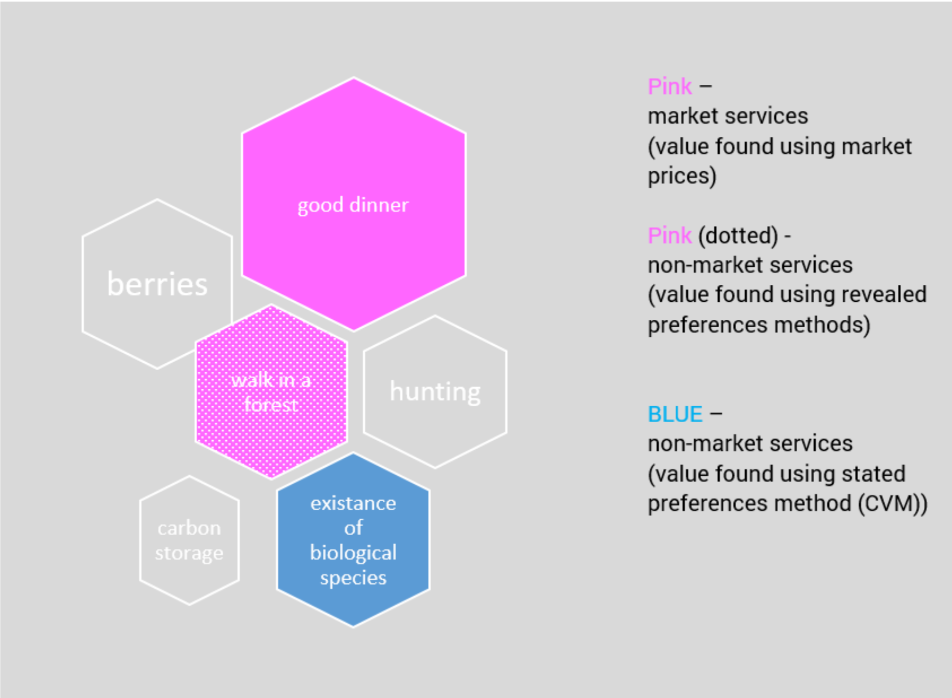

Figure 18. Examples of the contribution of market and non-market values to individual's welfare

As Statistics Estonia used Market Price and Revealed Preferences methods but also Stated Preferences (CVM - Contingent Valuation Method) as an alternative method for the valuation of ecosystem services of grasslands the results could be compared.

We tried to understand the similarities, differences and find the ways to complement overall results.

The total annual value obtained by Market Price or Revealed Preferences methods was higher than the one obtained by CVM. The total service value for the number of ecosystem services found by the selected preferred Market Price or Revealed Preferences methods was approximately 758 million € and is higher than the value found by CVM methods which is approximately 46 million€. Considering the nature and content of the contingent valuation method (CVM), which identifies how much the environmental goods (positively) influence the respondent's welfare, the difference between the values found using CVM and values identified using other valuation methods is not surprising given the different perspectives. The values obtained by Market Price or Revealed Preferences methods are found either on the basis of the market prices of the output or on the basis of the time value. Although both methods are based on something measurable (market price and time spent, respectively), neither method directly measures the value of an ecosystem service, which expresses its ability to improve the welfare of individuals. The CVM, however, directly measures the changes in welfare that are subjectively perceived by individuals.

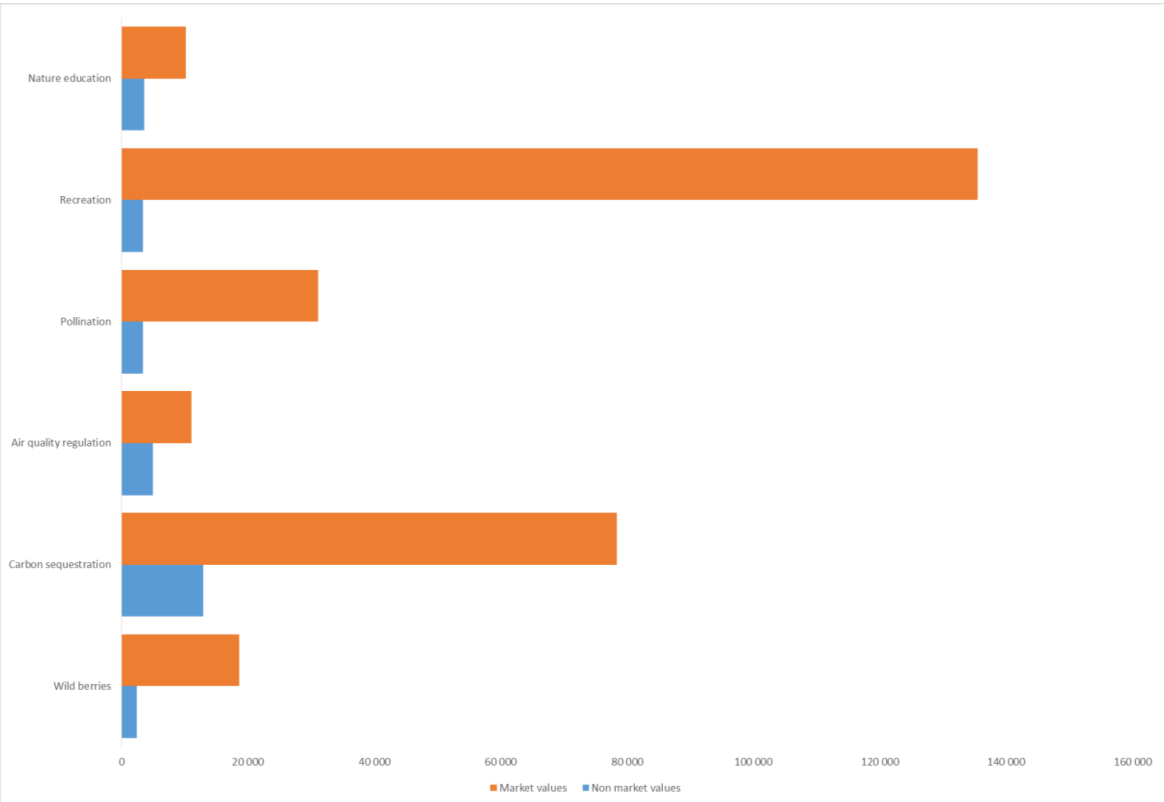

Figure 19. Comparison of the results (service value in thousand €) obtained by the selected Market Price or Revealed Preferences valuation methods and CVM for the selection of ecosystem services.

The total annual value obtained by Market Price or Revealed Preferences methods and CVM gave the results of different scale: the values differ significantly when measured by the Market Price or CVM.

There could be different reasons, we just highlight here two of the issues identified:

1. We try to discuss one of the issues related to the intermediate pollination service. Apparently, when evaluating the pollination service with Market Price method, a situation has arisen in

which the value of other ecosystem regulatory services was also attributed (either in part or in full) to pollination service. After all, when assessing the values of services on the basis of the Market Price of production, the sum of the values should not exceed the value of production. The value of the pollination service is found at the market price of agricultural production, based on the logic that if there is no pollination, there is no production (or there is considerably less production). However, the same approach can be taken for other services, in particular for regulatory services, which we did not assess. E.g. it can be argued that if there is no proper moisture regime in the soil, there is no production. Ideally, interaction of all component services contributing to the production of interest (currently agricultural production) need to modelled.

2. The contribution of ecosystem services. It is not yet agreed how to find the share of the contribution of ecosystem from the total service value. In case of expenditure based approaches which expenditures to include if basing the valuations on expenditures in some way. We described how the accounting system can record the contribution of the ecosystem to the value of the ecosystem services and benefits. The depth of handling of these aspects varies among services. In order to maintain certain coherence among the calculated services in the developed supply and use table and summary tables of the services, we did not include the calculation results referring to the narrow concept of ecosystem contribution.

For the compilation of the supply and use table, Market Price or Revealed Preferences methods were favoured as the ones tightly related to the valuation methods in national accounts, environmental accounts and statistics. But we wonder whether the CVM results could complement the results received by Market Price or Revealed Preferences methods.

The advantage of market value based valuation or revealed preferences over stated preferences is that they are based on real turnover, which makes the method fitting for accounting systems and statistics.

However, a major disadvantage of the actual cost approach is that the price of exchange value goods (market goods) does not fully and fairly include the value of ecosystem contribution (and therefore ecosystem services). For example, when valuing ecosystem provisioning services (e.g. agricultural production) through the market price of production, the question arises whether the output that seeks to value the supply service financially does include the ecosystem value in large? And if it does, to what extent? For example, what forces a farmer to add ecosystem value to the price of production? After all, production would become more expensive and competitiveness in the market would decrease.

9.1 Discussion

Despite the fact that the underlying concepts may be the same, environmental accountants and environmental economists sometimes seem to speak a different language: scientific and statistical methods, semantics and understanding of the valuation sometimes differ. Accountants think in the frames set by System of National Accounts and UN System of Environmental Economic Accounts. Environmental economists focus on monetary valuation of the contribution of natural capital to welfare.

The analysis of the contingent valuation study results for the valuing of several ecosystem services provide a new insight. The applicability of this additional source of information and methods as regards to the ecosystem services was analysed for valuation and ecosystem services accounts.

Our discussions and questions highlight the fact that statistics (and the underlying actual turnover accounting) and environmental economics use "different languages" to describe the relationship between the environment and the economic system.

While environmental economics began to explore the possibilities of monetary valuation of non-market (ie non-direct turnover) natural values as early as the 1960s, accounting and related statistics (including GDP) have until recently been based on real turnover, which according to accounting canons described "and" split between rows ". Undoubtedly, with such an approach, non-market natural assets (in modern terms ecosystem services) will be excluded from official statistics. Not only is the non-market values of nature not affected by the accounting of the problem of getting into trouble, but the accounting (and consequently also the statistics) is also stuck in describing non-market values of human capital. As an example, how is the value of labor reflected in a company's balance sheet? Or the value of the company's brand? Or the company's bad reputation as a polluter? Undoubtedly, it can be argued that all these elements are included in the sale price of the company and, in the case of listed companies, also in the share price. But are these undoubtedly existing values reflected in the accounts of a non-listed company and how?

The nature (ecosystems) value branch of environmental economics, and in particular its operational part, has focused mainly on social cost-benefit analysis to generate input and also on the financial assessment of environmental damage. The logic of economic accounting has not been taken into account at all in the development of environmental economics methods. Thus, for example, environmental economics can attribute the market value of all grass hay to grassland and the market value of wood to the forest ecosystem when talking about so-called exchange values. However, accounting puts the monetary value of hay on the value of agriculture and timber on the forestry (forest industry) line, leaving no red cross on the ecosystem. Methodologically, the same story is with the values obtained indirectly. For example, in the travel cost method (recreation services), which is widely used in environmental economics, the total value found (ie the total financial cost of reaching the site) is attributed to the natural object, claiming that it is the monetary equivalent of a natural object (such as a waterfall or boulder). And as such, it is also used as an input to the social cost-benefit analysis when it comes to, for example, the granting or non-granting of a special water use permit for hydropower production. However, the accounts take a completely different view of travel costs, which are probably described in the transport sector.

There is also a big difference between the environmental economics and the accounting approach in the direct measurement of natural values with CVM, which measures the monetary equivalent of natural values (mostly non-market, but not only!) to those how benefit. As this is not a real turnover, the accounts have completely ignored the resulting increase in welfare, ie it is not reflected in any way, and it is not described on any accounting line.

As can be seen from the above, the objectives of environmental economics and accounting have so far been different: the former measures the ability of natural assets (ecosystem services) to improve individual well-being and its monetary equivalent (for non-market values), the latter describes actual turnover (cash flows). These two approaches collide in the development of economic accounts and methodologies for ecosystem services.

The problems that arise when statistics want to start accounting for ecosystem services (and assets) using environmental economics methods stem from the different objectives of environmental economics and accounting. Environmental economics measures (or tries to measure) how much one or another nature value affects (increases) an individual's well-being. It does not make a fundamental difference whether the service consists of the so-called exchange value at the market price or is non-market. It is important to make different values comparable or one-dimensional in order to compare different resource use scenarios (social cost-benefit analysis!) And to select the most beneficial for society (ideally, of course, assuming that decision-makers are enlightened). What matters is the impact of the service being assessed on well-being, not whether it is a market or a non-market service. Only the methods used are different, ie the willingness to pay for the benefit is determined in different ways. In some cases the market price (hay and potatoes for example), in some cases the cost actually incurred but indirectly related to the service under assessment (travel cost method for example), in some cases where there is no real turnover at all, the use of a simulated market scenario (CVM). However, all these methods measure an individual's actual or hypothetical willingness to pay for a benefit and are therefore equivalent. Thus, from the point of view of environmental economics, the nature of value is the ability of something to positively affect the well-being of individuals and is measured by the willingness of individuals to pay, whether it is based on real turnover or hypothetical.

However, accounting (and the statistics based on it) have so far dealt with real turnover, described in a certain way, and without making a fundamental change, the financial equivalent of the value of ecosystem services found and to be found in environmental economics cannot be taken over. The main problem is that the turnover on the basis of which environmental economics assigns value to services is already described by the accounts in "other lines" (a few examples are given above). This is also the reason why the accounts cannot automatically attribute the market value of all agricultural production to the field ecosystem and all the travel costs of the hiking trail users to the ecosystems along the hiking trail. As the total turnover is described in the "other rows", the assessment of ecosystem services according to the accounting criteria (assuming a rigid adherence to the actual turnover) must be reduced to the number of ecosystem services to be created. In our example, profits are raised there as the component of actual turnover that is least related to the direct costs of the entities. The disadvantage of this approach is that the monetary value of the ecosystem service becomes so ridiculously small, which has been pointed out also by the members of the London group, for example. One can only imagine what will happen and which resource use scenarios will benefit from the decision-making process if the ecosystem value found in this way would be the input for the decision makers.

Whether and to what extent the market price of supply services includes the real value of the ecosystem service at all is a separate issue, and we have discussed it also in our respective London Group 2020 article: Two Languages or Two Narratives: Comparison of the Selected Market Price and Revealed Preferences Valuation Methods to the Stated Preferences Method [58],).

In conclusion, it is very difficult to keep economic accounts and produce statistics on ecosystem services without changing the established canons of accounting and statistics and opposing the individual welfare-based approach to environmental economics. However, such major paradigm shifts in machinery such as national statistics and GDP accounting is not a realistic goal in the context of this ecosystem services accounting project (and was not an aim as well).

If in case of natural ecosystems the CVM results could remain in a status of a background information, - the values are rather low, than in case of urban ecosystem supply accounts the importance of the service values obtained by contingent valuation method is relatively high. If in case of natural ecosystems 79 % of the value came from timber provisioning services and the service values of

1. [58] 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

selected comparable services lower by order of magnitude than for urban ecosystems the proportions are the opposite: service values measured by contingent valuation methods are higher and outweigh the ones measured by marked based methods. Chapter 10 gives an overview of urban thematic account and the feasibility of producing service values in conjunction of CVM and market based valuation methods.

9.2 Conclusion and future steps

The results of current work on ecosystem service valuation results treatment is probably just a opening of the series of the discussions. The results would be analysed and will be taken to those who are interested to develop whole area further. So far both approaches (market based and stated preferences) outline a certain side of ecosystem services.

As Market Price or Revealed Preferences methods do not allow to consider the value of the services which do not have a monetary equivalent in a market scenario, the non-inclusion of these services in the accounts will lead to the underestimation of the value of ecosystem services.

As market services and non-market services require a different approach for evaluation we are eager to develop further the informed discussions with those currently developing this field (e g Eurostat TF, UN London Group on environmental accounting, UN CEEA) and to develop the common positions on feasibility of combining and summing the results of Market Price or Revealed Preferences methods with Stated Preferences methods when finding monetary equivalent of single ecosystem services and total economic value.

Methods of environmental economics were elaborated mostly for social cost benefit analyses not for accounting. So, the methods have to be further developed in order to narrow down the gap between accounting and existing environmental economics. There are common features we can build upon like all ecosystem services contribute to welfare.

We have an opinion that all ecosystem services that increase welfare of individuals have a value regardless of their participation in the market. In case of urban environment which features high human influence and interest we propose to complement the results and to sum up the service values both of market and non market valuation methods.

There is also the question whether the ecosystem service value which is based on production Market Price method contains the contribution of the ecosystem adequately? And if not, could the Stated Preferences methods complement the results derived by Market Price or Revealed Preferences based methods for market services?

10 Urban thematic account

10.1 Concept and why it is difficult to classify urban ecosystems

Both scientists and also less qualified people in general have a fairly common and consensual understanding of what the forest looks like and the grassland looks like: the grassland is dominated by grasses and the forest is dominated by trees. Although the criteria for the transition of ecosystems can be debated (eg where a wooded meadow ends and a forest begins), the vast majority of meadows, forests and also bogs are so different from each other botanically (and more broadly biologically) that there is no need to be a scientist to determine the ecosystem.

The same cannot be said for urban ecosystems, which do not have such a uniform basis for classification. And that is where the problems of identifying and defining urban ecosystems begin. Different institutions try to set their own criteria, sometimes on the basis of subjective interest. For example, the classification of the forests surrounding a city as urban ecosystems or as forest ecosystems says nothing about its value but is rather statistical by nature. However, the possibility to decide on forest management issues by the City government may be reduced if the forest is administratively outside City borders and defined as a forest, instead of being defined as an urban ecosystem.

Thus, there seem to be two different ways of designating a forest as an urban ecosystem: urban ecosystem is considered to be one that is either the forest within the city administrative borders or where city inhabitants typically walk. However, both criteria are, unlike other ecosystems, non-biological and say nothing about the biological nature of the ecosystem, which is the basis for classifying other ecosystems, such as grassland, forest or bog. The urban ecosystem can be characterized by a meadow (eg a lawn around the Kadriorg Swan Pond), a forest (a part of Kadriorg Park with large trees, an alder at the Lepistiku public transport stop in Mustamäe, etc.) as well as a bog feature. If there is any substantive biological criterion that connects these ecosystems, then it is the degree of human impact, ie the "degree of artificiality" of the ecosystem. The latter is suitable for green areas of the city, such as flower beds and lawns, but not for forest parks located in the city (eg Glehn Park in Tallinn), where typical forestry activities is definitely carried out but with less intensity than in commercial forests.

A separate issue and also a criterion is how people subjectively perceive the urban ecosystem and its extent. Many people are likely to think about this issue when filling contingent valuation questionnaire. The natural solution to this question would be that "the urban ecosystem is what I feel as an urban ecosystem". Such an answer may be correct from the point of view of cognitive theory, but it hardly satisfies the needs of accounting and statistics.

In view of the above, it is clear that not an administrative, biological and subjective criterion taken separately can be used to define an urban ecosystem, but the achievement of the better result requires the development and use of a complex method that takes into account several different factors.

10.2 Methodological discussions on urban thematic account

As we have tied our work up with the ongoing work on the revision process of the SEEA EEA (https://seea.un.org/content/seea-experimental-ecosystem-accounting-revision) we consulted also the revisers (Carl Obst). Feasibility of some of the concepts described in mentioned guidelines (and related discussion documents) were tested: like separate satellite account for urban ecosystems (there are several other issues we are dealing with and which are relevant for revision like IUCN ecosystem types classification, definition and classification of the changes in extent account etc.).

AS we outlined in our grant proposal "The work of the revision process of the SEEA EEA (https://seea.un.org/content/seea-experimental-ecosystem-accounting-revision) will be followed and some of the essential aspects would be selected for the testing. The feasibility on some of the concepts described in mentioned guidelines were tested: like ecosystem types classification and separate satellite account for urban ecosystems."

Question Statistics Estonia raised was how to fit the asset based valuation results (recreational value of the parks, noise) into the ecosystem types based framework? We opened the discussion with the revisers of UN SEEA EA but topic area leads. Topic area leads indicated that the chapter on thematic accounting will include a discussion on accounting for urban ecosystems. However, compilers turned our attention to the fact that it would not provide definitive guidance on the types of measurement choices that we are looking to resolve. These choices were considered important but it was suggested that Statistics Estonia could make validly different choices depending on the question and the data available. Till the moment we had to make the accounting framework choices, the revision team had not finalised the plans for the chapter on thematic accounting for the revised SEEA EEA.

It was suggested that the description in the thematic accounting section would cover more than only extent. In particular because the distinction between extent and condition was considered tricky and depends in large part on scale of analysis. For example, blue-green space can be seen as distinct EA or as condition metrics within a wider EA. Urban accounting would discuss relevant ecosystem services and some discussion on relevant pressures. But as compilers of UN SEEA EA suggested the exact scope is still to be determined for every user of the guidelines.

Statistics Estonia raised the problems faced in treatment of the urban ecosystem services on two relevant working groups:

1) UNSD London group seminar on revision of UN SEEA EEA valuation and urban thematic account discussions. Proposal of UN SEEA EA urban thematic account contains a cross tabulation of ecosystem. Estonia's proposals for the revision of thematic urban account of UN SEEA EA chapter 13 were as follows, to:

1. develope/ describe hybrid approach between landscape and asset accounts in chapter 13.

2. include the notion on population density criterion in the urban ecosystem area (under morphological) criterion in chapter 13

We raised two questions on revision seminar organized by UNSD:

1. Why there is a need to classify urban ecosystems based by two typologies: assets and landscape?
2. What will be the bases for the monetary valuation and what would be the elementary spatial unit for monetary valuation?

Revisers informed us that as different ecosystem services biophysical and valuation models use landscape (eg. nature types for pollinator habitat) and assets (e.g. trees and air pollution mitigation), there is no single basic accounting unit that works for all available valuation methods.

We also addressed the issue that supply table in principle contains a cross-tabulation of ecosystem services and ecosystem extent (using landscape approach). Question was related to the issue how to fit the asset based valuation results (recreational value of the parks, noise reduction) into this framework (outlined on page 12 of the presentation of Francoise Soulard)[59]?
This was considered to be a challenge for the future research for revisers with no clear answers currently.

Other contributors also highlighted (Burkhard Schweppe-Kraft) that it is important also to consider and valuation of the benefits that are outside the economic sphere.

It was discussed that if urban ecosystem services (and other) markets are perfect in reflecting all direct and indirect effects than all benefits should be already included in actual exchange values. But as the markets are not perfect, the simulation of the exchange values for benefits that are not yet included could be justified. It was also noted that it is important to keep in mind that simulated values are different from welfare values.

In addition there is an issue which services to cover and how to aggregate and to find ecosystem contribution? The developers of the GEP approach (developed by BaolongHan-RCEES-China), suggested summing up different kinds of service values. In order to aggregate service values in GEP approach applied in China, ecosystem service physical values were translated into monetary units with an alternative engineering cost method. The GEP approach (developed by BaolongHan-RCEES-China), of summing up different kind of service values was discussed by compilers and was desired to be tested by project team members as well. Statistics Estonia debated the treatment of the urban ecosystem services also on a MAIA seminar on urban ecosystem accounting.

As urban ecosystems contribute to the welfare values in a direct way when question was raised how to integrate these welfare values in urban ecosystem accounts (in SNA compatible way), as these are the values generally not accounted/found in national accounts. How to add up these welfare based values (measured for example using CVM or CE methods) and other measured using market/exchange based values. The directions given by David Barton, indicated on a future research needs in the area urban ecosystem service valuation and treatments of the accounts.

10.3 Urban ecosystems thematic account, concept chosen

The criterion for classifying the urban ecosystem area, which has been developed and used in this work, is a complex criterion that considers both the population density and the distance of artificial areas from the ecosystem. Such criteria of urban ecosystem are expected to be closest to how people subjectively perceive it. Criteria and the selection process are described in chapter 10.4

As a framework for arranging urban ecosystems supply and extent tables the frameworks and concept outlined in UN SEEA EA chapter 13 were analysed. Considering the services chosen for valuation and data available, the extent account presentation using individual asset approach (table 13.7, p 292)

[59] Urban Ecosystem AccountsVirtual Expert Forum on SEEA EEA 2020Session 4: Thematic accounts and indicatorsJennie Wang and François SoulardEnvironmental Accounts and Statistics ProgramStatistics Canada / Government of Canada
https://seea.un.org/sites/seea.un.org/files/virtual_forum_2020_urban_areas_v2_final.pdf

splitting urban area into urban ecosystem assets and natural ecosystem types was chosen by project expert team. Framework is described in chapter 10.5

10.4 Criteria for defining urban areas

Stakeholders were consulted regarding the definition of urban areas. There was no clear definition of the urban areas applicable and accepted as consensus regarding the urban areas definition as described above.

Stakeholders suggested to analyse both Sustainable Development Goal 15. (Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss) as there are targets set what should be considered (https://sustainabledevelopment.un.org/sdg15) and Sustainable Development Goal 11 (Make cities and human settlements inclusive, safe, resilient and sustainable) and to focus on last one (https://sustainabledevelopment.un.org/sdg11) if to conceptualize urban area from sustainability perspective. There were two targets set:

1.GOAL 11.6 By 2030, reduce the adverse per capita environmental impact of cities, including by paying special attention to air quality and municipal and other waste management

2.GOAL 11.7 By 2030, provide universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities

The need to treat the city and the urban natural ecosystems was suggested so that the point of view is not the natural ecosystems but the urban area which also comprises natural ecosystems.

The complex criterion for classifying the urban ecosystem considers both the population density and the distance of artificial areas from the ecosystem as outlined below.

Experts also noted that with the capabilities and capabilities of modern GIS, the degree of uncertainty in the delimitation of ecosystems that can be caused by handling/cutting the ecosystems into square kilometres should be avoided. It was further suggested to consider a better spatial resolution - reduce the size of the square to 100 or 250m.

Experts emphasized that these criteria should be made so that they allow to form a complete urban area? So that thematic account would allow to reflect the changes if more greenery is created in a city or that a green area becomes urban.

Criteria for defining urban areas were:

- Human density greater than or equal to 200 people per square kilometre.
- The share of infrastructure is greater than or equal to 10%.
- Areas are at least 1 km^2 in size. The 1 km^2 area criterion does not apply to the land area in the high seas and "large" lakes, i.e. the urban area may be <1 km^2 when surrounded by (360 *) with open sea, Lake Peipsi or Lake Võrtsjärv. The size of the individual squares/grid was set on 100mx100 m as additional criteria.

Objects / phenomena we consider as the infrastructure (data come from the Estonian topographic database) are the: building under construction, residential or community building, greenhouse, under the roof, next to or in a production building, other (building), ruined places, foundation, production yard, bus station, pedestrian area, the runway, traffic area, parking, sport, other (road), bowling alley, byway, other national road, main road, ramp or connecting road, the street, support road.

10.5 Urban ecosystem extent

For the compilation of the urban ecosystem extent, proposal outlined in UN SEEA EA chapter 13 was analysed. Considering the services chosen for the valuation and available data, the presentation of extent account that used individual asset approach (table 13.7, p 292) which split urban area into urban ecosystem assets and natural ecosystem types was chosen by project expert team.

Basic mapping units were classified according to the derived urban ecosystem extent framework. Basic mapping units were adjusted in one occasion: private yards were split into green (urban assets: private yards) and artificial area (buildings) based on the data in building register.

Derived ecosystem extent was used as ecosystem dimension of the urban ecosystem services supply table, which can be seen in Table 77.

Ecosystems/map units in urban areas can be grouped into categories of urban green, natural green and urban grey areas. Urban ecosystem extent account is hence spatially explicit.

10.6 Urban ecosystem services

Defining urban ecosystem services was taken up in parallel and the methods were analysed and stakeholders were consulted in order to identify relevant and feasible flows to measure. Regarding the methods we have a „mixed basket“ due to fact that we have both natural (incl. seminatural) and urban green areas represented and also respective services to be captured. We mean that in one hand we have the services which are provided by natural ecosystems and in another hand we have services unique for urban environments. So, parallel methods were used and planned: market based, expenditure transfer, expenditure based , time use based approach, travel cost approach etc. depending on a service and we use the CVM study results (study just completed by Tallinn Technical University). Chapter 5 gives an additional insight into the process of the selection of the services for monetary valuation in urban areas and Table 9 displays the ecosystem services chosen for the monetary valuation with exchange value based methods and CVM study in urban ecosystems alongside with those in natural/semi-natural ecosystems.

Urban ecosystem services valued by exchange based methods and which are produced by natural ecosystem are outlined in chapter 6 and described and discussed under the specific valuation approaches in chapter 7.

The services covered are all relevant to the various urban natural ecosystems types. The services specific only for urban ecosystems are handled in subchapters 10.6.1.1 (Organic waste which is used for producing compost) and 10.6.1.2 (water drainage).

CVM results for urban ecosystems are described in chapter 10.6.2.

Allocation of urban ecosystem services values to urban ecosystem types e.g. producing a supply table is described and displayed in chapter 10.7.

10.6.1 Urban ecosystem services valued by exchange based methods

Urban ecosystem services valued by exchange based methods and which are produced by natural ecosystem are outlined in chapter 6 and described and discussed under the specific valuation approaches in chapter 7. The services covered are all relevant to the various urban natural ecosystems types. The services specific for urban ecosystems are handled in subchapters 10.6.1.1 (Organic waste which is used for producing compost) and 10.6.1.2 (water drainage) and CVM results for urban ecosystems are described in chapter 10.6.2.

10.6.1.1 Urban ecosystem services valued with exchange value based methods: Organic waste which is used for producing compost

According to CICES v5.1 the ecosystem service of decomposition of biological materials and their incorporation in soils is described as services that ensure that the organic matter in our soils is maintained (see also Table 76). In case of urban areas green areas, cemeteries, rows of trees and urban forests provide biomass suitable for soil formation.

Table 65. Definition of the ecosystem service of decomposition of biological materials and their incorporation in soils to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Decomposition and fixing processes and their effect on soil quality	*2.2.4.2*	*Ensuring the organic matter in our soils is maintained*	*Decomposition of biological materials and their incorporation in soils…*	*…that maintains their characteristics necessary for human use*	*Decomposition of plant residue; N-fixation by legumes*	*Maintenance of soil quality; legumes used to increase/maintain N-levels in soil*

In this study, tree leaves collected from green areas and cemeteries maintained by the City Government of Tartu are used to determine the monetary value of the formation of organic matter.

The areas of green areas and cemeteries maintained in 2018 and 2019 have been obtained from the Department of Communal Services of Tartu City Government. There are totally 205.3 hectares of areas covered with trees and bushes, includes 119.3 ha urban forests, 38.8 ha cemeteries and 47.2 ha various rows of trees (such as alleys, hedges, etc.). For the calculation of the monetary value of the formation of organic matter areas from which leaves of trees and bushes are collected and composted were selected. In 2018 and 2019, leaves were collected from 155.8 hectares and taken for composting.

The quantities of leaves transported for composting have been obtained from OÜ Fasetra, which is engaged in composting tree leaves collected from green areas of the city of Tartu. In 2018 and 2019, 1353 and 1361 tons of leaves were taken for composting, respectively.

The sales price of organic matter is obtained as the average of the sales prices of three different compost producers and in 2019 it was 25 euros / m3, excluding VAT.

According to Fasetra OÜ and the literature, the ratio of leaves to compost is 4: 1. [60]

[60] Bachert C.; Bidlingmaier, W.; Wattanachira, S. 2008. Open windrow composting manual. Bauhaus-University Weimar & Knoten Weimar GmbH. 60 p.

According to the literature, the density of finished compost is 500 kg/m3.[61]

Based on the basic map of ecosystems 654.9 ha rows of trees, 329.6 ha cemeteries and 7366.8 ha urban forests are located in Estonian urban areas. Total area is 8351.3 ha.

Using the weight of the leaves collected from maintained green areas of the city in 2018 and 2019 and the fact that the ratio of leaves to organic matter is 4:1 the amount of organic matter formed was 338 and 340 tons, respectively. Taking into account that the density of the finished compost is 500 kg / m3, the volume of organic matter formed was calculated (676 m3 and 680 m3, respectively). Using the volume of organic matter formed and the area of the area to be maintained, it was found that organic matter was formed at 4 cubic meters per hectare. Based on the fact that in 2018 and 2019 the sales price of one cubic meter of organic matter was 25 euros, the value of organic matter formed per hectare is 108 and 109 euros. (See also Table 66.)

Table 66. Calculation of monetary value of ecosystem service of decomposition of biological materials and their incorporation in soils

Name and unit of the indicator	Year	
	2018	**2019**
Surface of maintenance area, ha	155.8	155.8
Leaf mass, ton	1353	1361
Mass of organic matter formed, ton	338	340
Volume of organic matter formed, m3	676	680
Volume of organic matter formed m3/ha	4	4
Monetary value of organic matter, €/ha	108	109
Total monetary value of organic matter of urban green areas in Estonian urban areas, €	901 940	910 292

Urban forests, cemeteries and rows of trees located on the territory of the city of Tartu, with a total area of 205.3 hectares, offer an organic matter formation service for 22 172 and 22 378 euros, respectively.

Herbaceous biomass which remains on the ground after mowing and in autumn, has not been taken into account. Experience has shown that the amount of herbaceous biomass in urban areas is significantly less than the amount of leaves therefore, until the quantities are specified, the monetary value of herbaceous biomass can be excluded.

If the monetary value of the organic matter formation service in urban forests, cemetery and rows of trees (hedges, alleys, etc.) were 108 euros/ha in 2018 and 109 euros/ha in 2019, then the total value of the organic matter formation service was 901 940 euros and 910 292 euros, respectively.

Table 67 shows ecosystem service value of provisioning organic waste which is used for producing compost by ecosystem assets in urban areas set in the frame of classification of urban ecosystem assets.

Table 67. Ecosystem service value of provisioning organic waste which is used for producing compost by ecosystem assets in urban areas, 2019.

	Ecosystem/Map unit	VALUE of the ecosystem service, 2019 (€)
Urban green		**107 311**
	Cemetery	35 931

[61] Compost Specifications for Landscape Industry (2016) The Landscape Institute, British Association of Landscape Industries (BALI), National Building Specifications (NBS) ja Waste and Resources Action Programme (WRAP)

	Line of trees	71 380
Natural and semi-natural ecosystems		**802 981**
	Forest	802 981

10.6.1.2 Urban ecosystem services valued with exchange value based methods: Regulating the flows of water in our environment –rainwater drainage in urban areas

According to CICES v5.1 rainwater drainage is described as a service that regulates the flows of water in our environment. Drainage of the rainwater by soil reduce damage magnitude and frequency of flood/storm events (see also Table 61). Rainwater drainage can be considered as a service of both biotic and abiotic ecosystems. The biotic aspect stems from the ability of plants to absorb and evaporate water from the soil. The abiotic aspect is the direct evaporation from the soil surface and also the ability of the soil to infiltrate rainwater. In the present study, the monetary value of the rainwater drainage service is calculated based on the ability of the soil to infiltrate rainwater.

Table 68. Definition of the ecosystem service of regulating the flow of water to CICES v5.1

Class	Code	Simple descriptor	Ecological clause	Use clause	Example Service	Example Goods and Benefits
Hydrological cycle and water flow regulation (Including flood control, and coastal protection)	*2.2.1.3*	*Regulating the flows of water in our environment*	*The regulation of water flows by virtue of the chemical and physical properties or characteristics of ecosystems….*	*…that assists people in managing and using hydrological systems, and mitigates or prevents potential damage to human use, health or safety*	*The capacity of vegetation to retain water and release it slowly, or the capacity of soil to drain rainwater and prevent a flood.*	*Mitigation of damage as a result of reduced magnitude and frequency of flood/storm events*

In this study the cost-based method, in particular the replacement cost method, is used to calculate the monetary value of the rainwater drainage service in urban areas. This method assumes that the costs of replacing ecosystems provide useful estimates of the value of these ecosystems or services. This is based on the assumption that, if people incur costs to replace the services of ecosystems, then those services must be worth at least what people paid to replace them. Thus, the methods are most appropriately applied in cases where replacement expenditures have actually been, or will actually be, made. The value of the rainwater drainage service is expected to be equal to the cost of operating sewerage system, without activated sludge treatment equipment.

The urban green area includes green area, cemetery, tree strip, private courtyard, and urban forest. In Estonia the surface of urban green area is ca 29 599 hectares.

Assuming that urban areas cover the territory of Estonia relatively evenly, the average precipitation in Estonia is used in this calculations. In 2019, according to the State Weather Service, the average amount of precipitation was 0.675 m3/m2.[62]

The soil of the urban's green areas is not natural, but rather a mixture of different soils that have been brought here as a surface. Therefore, an average infiltration coefficient (10%) is used in the calculations.[63].

The wastewater treatment system consists of pipelines and treatment equipment that is divided as stage I and II equipment. The first stage equipment are for example pipelines and debris-, sand-, and oil traps. Activated sludge treatment equipment belongs among to stage II equipment. The rainwater collection system consists of pipelines and I stage treatment equipment. This assumption was used to find the price of rainwater drainage.

According to the Estonian Association of Water Companies the average price of sewerage for residents was 1.57 €/m3 in 2019. [64] According to experts, 2/3 of this money is spent on operating an activated sludge treatment equipment and 1/3 on operating pipelines and stage I treatment equipment. Thus, operating a rainwater collection system costs 0.53 €/m3.

To calculate the value of the service initial data were collected from the following sources:

Name of the dataset	Data type	Source
Average amount of precipitation in Estonia, in 2019	Statistics	The State Weather Service of the Estonian Environment Agency[65]
Average rainwater infiltration coefficient, %	Literature	Groundwater Commission [66]
Average price of sewerage for resident, €/m3, in 2019	Statistics	Estonian Association of Water Companies [67]

Multiplying the area of urban green areas by the average precipitation of 2019 the total precipitation was calculated. Assuming that on average 10% of this rainwater infiltrates, the volume of infiltrating precipitation is ca 19.9 million cubic meters. In 2019, average sewerage price for residents was 1.57 €/m3. Based on assumptions made above, operating a rainwater collection system costs 0.53 €/m3. This price can be considered as the authorized price for the operation of rainwater sewerage. Multiplying the volume of infiltrating rainwater and authorized price of rainwater collection, the monetary value of infiltrated rainwater is calculated. Monetary value of infiltrated rainwater of urban green areas is ca 10.5 million euros. (See also Table 69)

[62] State Weather Services. Overview of weather on 2019. https://translate.google.com/?sl=et&tl=en&text=ilma%20%C3%BClevaade%202019.%20aasta%20&op=translate

[63] Põhjaveekomisjon (2004) Eesti põhjavee kasutamine ja kaitse. http://www.maves.ee/Projektid/2004/PV_raamat.pdf

[64] Eesti Vee-ettevõtete Liit. Veeteenuste hinnad. http://evel.ee/teabepank/infomaterjalid/

[65] Keskkonnaagentuur. Riigi Ilmateenistus. https://www.ilmateenistus.ee/ilm/prognoosid/4-oopaeva-prognoos/

[66] Põhjaveekomisjon (2004) Eesti põhjavee kasutamine ja kaitse. http://www.maves.ee/Projektid/2004/PV_raamat.pdf

[67] Eesti Vee-ettevõtete Liit. Veeteenuste hinnad. http://evel.ee/teabepank/infomaterjalid/

Table 69. Calculation of monetary value of ecosystem service of rainwater drainage in urban areas.

Name and unit of the indicator	Indicator value, 2019
Average rainwater infiltration coefficient, %	10
Average amount of precipitation in Estonia, m3/m2	0.675
Area of urban green areas, m2	295 991 500
Volume of precipitation, m3	199 794 262
Volume of infiltrating rainwater, m3	19 979 426
Average sewerage price for residents, €/m3	1.57
Authorized price of rainwater collection, €/m3	0.53
Monetary value of infiltrating rainwater, €	10 481 327

The results are distributed in proportion by area to urban ecosystem types, including green areas, urban forests, private courtyards, cemeteries, and tree strips. Table 63 shows ecosystem service value of rainwater drainage in urban areas set in the frame of classification of urban ecosystem assets.

Table 70. Ecosystem service value of rainwater drainage by ecosystem assets in urban areas, 2019

	Ecosystem/Map unit	VALUE of the ecosystem service, 2019 (€)
Urban green		**7 872 667**
	Green space	1 960 057
	Cemetery	116 729
	Line of trees	231 894
	Private Yard	5 563 987
Natural and semi-natural ecosystems		**2 608 659**
	Forest	2 608 659

10.6.2 Urban ecosystem services valued with CVM

When conducting the urban area CVM study, it had to be taken into account that the basis for classifying the urban ecosystem is quite different from the other ecosystems studied (forest and wetland). The urban area consists of many different ecosystems such as large parks, small parks in the middle of the city, urban forests, tree alleys, private courtyards, etc. (complete list is given in Table 71).

The presence of different ecosystems in the urban area made it difficult to compile the CVM questionnaire and to interpret the results later. The aim of the study was to find the monetary equivalent for different services of different urban ecosystems. To achieve this, respondents were asked to rank (according to subjective importance) different urban ecosystems in addition to urban ecosystem services (see Table 72). By dividing the total willingness to pay between ecosystems and ecosystem services (both ranked according to subjective preferences), it was possible to find monetary equivalent to all services of all studied urban ecosystems. The methodology of contingent valuation can be read further in chapter 6.2.

The survey is based on 720 questionnaires and the sample structure was representative of the Estonian adult population. Similar to the forest survey, the percentage of positive respondents (91%) was very high as in the case of forest and wetland ecosystem services.

Of the urban ecosystems ranked on the basis of subjective preferences (Table 71), large parks are unrivalled (23.3% of total value, WTP 4 million euros). In second place are small parks (17.3%, WTP 3 million euros) and in third place urban forests (15.9%). The last places in the list are relatively smaller urban green areas such as *Lawn strips and flower beds by the sidewalks* (10.5%) and *Lawn strips by the road and between lanes* (10.0%). The ranking of privately owned gardens is very similar to the latter (also 10.5%). The result of urban ecosystem ranking shows that people appreciate larger green areas for public use more.

Table 71. Relative importance of urban ecosystems and the corresponding WTP

Urban Ecosystem	**Importance**	**% total value**	**WTP (thousand EUR)**
Big parks (e.g. Kadriorg, Glehni park)	1.	23.3	4028.3
Small parks in the City centre (e.g. Tammsaare park, Hirvepark)	2.	17.3	2985.9
Forests within the city borders (e.g. Nõmme forest, Stroomi forest)	3.	15.9	2747.6
Tall landscaping (trees, alleys) by the road	4.	12.6	2176.5
Privately owned gardens (e.g. Nõmme, Merivälja)	5.	10.5	1815.3
Lawn strips and flower beds by the sidewalks	6.	10.5	1810.3
Lawn strips by the road and between lanes (e.g. Sõpruse av.)	7.	10.0	1723.9
TOTAL		**100.0**	**17287.75**

The relative preferences of urban ecosystem services and the corresponding WTP are presented in Table 72. People value *City air purification* (14.9% of the total value, WTP 2.6 million euros) the most among urban ecosystem services. This is followed by *Photosynthesis* (11.9%) and *providing recreation and leisure opportunities* (10.9%). The third place of this cultural service is the main difference compared to forest and wetland ecosystems, where this recreational service was penultimate (see chapter 6.2). This clearly shows that people value urban and natural ecosystem services differently.

Table 72. Relative importance of services of urban ecosystems and the corresponding WTP

Urban area ecosystem service	**Importance**	**% (of inverse value)**	**WTP (thousand EUR)**
City air purification	1.	14.9	2579.0
Photosynthesis (oxygen production)	2.	11.1	1924.8
Providing recreation and leisure opportunities	3.	10.9	1884.9
Traffic noise reduction	4.	10.3	1773.5
Habitat supply for biological species (e.g. birds)	5.	10.2	1766.1
Ensuring the diversity of urban space	6.	9.7	1673.1
Urban microclimate regulation and carbon sequestration	7.	9.7	1674.5
Offering aesthetic pleasure (flower buds, alleys)	8.	8.1	1401.7
Providing shade for people (e.g. from wind and sun)	9.	7.9	1360.7
Providing opportunities for environmental education	10.	7.2	1249.4
TOTAL		100	17287.75

The overall results of the city's CVM are presented in Table 75.

This summary table is a matrix compiled based on urban ecosystems and ecosystem services ranking. The table shows a monetary equivalent of all ecosystem services of all urban ecosystems studied. In the first place is *City air purification* by *Big parks* (601 thousand euros/year). In the last place is *Providing* *opportunities for environmental education* by *Lawn strips by the road and between lanes* (125 thousand euros/year).

Although the monetary equivalent of the highest rated ecosystem service of the highest rated urban ecosystem differs more than four times from the lowest rated ecosystem service on lowest rated ecosystem, however, it can be argued that the differences between urban ecosystem services are not as large as might have been expected. This shows that preferences of people vary quite a bit, one prefers lawns, the other large parks and the third flower beds. But all these ecosystems are important in urban green space.

Urban ecosystems presented in urban CVM were further connected with ecosystem types/map units from our extent map to homogenize the results and allow the spatial allocation of service values. This was first done by defining which ecosystem types/map units represent which urban ecosystems presented in urban CVM (Table 73). Then the values of ecosystem services for ecosystems found by CVM were allocated to ecosystem type assets based on area.

Table 73. Urban ecosystems from CVM and their equivalent(s) from ecosystem extent map

Urban ecosystem from CVM	**Equivalent(s) from ecosystem extent map**
Big parks (e.g. Kadriorg, Glehni park)	Green space, Cemetery
Small parks in the City centre (e.g. Tammsaare park, Hirvepark)	Green space, Cemetery
Forests within the city borders (e.g. Nõmme forest, Stroomi forest)	Forest
Tall landscaping (trees, alleys) by the road	Line of trees
Privately owned gardens (e.g. Nõmme, Merivälja)	Private Yard, Horticultural land
Lawn strips and flower beds by the sidewalks	Green space
Lawn strips by the road and between lanes (e.g. Sõpruse av.)	Green space

Table 74 shows ecosystem services and their values found by CVM by ecosystem assets in urban areas set in the frame of classification of urban ecosystem assets.

Table 74. Ecosystem service values found by CVM by ecosystem assets in urban areas, 2019, thousand EUR

		Air quality	**Climate regulation**	**Shade provision**	**Noise mitigation**	**Habitat conservation**	**Recreation**	**Nature education**	**Aesthetic experience**	**TOTAL**
Urban green		**2 169.1**	**3 027.3**	**1 144.5**	**1 491.6**	**1 485.4**	**1 585.3**	**1 050.9**	**2 586.1**	**14 540.2**
	Green space	1 487.6	2 076.1	784.9	1 023.0	1 018.7	1 087.2	720.7	1 773.6	9 971.8
	Cemetery	86.0	120.0	45.4	59.1	58.9	62.9	41.7	102.5	576.6
	Line of trees	324.7	453.2	171.3	223.3	222.4	237.3	157.3	387.1	2 176.5
	Private Yard	261.3	364.7	137.9	179.7	179.0	191.0	126.6	311.6	1 751.9
	Horticultural land	9.5	13.2	5.0	6.5	6.5	6.9	4.6	11.3	63.4
Natural and semi-natural ecosystems		**409.9**	**572.0**	**216.3**	**281.9**	**280.7**	**299.6**	**198.6**	**488.7**	**2 747.6**
	Forest	409.9	572.0	216.3	281.9	280.7	299.6	198.6	488.7	2 747.6

Table 75. WTP for all studied services of all urban ecosystems, thousand EUR

	Big parks	Small parks in the City centre	Forests within the city borders	Tall landscaping (by the road	Privately owned gardens	Lawn strips and flower pots by the sidewalks	Lawn strips by the road and between lanes	TOTAL	%
City air purification	600.94	445.44	409.88	324.69	270.81	270.06	257.17	**2578.99**	14.92
Photosynthesis (oxygen production)	448.50	332.45	305.91	242.33	202.12	201.56	191.93	**1924.80**	11.13
Providing recreation and leisure opportunities	439.20	325.56	299.57	237.31	197.93	197.38	187.95	**1884.90**	10.90
Traffic noise reduction	413.24	306.32	281.86	223.28	186.23	185.71	176.85	**1773.49**	10.26
Habitat supply for biological species (e.g. birds)	411.52	305.04	280.68	222.35	185.45	184.94	176.11	**1766.07**	10.22
Ensuring the diversity of urban space	389.85	288.98	265.91	210.64	175.69	175.20	166.83	**1673.10**	9.68
Urban microclimate regulation and carbon sequestration	390.18	289.22	266.13	210.82	175.83	175.35	166.98	**1674.52**	9.69
Offering aesthetic pleasure (flower buds, alleys)	326.62	242.10	222.78	176.47	147.19	146.78	139.77	**1401.72**	8.11
Providing shade for people (e.g. from wind and sun)	317.07	235.03	216.26	171.32	142.89	142.49	135.69	**1360.74**	7.87
Providing opportunities for environmental education	291.13	215.80	198.57	157.30	131.20	130.83	124.59	**1249.43**	7.23
TOTAL	**4028.25**	**2985.94**	**2747.56**	**2176.51**	**1815.32**	**1810.30**	**1723.87**	**17287.75**	100

10.7 Supply table and treatment of ecosystem service values in urban areas

Treatment of the urban ecosystem services depend on the choices made regarding the framework selected and data sources. As urban area contains both urban ecosystem assets and natural ecosystems, the service values of different approaches had to be combined.

Valuation of ecosystem services in urban areas combines several asset types (urban ecosystem assets and natural ecosystems) and valuation approaches (revealed and stated preferences). Therefore a matrix consisting of three methodological blocks were formed to show the distribution of the service values for ecosystem assets under urban ecosystem account (Table 76).

Subdivision to urban specific services valuation methods and natural ecosystem specific valuation methods under exchange based values can be done as in addition to values of ecosystem services obtained from the overall valuation of the nature ecosystem services, valuation of organic waste used for producing compost and water infiltration were carried out separately only for urban areas.

Table 76. Allocation of the valuation results of ecosystem services obtained by different approaches in urban ecosystem accounts.

<table>
<tr><th></th><th colspan="2">Exchange based values</th><th>Urban CVM</th><th>CVM natural ecosystems</th></tr>
<tr><td>Urban ecosystem assets</td><td>Service valuation of organic waste used for producing compost, water infiltration by urban ecosystem assets were carried out separately.</td><td rowspan="3">Service values for some of the urban ecosystem assets and urban natural ecosystems in urban areas are obtained from the overall valuation of the services (described in chapter 8).</td><td>10 service values found with urban CVM are attributed to urban ecosystem assets.</td><td>-</td></tr>
<tr><td>Natural ecosystems</td><td>-</td><td>Forests in urban areas obtain service values from urban CVM as forest was included in the questionnaire as an urban ecosystem asset</td><td>Forest, wetland, grassland ecosystems in urban areas obtain service values based on the results of the respective CVM studies.</td></tr>
<tr><td>Artificial areas (grey)</td><td>-</td><td>-</td><td>-</td></tr>
</table>

Due to the structure of the urban extent account (includes urban ecosystem assets and natural ecosystems) and valuation approaches (revealed and stated preferences), these methodological blocks were formed to show the distribution of the service values for ecosystem assets in urban areas. The issues regarding the treatment of the values of the services of urban ecosystems was analysed with the experts.

In Estonia we have discussed the feasibility of the aggregation of the service values on a pilot bases to reflect the feasibility of compilation of the value of flows of selected ecosystem services to one single monetary estimated values by ecosystem types.

Paragraph 9.17 of the manual UN SEEA EA outlines in chapter 9 „Accounting for ecosystem services in monetary terms“ says that aggregate measures of ecosystem services can be derived by summing across columns (i.e., to estimate the total supply or use of a single service) and by summing across rows (i.e. to estimate the total supply by an ecosystem type or the total use by type of economic unit). This aggregate measure gross ecosystem product (GEP) is equal to the sum of all final ecosystem services (i.e., used by economic units) at their exchange value supplied by all ecosystem types located within an ecosystem accounting area over an accounting period, less the imports of ecosystem services from ecosystem assets outside the EAA. GEP was first calculated in China (Ouyang et al., 2020)[68].

We tried the comprehensive approach and feasibility of the aggregation as we think that in urban ecosystems which comprises different asset types and lot of non-market ecosystem services, the aggregations to a scale may convey added value.

We have understood that in case of China where GEP was initially tested, government now requires consideration of ecological benefits, as measured by GEP, in the evaluation criteria of local governments' performance, which could create real accountability among officials for how they affect ecosystem services (Ouyang et al. 2020).

In case of urban thematic account the services provided by distinctive urban areas could in principle be compared based on the GEP profiles if theoretical and conceptual difficulties will be solved.

The GEP approach (developed by BaolongHan-RCEES-China), of summing up different kinds of service values was discussed by compilers and was desired to be tested by project team members as well.

Statistics Estonia debated the treatment of the urban ecosystem services in the context of urban ecosystem accounting with the experts of Statistics Netherland as in urban areas the considering and accounting for nonmarket values is more justified than on natural ecosystems due to the close proximity and embedded nature of the human settlements and ecosystems. Experts suggested to try to analyse and the values of ecosystem services received by these methodological approaches per ecosystem types.

Table 77 blocks A-C display the values of ecosystem services according to the allocation matrix of the valuation results obtained by different approaches in urban ecosystem accounts.

[68] Ouyang, Z., C. Song, H. Zheng, S. Polasky, Y. Xiao, I. J. Bateman, J. Liu, M. Ruckelshaus, F. Shi, Y. Xiao, W. Xu, Z. Zou, and G. C. Daily (2020), 'Using Gross Ecosystem Product (GEP) to Value Nature in Decision Making', Proceedings of the National Academy of Sciences, 117(25) 14593-14601.

Table 77. Urban ecosystem services supply table. A. Results from exchange value based valuation methods in urban areas, 2019, thousand €

Ecosystem/Map unit	Fodder	Agricultural production	Wild berries and mushrooms	Wild game	Timber	Peat	Organic waste	Global climate regulation:	Air quality regulation	Pollination	Rainfall infiltration	Recreation	Recreational hunting	Nature education	TOTAL
Urban green		**70.1**					**107.3**		**345.3**	**456.7**	**7 872.7**	**2 755.3**		**1 084.2**	**12 691.5**
Green space									85.6	118.9	1 960.1	675.9		445.8	**3 286.3**
Cemetery							35.9		5.1	1.1	116.7	40.3		10.2	**209.3**
Line of trees							71.4		10.1	124.8	231.9	54.9		26.8	**519.9**
Private Yard									243.0	200.7	5 564.0	1 950.0		572.6	**8 530.3**
Horticultural land		70.1							1.5	11.2		34.1		28.8	**145.7**
Urban grey									**0.4**	**62.2**		**1 417.9**		**848.4**	**2 328.9**
Buildings and other facilities										0.7		1 041.3		609.5	**1 651.5**
Building												546.2		320.9	**867.2**
Airport										0.03		5.3			**5.3**
Railroads										0.04					**0.04**
Port												0.5			**0.5**
Area used for sport activities										0.6		42.8		3.0	**46.4**
Roads															
Production yard												446.5		285.6	**732.1**
Other artificial areas, excluding private yard									0.4	61.5		376.6		239.0	**677.4**
Inland habitats with no vegetation										60.2		374.3		238.9	**673.4**
Wasteland									0.2	0.8		1.7		0.0	**2.8**
Power lines									0.2						**0.2**
Excavation sites										0.1		0.1			**0.1**
Landfill															
Forest ride									0.01	0.5		0.4		0.1	**1.0**
Natural and semi-natural ecosystems	**95.9**	**64.1**	**279.0**		**2 426.7**	**1.5**	**803.0**	**1 128.3**	**142.2**	**404.0**	**2 608.7**	**2 276.3**		**604.5**	**10 834.2**
Forest			278.2		2 426.7		803.0	1 128.3	113.9	87.8	2 608.7	1 299.3		422.4	**9 168.2**
Grassland	74.4		0.2						18.7	311.3	0	543.4		92.3	**1 040.3**
Cropland, excluding horticultural land	21.4	64.1							9.4	4.6	0	281.0		13.6	**394.1**
Wetland	0.1		0.6			1.5			0.2	0.3	0	16.9		3.4	**22.9**
Coast										0.03		2.4		4.4	**6.8**
Inland waterbodies												133.3		68.5	**201.8**
Other									**0.1**	**0.4**		**3.1**		**0.3**	**3.8**
Grand Total	**95.9**	**134.2**	**279.0**	**0.0**	**2 426.7**	**1.5**	**910.3**	**1 128.3**	**488.0**	**923.2**	**10 481.3**	**6 452.6**	**0.0**	**2 537.4**	**25 858.4**

B. Results from urban CVM including urban green spaces and forests in urban areas, 2019, thousand €

Ecosystem/Map unit	Air quality	Climate regulation	Shade provision	Noise mitigation	Habitat conservation	Recreation	Nature education	Aesthetic experience	TOTAL
Urban green	**2 169.1**	**3 027.3**	**1 144.5**	**1 491.6**	**1 485.4**	**1 585.3**	**1 050.9**	**2 586.1**	**14 540.2**
Green space	1 487.6	2 076.1	784.9	1 023.0	1 018.7	1 087.2	720.7	1 773.6	9 971.8
Cemetery	86.0	120.0	45.4	59.1	58.9	62.9	41.7	102.5	576.6
Line of trees	324.7	453.2	171.3	223.3	222.4	237.3	157.3	387.1	2 176.5
Private Yard	261.3	364.7	137.9	179.7	179.0	191.0	126.6	311.6	1 751.9
Horticultural land	9.5	13.2	5.0	6.5	6.5	6.9	4.6	11.3	63.4
Urban grey									
Buildings and other facilities									
Building									
Airport									
Railroads									
Port									
Area used for sport activities									
Roads									
Production yard									
Other artificial areas, excluding private yard									
Inland habitats with no vegetation									
Wasteland									
Power lines									
Excavation sites									
Landfill									
Forest ride									
Natural and semi-natural ecosystems	**409.9**	**572.0**	**216.3**	**281.9**	**280.7**	**299.6**	**198.6**	**488.7**	**2 747.6**
Forest	409.9	572.0	216.3	281.9	280.7	299.6	198.6	488.7	2 747.6
Grassland									
Cropland, excluding horticultural land									
Wetland									
Coast									
Inland waterbodies									
Other									
Grand Total	**2 578.99**	**3 599.31**	**1 360.75**	**1 773.49**	**1 766.09**	**1 884.90**	**1 249.42**	**3 074.81**	**17 287.76**

C. Results from CVM study of forest, wetland, grassland in urban areas, 2019, thousand €

Ecosystem/Map unit	**Medicinal herbs**	**Wild berries and mushrooms**	**Global climate regulation: carbon sequestration and storage**	**Air quality regulation**	**Pollination**	**Maintenance of soil fertility**	**Habitat conservation**	**Recreation**	**Nature education**	**TOTAL**
Urban green										
Green space										
Cemetery										
Line of trees										
Private Yard										
Horticultural land										
Urban grey										
Buildings and other facilities										
Building										
Airport										
Railroads										
Port										
Area used for sport activities										
Roads										
Production yard										
Other artificial areas, excluding private yard										
Inland habitats with no vegetation										
Wasteland										
Power lines										
Excavation sites										
Landfill										
Forest ride										
Natural and semi-natural ecosystems	**82.9**	**23.4**	**53.7**	**0.5**	**56.6**	**33.0**	**163.3**	**16.9**	**108.3**	**538.7**
Forest	18.5	22.2			11.9	8.2				**60.8**
Grassland	60.5		53.1		44.7	24.8	156.8	16.6	105.2	**461.7**
Cropland, excluding horticultural land										
Wetland	3.9	1.2	0.6	0.5			6.6	0.2	3.2	**16.1**
Coast										
Inland waterbodies										
Other										
Grand Total	**82.9**	**23.4**	**53.7**	**0.5**	**56.6**	**33.0**	**163.3**	**16.9**	**108.3**	**538.7**

In addition, Figure 20 shows schematically the proportions of the services provided by urban ecosystem. On a left side in pink colours the values measured by exchange based methods and on a right side in blue colours the services measured by contingent valuation methods are displayed.

If in total values both methods (exchange based and CVM) give the results to a certain degree of the comparable scale currently than the allocation of valuation results to urban ecosystem assets and types reveals the differences: natural ecosystems in urban areas and urban green assets are characterized by different services provided on different scales. Also the pattern of ecosystem types providing ecosystem services by exchange based methods and CVM is not similar. CVM results highlight urban green space and tree rows while exchange based methods highlight urban private yards and urban forest. By both methods it seems that this group of urban green assets and private yards (in addition also urban forests) are contributing big share of the services value.

Gathering all valuation results in one framework raised the questions of coverage and comparability. For example rainfall infiltration, timber provisioning and compost producing services dominate exchange based values. Each of those values taken separately seem justified in first glance. The under coverage of the certain natural ecosystem types by CVM studies is also noticeable. Presence of only one natural ecosystem type (forest) was predetermined by the CVM questionnaires. This is well reflected in the CVM results as well. In another hand CVM gives the value to the several regulatory services which have been considered difficult to cover currently. The potential overlap between the results received by these methods was discussed as well.

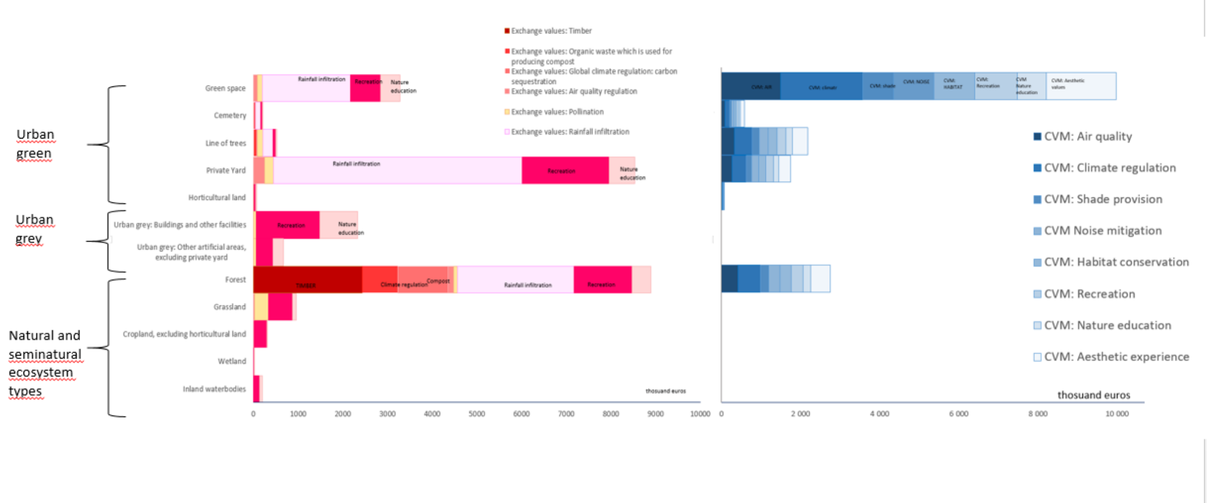

Figure 20. Illustrative chart of the services values provided by urban ecosystem types, thousand euros

Table 78 shows also numerically that in a range of given services and selected assets structure, urban green assets contribute 28.2 million and natural ecosystems 13.5 million euros. Exchange based methods count for 23.5 million and contingent valuation methods 17.3 million. Table 77 shows the calculated values by asset types. If to look into the values in more detail than we see how the values of water infiltration (10.4 million) service and recreation (6.4 million) dominate, followed by timber provision (2.4 million). The biggest green assets private yards and green areas together with forest in a city contribute the biggest amount of services. This of course depends on a number of aspects again.

Table 78. Urban ecosystem service values by valuation methods and urban ecosystem asset types, million euros

	Exchange based values	Urban CVM	CVM natural ecosystems
Urban ecosystem assets "urban green"	12.7	14. 5	-
Natural ecosystems "natural and semi natural ecosystems"	10.8	2.7	0.5
Artificial areas (grey)	2.3	-	

10.8 Discussion

The need to treat the city and the urban natural ecosystems was suggested by stakeholders so, that the point of view should not the natural ecosystems but the urban area(green and grey) which also comprises natural ecosystems. Due to that the complex criterion for classifying the urban ecosystem which considers both the population density and the distance of artificial areas from the ecosystems was developed.

Our complex, multi-part criterion* described in chapter 10.4 improves the incompatibilities of administrative urban areas-boundaries (these exist due to the quite random expansion of some cities ' boundaries after last reform of administrative areas), but it is inevitably considered to be subjective and therefore also offensive.

Framework chosen for urban thematic ecosystem account, described in chapter 10.5, comprising urban green assets and natural ecosystems allows to allocate both the service provided by natural ecosystems present in city space and also allocate the values to artificially modified typical green artificial areas.

Ideally the compiled matrix e.g. supply table by urban ecosystem types should accommodate all relevant flows of ecosystem services.

The feasibility of aggregation of the service values as described in GEP approach was discussed and will be considered also in a future. Due to comprehensive analyses, the attempt for aggregation revealed, at first, several gaps in sense of covered ecosystems. These coverage issues of course need first attention.

It is also noteworthy that certain valuation methods may distort the picture. Currently rainfall infiltration dominates the values: in private yards and green spaces higher values are calculated for rainwater infiltration. In forests, rainwater infiltration is the second most important service in terms of monetary value in current selection of services and urban ecosystems context. This is due to the valuation method as well as monetary value of this service is calculated by using replacement cost method. The calculation assumed that all urban areas with soil surface absorb rainwater. As private yards, green spaces, and forests make up large part of total urban area and city parks form a relatively large share of city forest, the value of the service is also distributed primarily between these areas. It is however disputable if the value calculated by exchange based methods and relevant for high density areas could be attributed to the areas with significant share natural ecosystems.

Same applied for the compost from forest areas which showed quite high results and revealed the possible problems while applying market prices in this case.

As regards the aggregation of various services we are of the opinion that in case of urban environment and services which feature high human influence and interest we propose to complement the results and to sum up the service values both of market and non market valuation methods. We have an opinion that all urban ecosystem services which increase the welfare of individuals have a value regardless of their participation in the market.

Urban ecosystems are of particular importance compared to other ecosystems, as it is in urban areas that a large number of people come into contact with ecosystems in a concentrated way and consume the values of ecosystem services. Given the extent of human exposure to ecosystems in urban areas, it is clear that regarding many ecosystem services, urban ecosystems play an important role in influencing the welfare of urban dwellers. This applies both to cultural services (such as recreation) and to regulatory services that affect the quality of the urban environment (such as air purification from PMs).

Finding out the value of services of ecosystems in urban areas is more difficult than in the case of natural ecosystems. In an urban area, we cannot talk about one ecosystem, but many different ecosystems that offer different services. In addition, the question arises, how many ecosystems should be studied in urban areas? For example, which elements of urban landscape should be aggregated and which should be treated as separate ecosystems, which elements can be separated at all in the detail (square size) selected on the map, etc. It is also important how people perceive and differentiate urban ecosystems and their services. This is clearly shown by the fact that the CVM study revealed that urban ecosystem services were ranked quite differently from natural ecosystem services in terms of subjective importance. For example if the recreational service was not considered important in natural ecosystems than it was considered important in urban areas.

The urban CVM survey carried out in the framework of this project was modified under time pressure, namely the survey had to be carried out before the nomenclature of urban ecosystems used in this project was developed. Consequently, the study has several shortcomings. Thus, the list of urban ecosystems used in the work does not unambiguously correspond to the list of ecosystems ranked according to importance in the CVM study. This required aggregation in subsequent data processing. Also included in the survey were several natural ecosystems in urban areas, such as grassland and wetlands. Thus, wetlands and grasslands in urban areas had to be assigned a value from the overall CVM of grasslands and wetlands, which is likely to lead to an underestimation of wetlands and grasslands ecosystems services in urban areas. In future projects, all ecosystems in urban areas should definitely be considered as urban specific, the value of which must be examined separately from natural (i.e. non-urban) ecosystems.

As to ecosystem services in urban areas, more attention should be paid to services that are specific to urban areas. Regulatory services such as carbon sequestration as well as water purification provided by natural ecosystems are not urban specific. The quality of the environment in a spatially limited urban area does not really depend on the volume of provision of these services. The evaluation should focus on services that have a direct impact on the urban environment and the welfare of the people living there. Such services include, for example, rainwater infiltration and air purification from PM which actually also were valued on current work.

More attention should be paid to the way in which urban ecosystems have an impact on the urban cosystem services. Given that a large proportion of people are exposed to ecosystems on a daily basis and consume cultural services in urban areas, the methodology for assessing cultural ecosystem services in urban areas should be revised. At present, for example, the same methodology as for natural ecosystems has been used to evaluate recreational services in urban areas. However, this may not accurately reflect the high recreational value of urban ecosystems. The assessment of the recreational value of natural ecosystems on the basis of exchange value has been based on visits to health and hiking trails. In order to visit such trails, people usually have to make a special trip, which is relatively rare, for example once a week. However, people are exposed to urban ecosystems on a daily basis, such as going to work through a park or alley, walking in a park or green area after work, and so on. Nor, for example, can the welfare that comes from looking at urban ecosystems on public transport be underestimated. In view of the above, there is reason to presume that urban ecosystem services will remain underestimated with the current use of methods.

When applying the simple CVM method, it can be feared that the services of urban ecosystems are considered so common due to their daily exposure that they are not recognized in the formation of welfare. The problem is how to bring out the real increase in people's welfare. In addition to the classic CVM willingness to pay approach, other methods should be used, in which respondents are asked to compare different scenarios and thereby express their willingness to pay.

What concerns regulative services and the fact that these need specific calculation methods which are resource extensive to calculate, the efforts taken by others could have been made of best use. This of course in case local urban conditions allow so. The Institute for Development for Environment, Food and Rural Affairs of the United Kingdom has carried out an in-depth study to calculate the monetary value of ecosystem services. Using the benefit transfer method, it needs to be investigated if benefit transfer method is applicable and whether it is possible to calculate the monetary values of regulative ecosystem services for Estonian urban ecosystems as well. As for example it is not sensible to use the benefit transfer method to calculate the monetary value of provisioning and cultural ecosystem services as these services depend quite a lot on local circumstances.

Users' opinions on a suitability of the framework and methods for service valuation and compilation of the supply table of urban ecosystem services supply would be needed as well.

11 Asset accounts

For the creation of the asset account first the concept of the assets and asset account and their relation to National Accounts were studied. Next the applicability of the methodology explained in SEEA EEA chapter 7.2 and the availability of relevant data in National Accounts were analysed. Also consultations with colleges from more experienced NSI and National Accounts were carried out in order to evaluate the feasibility and quality of the data.

11.1 Application of the net present value approach

Ecosystem asset value is possible to calculate with the net present value of the future flows of income associated with the different ecosystem services. According to the System of Environmental-Economic Accounting 2012 chapter 5.114 “the logic of the NPV approach requires estimating the stream of ecosystem service values that are expected to be earned in the future and then discounting these resource rents back to the present accounting period. This provides an estimate of the value of the asset at that point in time.”

Also colleague from National Accounts were consulted about this subject and it was agreed that perpetual inventory method (PIM) which is used to calculate assets values in National Accounts cannot be used for ecosystem assets. In order to use PIM for asset valuation it is necessary to know time series of investments that were made for the asset, but it is not the case for ecosystems as investments are rather not made for natural resources. NPV approach can be used to calculate asset values by ecosystem types from the value of the associated services.

The asset value K_0 is calculated using the NPV formula:

$$K_0 = \sum_{t=1}^{T} \frac{d_t}{(1+r)^t}$$

where d_t is a flow of income in year t, r is a discount rate and T is an asset life.

If we assume that the stream of future flows is constant (d_t=d), then the formula simplifies to

$$K_0 = \frac{d}{r \times a}$$

where a is the annuity factor, calculated with formula:

$$a = \frac{1}{1 - \frac{1}{(1+r)^T}}$$

In order to use above mentioned formula some assumptions had to be used in the grant project:

- Stream of future flow of ecosystem services values is constant;
- Discount rate is 3% for provisioning and 2% for cultural and regulating services. Discount rate is lower for those services which are more difficult or impossible to substitute or which are scarcer. These discount rates were chosen following the example of Statistics Netherlands;

- Asset lifetime is 100 years for all services – this assumption is used in this project but it could also be assumed to be infinity or even shorter than 100 years if this information would be available. As this is first attempt to calculate asset value the same assumption as Statistics Netherlands made was used in this grant project. Analyses of available information to determine more accurate asset lifetime would be possible subject for future.

11.2 Results

Asset values were calculated both for exchange value based and contingent valuation based methods and also for different ecosystem types. Results of different values can be seen as follows.

Table 79 shows results of exchange based methods. It is seen that total asset value was 27 417 million € in 2019 and the biggest contribution came from timber production service, it had also the highest service value. The highest asset value came from forest ecosystem forming more than 71% of total asset value (presented in Table 80).

Table 79. Asset values of ecosystem services based on exchange value methods, 2019 million €

Service	Service value	Asset value
Fodder	23.6	744.7
Agricultural production (crops)	32.3	1 019.8
Herbaceous biomass used for producing energy (bioenergy)	0.1	4.2
Wild berries, mushrooms	18.6	587.1
Wild game	8.7	275.3
Timber	338.6	10 699.5
Peat	34.9	1 101.6
Forest seed	0.1	3.7
Provisioning services - total	456.8	14 435.8
Global climate regulation: carbon sequestration	78.3	3 376.3
Air quality regulation	11.1	477.0
Pollination	31.1	1 341.6
Regulating services - total	120.5	5 194.9
Recreation	135.5	5 837.9
Recreational hunting	35.0	1 510.1
Nature education	10.2	438.4
Cultural services - total	180.7	7 786.4
Total	758.0	27 417.2

Table 80. Asset values of ecosystem types based on exchange value methods, 2019 million €

Ecosystem type	Provisioning services	Regulating services	Cultural services	Total
Forest	11 439	4 214	3 877	**19 529**
Grassland	430	520	849	**1 799**
Cropland	1 431	121	956	**2 509**
Wetland	1 135	33	1 066	**2 234**
Artificial area		306	487	**793**
Coast (SHORES)	0	0	43	**43**
Inland waterbodies			500	**500**
Other	0	1	9	**10**
Total	**14 436**	**5 195**	**7 786**	**27 417**

Table 81 shows results of contingent valuation based methods. It is seen that total asset value was 1 889 million € in 2019 and the biggest contribution came from global climate regulation: carbon sequestration service, it had also the highest service value. The highest asset value came from forest ecosystem forming almost half of the total asset value (presented in Table 82).

Table 81. Asset values of ecosystem services based on contingent valuation methods, 2019 million €

Service	Service value	Asset value
Medicinal herbs	4.2	131.8
Wild berries, mushrooms	2.3	74.0
Provisioning services - total	**6.5**	**205.8**
Global climate regulation: carbon sequestration	12.9	554.6
Air quality regulation	4.9	211.3
Pollination	3.3	142.9
Maintenance of soil fertility	4.1	175.7
Habitat conservation	7.0	300.5
Regulating services - total	**32.1**	**1 384.9**
Recreation	3.3	144.0
Nature education	3.6	154.1
Cultural services - total	**6.9**	**298.1**
Total	**45.6**	**1 888.9**

Table 82. Asset values of ecosystem types based on contingent valuation methods, 2019 million €

Ecosystem type	Provisioning services	Regulating services	Cultural services	Total
Forest	99	697	117	**914**
Grassland	49	433	106	**588**
Wetland	57	255	74	**387**
Total	**206**	**1 385**	**298**	**1 889**

12 Visualisation of the results of ecosystem accounts and communication

Compiled accounts were made available (produced and published) and were analysed with the main users, among others Ministry of Environment and Ministry of Finance. Making the accounts available for the general public would serve also as a tool for getting possible feedback.

Project team statisticians worked together with the Marketing and Dissemination Department for choosing the dissemination channel. Visualization using routine visualization procedures seemed the best solution regarding the impartially and objectively statistics and the future mainstreaming of this area of statistics as well. In addition the interactive map user interface was created and visualization on the spatial data was tried out.

Dedicated section for ecosystem accounting was developed in Statistics Estonia web site thematic area Environment - Biodiversity protection and land use: https://www.stat.ee/en/find-statistics/statistics-theme/environment/biodiversity-protection-and-land-use. Project methodological report is made available on a website in digital format as well. In addition also the recording of the methodological seminar where methodologies and main results were discussed was made available.

12.1 Visualization using web infographics

Ecosystem extent account by ownership types and the supply and use tables of ecosystem services were made available on website thematic page of Statistics Estonia in subject page Environment – Biodiversity protection and land use (https://www.stat.ee/en/find-statistics/statistics-theme/environment/biodiversity-protection-and-land-use) with the references to metadata descriptions and to the database datasets.

For the visualization of the statistics Statistical Office uses standardized web based visualisation tools. The main distribution channel is the website and Statistical Database, where all statistics is made available. The website is in Estonian and in English and is developed according to WCAG 2.0 AA accessibility standards. In addition to Estonian language the website also has a mirror English language page. Automatically renewable tables and graphs

In order to visualize data on a web, data had to be first made available in a statistical a database. The database is available on the website and allows users to create visualization, self-tabulation, it is API readable to create new products and visualisations. Statistical outputs (e.g. press releases, ready-made tables, charts, maps connected to statistics, info graphics, and videos) and metadata could be disseminated using tools and formats that facilitate re-dissemination by the media or any other users. In future, these info graphics could be linked in press releases and on website news.

In Customer Service are consultants whose responsibility is to answer requests and explain statistical outputs and guide to the applications where data is available. Help for users is provided mostly by phone or by e-mail. There is also a chat bot called ITI available on our website who helps users to find or answers most common questions or directs to customer service.

12.2 Visualization using ArcGIS and ArcGIS Online

In 21st century, interactive maps have become quite powerful tools to visualize the data and technological advances allow to present the data more readable, while including analytics and/or aggregated information, which provides the option to compare, analyse and conclude, depending on the needs and interests of the users.

In this project, illustrative maps were produced for ecosystem extent and ecosystem services which can be seen under chapter 4 for ecosystem extent and chapter 7 where the services and results, including spatial allocation of the values, are described.

In addition, as a new achievement the interactive dashboards in ArcGIS Online were created to illustrate spatial data, which guides and gives the user a chance to see, how ecosystem accounts, both extent and services, are distributed across Estonia.

So far, three spatial levels were used – counties, municipalities and 500x500m square grids. First two levels previously mentioned have the idea to give overview within administrative divisions, while 500x500m square grids give more specific distribution either within a single county or municipality, so that users could see, which areas have more potential. The use of counties and municipalities have vital role, since local governments want and need to know, what and how services are present within their territory. Users can view the data (ecosystem extent and services) based on the selection of administrative units. They can also select a service and further refine the selection by ecosystem types or administrative unit to see the corresponding values of the ecosystem service. These dashboards will be combined into single application (ArcGIS Experience), which is available here: https://experience.arcgis.com/experience/6f4d584477e8427bbb0597b03319f9ea/ . The interactive dashboards in ArcGIS on Estonian ecosystem accounts is the first prototype and still under development. As the interface is aimed mainly for experts from national audience, the user language is Estonian.

In total, at least 10 ecosystem services values will be spatially visualised having the following capabilities (as of June 2021):

- Choose county and/or municipality, to see detailed overview of the area (500x500m grids)
- Have a overview of different values of the ecosystem services national, county, municipal and grid level, depending on the level chosen (Figure 21, Figure 22). In addition, ecosystem classes, types and value filters also have same capabilities. In case of recreative and game hunting, specific areas (hunting communes) also have been added.
- Get an overview of multiple indicators and diagrams, which show the distribution municipalities by value (both total and per hectar), ecosystem types and classes and compare them with each other.
- Filter out areas by total value, per hectar (counties and municipalities) and total value in grid.
- In case of ecosystem, overview of classes and types will be given – share within counties, municipalities and 500x500m grids by using 3rd level types (total areas) as a basis for the aggregation to 1st level classes and 2nd level types.

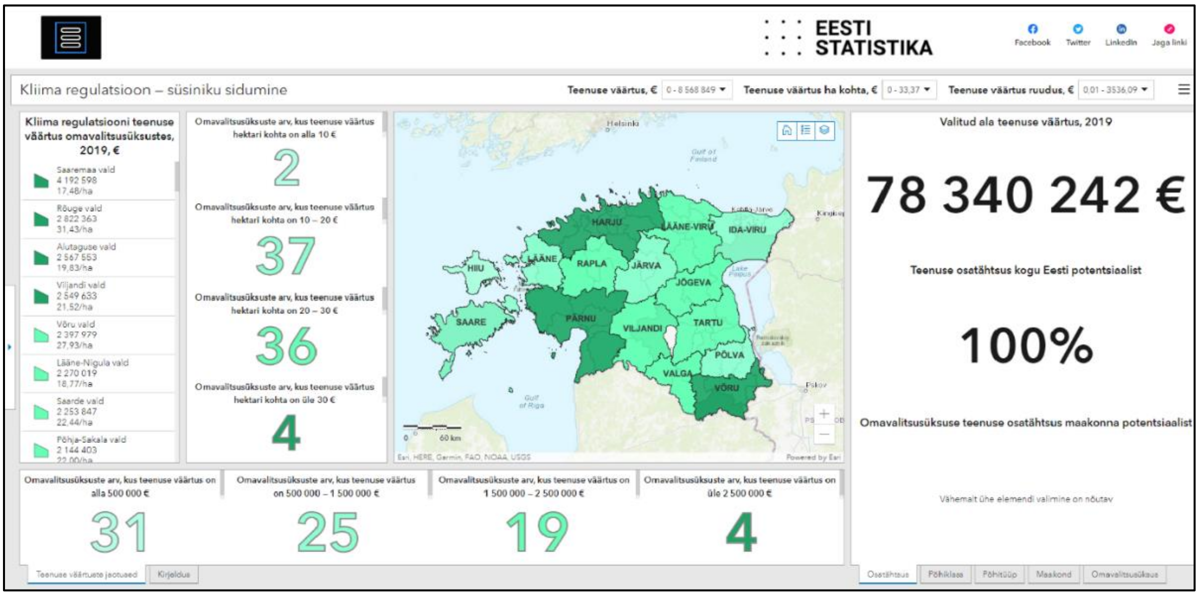

Figure 21. Dashboard overview of the climate regulation service (test stage).

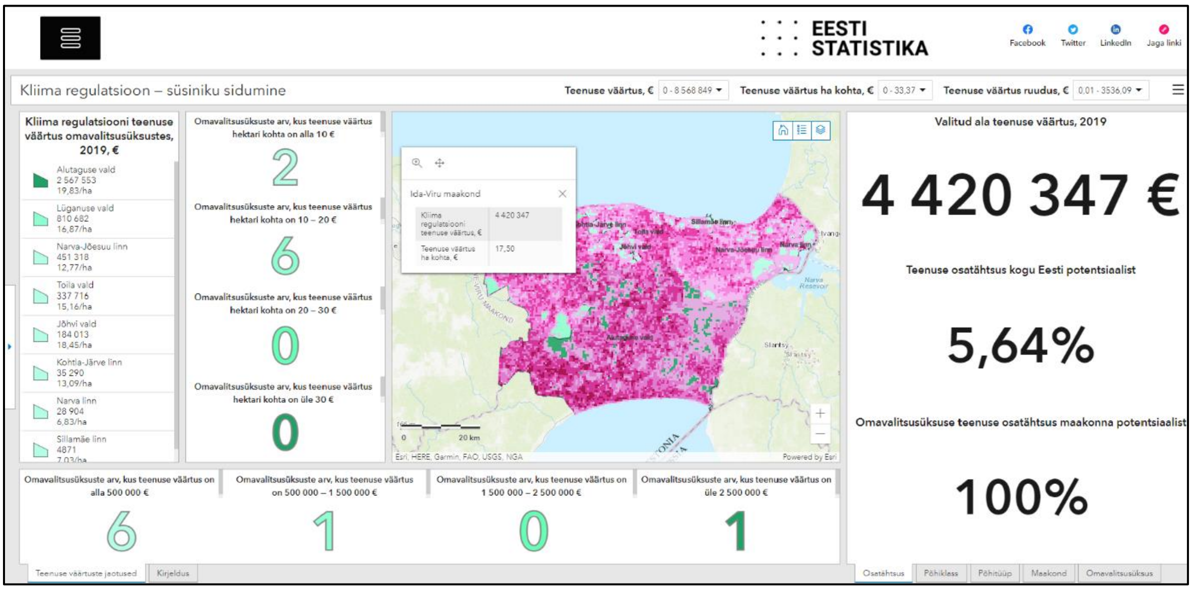

Figure 22. Example of Ida-Viru county in climate regulation result (test stage).

For the future, the application is going to be public, giving the chance to get user feedback and continue with additional developments of the dashboard/application – what to add, change or delete. In addition to user feedback, potentially other capabilities could be added:

- Smaller grids, 250x250m for example
- 3rd level ecosystem types and its analytics
- Additional aggregated statistics or improved comparison between counties and municipalities
- Adding English language
- Continue adding extra services to application

12.3 Communication of the results in the statistical community

Dedicated section of the biodiversity and land use in a Statistical Office web page contains main tables and links here: https://www.stat.ee/en/find-statistics/statistics-theme/environment/biodiversity-protection-and-land-use

During the project several presentations with the aim of getting the feedback were made. The indication on the funding from Eurostat grant was made. Presentations were made on following international forums:

1. Ecosystem Services partnership 3rd conference, T17From assessment to accounting: how countries experience the development of NCA. Insights from applications. Lessons learned on accounting for ecosystem services: bridging the values of services and measures taken. June 7-10 2021. Kaia Oras (Statistics Estonia), Aija Kosk and Üllas Ehrlich (Tallinn University of Technology), Kätlin Aun (Statistics Estonia); Grete Luukas (Statistics Estonia). UN London Group on Environmental Accounting, October 2020

2. 6thJoint OECD/UNECE Seminar on Implementation of SEEA. Session: SEEA ECOSYSTEM ACCOUNTS (SEEA-EA) AND ITS RELEVANCE IN POLICY AND DECISION MAKING March 9th 2021. Kaia Oras (Statistics Estonia), Üllas Ehrlich (prof., Tallinn University of Technology), Kätlin Aun (Statistics Estonia); Grete Luukas (Statistics Estonia)

3. Chance for Better Policy: Can Ecosystem Account Provide a Missing Link between the Services Provided by Ecosystems and the Land Owners; 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)

4. 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)

5. Eurostat Task Force on Ecosystem Accounting, June 24, 2021, internal document

13 Analyses of the potential of developed ecosystem accounts

The insight into the applicability and the relevance of developed account from the perspective of the users was analysed. Analytical paper was written [69]on the policy relevance of the valuation results and presented on a London Group meeting of Environmental Accounting in 2020.

It is hoped that in medium term the compiled extent account and supply and use type account of ecosystem services will be the basis and provide the tool for planning on national scale. The series of the accounts that will be further developed would build a functional bridge (taking nature into account) between the information about ecosystems and the services these provide and the information available in national accounts.

As financial support for the preservation (restoration and conservation) of ecosystems and biodiversity is debated the investigation made and new knowledge generated about the value of the provided ecosystem services will feed into this work. In addition to the preservation of the management of the semi-natural areas that are already managed (30 000 ha), a new goal has been set: conservation management of additional 15 000 ha of semi-natural grasslands by year 2030 according to the targets set by Nature Conservation Development Plan. Reaching this goal needs targeted measures. There are additional goals for conservation management of 50 000 ha in years to come.

Semi-natural grasslands mainly exist in our latitude (natural conditions of temperate climate) only if managed regularly. Otherwise they will naturally convert into shrubberies and later into forest ecosystems. On the other hand semi-natural grasslands can be turned into intensively managed grasslands (including ploughing, sowing, monoculture creation, pesticide and fertilizer use) or arable land. Grasslands can also be converted into urban areas.

The focus of the analyses was on the question how ecosystem accounts can be used for better policy regarding management of semi-natural grasslands. Could the extent and supply accounts in principal be used for targeting the measures and for analysing the alternative uses of grasslands? We analysed whether linking ecosystem extent, ownership dimension and services account could provide an added value in policy regarding ecosystems preservation.

The idea that cadastral parcels would facilitate the linkage between ecosystems and economic units/activities was tested. The link to the economic and institutional dimension was created and the breakdown by institutional activities was added as a separate layer to the opening extent account.

Developing ownership dimension in the extent accounts was considered to be the first and easier step for better policy which is important from the viewpoint of targeting measures. As the focus was the monitoring of the policy goals regarding the management of semi-natural grasslands, table below displays the area of the grasslands by ecosystems type, management status and ownership type as it was developed for the analyses.

---

2. [69] Chance for Better Policy: Can Ecosystem Account Provide a Missing Link between the Services Provided by Ecosystems and the Land Owners; 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/1k1v8cTKtO7zRXdH_NlgABUHLqXqZ6X46/view

Table 83. Ecosystem extent by ecosystem types and ownership categories

Institutional sector/ EUNIS ecosystem classification	General government	Corporations	...of which State Forest Management Centre	Households	Rest of the world	Un-known	TOTAL
Coastal	632	1556	1 353	644	100	65	2 997
Constructed, industrial and other artificial habitats	55 190	35558	[illegible]	[illegible]	[illegible]	3 259	176 577
Grasslands and lands dominated by forbs, mosses or lichens	29 224	67413	29 091	110 059	3805	2 056	212 556
Habitat complexes	5 739	4900	1 926	9 343	457	178	20 618
Heathland, scrub and tundra	3 333	5027	1 902	10 282	539	189	19 370
Inland surface waters	11 354	21603	18 753	6 712	185	1 242	41 095
Inland vegetated or sparsely vegetated habitats	19 420	27300	10 551	19 874	591	1 709	68 894
Marine	2 439	7576	5 507	9 164	1 197	132	20 507
Mires, bogs and fens	17 413	208592	201 043	15 606	536	19 281	261 428
Regularly or recently cultivated agricultural, horticultural habitats	103 232	323761	6 393	661 207	8 377	5 706	1 102 284
Woodland, forest and other wooded land	113 178	1528812	1 049 105	680 055	15 654	81 392	2 419 091
NA	202	464	303	357	15	23	1 062
TOTAL	361 356	2232562	1 334 720	1 603 376	33 954	115 232	4 346 480

More detailed levels are available in both dimensions

Under the category "Management status", the area (ha) of semi-natural grasslands to be managed by 2030 (according to the targets of the Nature Conservation Development Plan), the area (ha) of currently managed semi-natural grasslands and the area (ha) of semi-natural grasslands that needs to become managed are displayed by ecosystem types. Under the ownership part of the table the ownership status of the grassland ecosystems, classified according to the ownership types of economic statistics, is outlined. The additional area of semi-natural grasslands to be managed in case of wooded meadows, alluvial meadows and Nordic alvars is remarkable. It should be still noted that the data on grassland ecosystem extent account were still in revision.

Table 84. Grassland ecosystems by type, management status and ownership, 2019. Semi-natural grassland ecosystems types (NATURA) are presented on grey background.*

Ecosystem type	AREA, ha	Management status, ha			Ownership, ha									
	hectars	To be managed according to the target	Managed	Additional need	Financial corporations	General government	Households	Hosueholds as physical persons	Non financial corporations	NPISH	Rest of the world	State Forest Management Centre	Unknown
Grassland	498 505	n.t.	n.r.	n.r.	263	63 176	176 876	114 272	91 933	1 576	7 780	39 261	3 369
Semi-natural grassland	241 953	n.t.	n.r.	n.r.	166	32 102	89 241	36 284	39 707	1 015	5 382	35 830	2 225
Semi-natural grassland according to the NATURA classification	97 044	n.t.	43100	8930	62	8 950	29 419	13 646	11 140	430	3 104	29 402	892
Boreal baltic coastal meadows (1630)	19 946	10800	11891	a	19	2 339	6 384	2 681	1 901	121	1 191	5 195	116
Fixed coastal dunes with herbaceousvegetation ("grey dunes") (2130)	397	n.t.	n.r.	n.r.		45	76	15	29	1	9	221	2
Dry sand heaths with Calluna and Empetrum nigrum (2320)	43	n.t.	n.r.	n.r.		8	18	7	3	0	6	1	0
Inland dunes with open Corynephorus and Agrostis (2330)	27	n.t.	n.r.	n.r.		1	0	0	2	0		24	0
European dry heaths (4030)	**561**	**290**	**57**	**233**	0	**208**	124	37	32	0	6	**154**	1
Juniperus communis formations on heaths or calcareous grasslands (5130)	**3 837**	**500**	**473**	**27**	7	151	**1 898**	657	346	26	249	471	32
Xeric sand calcareous grasslands (6120)	32	n.t.	n.r.	n.r.		1	19	3	0	0	9		0
Calaminarian grasslands of the Violetaliacalaminariae (6130)	0	n.t.	n.r.	n.r.		0	0	0	0	0			0
Semi-natural dry grasslands and scrubland facies on calcareous substrates	5 381	2420	2487	a	9	419	1 968	998	715	27	241	974	29
Fennoscandian lowland species-rich dry to mesic grasslands (6270)	**6 175**	**1880**	**1534**	**346**	4	440	**2 320**	1 303	808	28	155	1 055	63
Nordic alvar and precambrian calcareous flatrocks (6280)	**14 616**	**7700**	**5161**	**2539**	10	955	**5 826**	2 035	2 257	63	711	2 712	48
Molinia meadows on calcareous, peaty or clayey-silt-laden soils (6410)	3 693	650	710	a	0	154	895	366	504	5	113	1 636	19
Hydrophilous tall herb fringe communities (6430)	3 641	370	1214	a	2	455	944	470	565	19	32	1 135	19
Northern boreal alluvial meadows (6450)	**25 811**	**12200**	**8975**	**3225**	2	2 321	4 250	2 275	2 570	74	122	**13 735**	462
Lowland hay meadows (6510)	5 348	1340	2587	a	7	877	1 896	915	706	47	80	750	70
Fennoscandian wooded meadows (6530)	**4 569**	**3300**	**1169**	**2131**	0	433	**1 685**	916	509	16	118	872	20
Fennoscandian wooded pastures (9070)	**2 965**	**1650**	**1221**	**429**	1	144	**1 117**	**969**	192	3	63	466	11
Other natural grassland	144 908	n.t.	n.r.		105	23 152	59 822	22 638	28 567	586	2 278	6 428	1 333
Cultivated grassland	256 552	n.t.	n.r.		97	31 074	87 634	77 988	52 226	561	2 398	3 431	1 144
Permanent grassland	256 552	n.t.	n.r.		97	31 074	87 634	77 988	52 226	561	2 398	3 431	1 144
Environmental non-sensitive permanent grassland	255 998	n.t.	n.r.		97	31 016	87 471	77 813	52 141	561	2 385	3 371	1 144
Environmental sensitive permanent grassland	554	n.t.	n.r.			58	163	175	86	0	12	59	0

*- data on grassland ecosystem extent account were still in revision.

To sustain the current level of maintenance of semi-natural grasslands and to design new financial instruments, it is important to see what kind of owners (and economic sectors) are responsible for the management of valuable ecosystem types which are contributing to the provisioning of the basket of market and non-market ecosystem service flows.

It can be seen that a majority of wooded meadows and alvars (marked with blue arrows) as well as other semi natural grasslands are owned by households. State Forest Management Centre (SFMC) owns quite a big share of alluvial meadows (marked with brown arrows). Dry heaths are owned in majority by government (marked with lilac arrows). The targeted measures for these owners are different. Households need additional subsidies, State Forest management Centre has their own budget for the management works. State has certain responsibilities for the management of resilient ecosystems.

In general we think that extent account together with a simple ownership dimension has a potential to provide a relatively robust planning and monitoring framework for the development of targeted measures.

In a situation where the value of land would include the value of the services supplied by the ecosystems, ecosystem extent, ecosystem services account and the ownership dimension will become more significant.

Data could be probably used to analyse alternative uses of land where the ecosystem reside and these data could be important for landowners and everyone who decides on the purpose of the cadastre unit. Therefore it is important that the value of the land should include the value of the services supplied by the ecosystem on it. And we think that it is important to further develop the ha-based values of services.

Considering the alternative use of ecosystem and need specific subsidies, the measures for supporting potential desired alternatives (f.e switch to semi natural) should be targeted to the owners of the land. For the landowners the management of land has to be profitable (considering the whole spectrum of the services). It is quite understandable and obvious that households and businesses need distinctive measures.

We also questioned whether the financial support for the preservation (restoration and conservation) of semi-natural grasslands is adequate considering the scope and magnitude of the services provided by these ecosystems? For doing so we tried to link the size and target of the financial support for preservation (restoration and conservation) of ecosystems and biodiversity with grassland ecosystem types and provided services values in a meaningful way?

We have been curious to compare the services provided, expenditures made and subsidies received. We were also reassured by several studies carried out in this area that service values in monetary terms over the ecosystems could be added up (for example Zhiyun Ouyang et al [70]).

Article we published displays the figures but in general we observed the several bottlenecks to work in future:

1. We had to admit (as in case of alternative land use above) that important services are missing from the valued services. It is not fully appropriate to make the conclusions based on the limited number of services that were valued during the pilot project. The range of the services was not fully represented and the important ecosystem services – for example the provisioning of the habitats is not among the valued services.
2. Provisioning services dominate. Of the total value (5.4 million €) of the given selected ecosystem services of semi-natural grasslands, the biggest share (2.1 million €) is made up by ecosystem contribution of fodder production measured using the rent price method. Thereof it seems that other ecosystem services are rather undervalued. Recreation services contribute

[70] Gross Ecosystem Product (GEP): A Tractable Approach for Bringing Ecological Information into Decision-Making; Zhiyun Ouyang et al; https://seea.un.org/sites/seea.un.org/files/gep-_qinghai_case_pnas_final_submission_20200117_1.pdf

next biggest share. Much wider spectrum of ecosystem services needs to be measured and taken into consideration. Relevant policy needs also need to be translated into the accounting framework.

3. Currently the data on subsidies is not available on a detailed ecosystem type level which could allow more straightforward comparisons.
4. The aggregation of the services provision and the aggregation of the subsidies paid is not the same.

13.1 Discussion and future thoughts on relevance and use of accounts

In general we think that extent account together with a simple ownership dimension has a potential to provide a relatively robust planning and monitoring framework for the development of targeted measures.

In a situation where the value of land would include the value of the services supplied by the ecosystems, ecosystem extent, ecosystem services account and the ownership dimension will become more significant.

Data could be probably used to analyse alternative uses of land where the ecosystem reside and these data could be important for landowners and everyone who decides on the purpose of the cadastre unit. Therefore it is important that the value of the land should include the value of the services supplied by the ecosystem on it. And we think that it is important to further develop the ha-based values of services

Why is the analysis of the alternative uses of ecosystem important? Based on the discussions of the London Group meetings on valuation in chapters of UN SEEA EA and according to the opinions of experts, the added value of the ecosystem accounts is the usefulness of it from the perspective of relative valuation. We hope that if the bottlenecks mentioned above could be solved the data on ecosystem accounting can be used to analyse alternative uses of land.

In addition the principle of marginal value should be taken into account as well when calculating the unit value (e.g. €/ha) and developing management policies for different ecosystems. According to the marginal value principle, the fewer are ecosystem units, the higher the value of one unit is to the society. So, under certain circumstances the marginal nature of the values will start influencing the total to be considered. For example when the habitats of certain species become really rare, they increase in value and increase the total value. The decline in certain services may not be important for the private owner of the ecosystem but could be important for the society as a whole. Taking the marginal value into account, the state could give priority to subsidizing the preservation of rare (small area) ecosystems like semi-natural grasslands, old forests etc.

ANNEX 1. Summary: Presentation of the results of the development of ecosystem accounting in 2019 by Statistics Estonia and plans for 2020-2021

Memo

February 21 at 10:00 in Room 301 of the Ministry of the Environment

Participants: Kaia Oras, Kätlin Aun, Argo Ronk, Grete Luukas, Kadri Möller, Üllas Ehrlich, Aija Kosk, Eleri Kautlenbach, Piret Kiristaja, Madli Linder, Merit Otsus, Irje Möldre, Mati Valgepea, Indrek Laas

Presentation: Statistics Estonia_accounting for ecosystems_21_02_design.pdf. Link sent in email. Report: Statistics Estonia „Methodological report. Development of the land account and valuation of ecosystem services regarding grassland ecosystem services", 2019, sent earlier.

1. Overview of the 2019 project report and results, feedback and comments
   1.1. An overview of environmental accounts and how ecosystem accounts fit into the framework of environmental accounts was given.
   1.2. An overview of the ecosystem extent account / land account was given: the compilation of Estonian ecosystem base map, ecosystem classifications (LULUCF, EUNIS), distribution of ecosystems / landowners by institutional sectors and activities.

      Discussion

      • Currently, the base map is not final, the final report has not been approved, and some technical issues need to be resolved regarding the creation of a new extent account.

   1.3. Introduction to the monetary valuation of grassland ecosystem services was given: selection process of the services, tested valuation methods, results and visualization of results on a map.

      Discussion

      • The contribution of an ecosystem from the total value of an ecosystem service is obtained by deducting economic and other costs from the value of the output of the ecosystem service entering the economy.

      • The real supply, i.e. the flow of the service entering the economy, has been evaluated. The definition of terms in both Estonian and English needs to be undertaken in the near future as there is a need to clarify and harmonize terminology (the stock of the service, potential supply, actual supply, flow, use).

      • Service supply maps are experimental. The allocation of the use of ecosystem services on the map has been made on the basis of actual (empirical) data available to Statistics Estonia. In order to specify the assessment of the monetary value of ecosystem services by ecosystem types, the result of the ELME project are a valuable input (game supply service, etc.).

      • Recreational service: what is the contribution of nature when man has created the infrastructure? Taking hunting tourism into account when evaluating the service? The question was raised that it would be necessary to analyze whether the data used (FACE survey) on expenditure on hunting correspond to Estonian conditions.

   1.4. Overview of the results of the total value of grassland ecosystem services, distribution of ecosystem types by area between landowners and by monetary value between ecosystem services was given. Introduction of the willingness to pay (WTP) method and results was given.

1.5. Description of the table on the provision and use of ecosystem services was given. Statistics Estonia is waiting for feedback on the 2019 project report and results by 15th March.

Discussion and recommendations for further analysis

• Can the results of the work be used to assess alternative land uses (wind, solar parks)? Classification of technogenic areas (cooperation with ELME project). The completion of the "Analysis of Local Benefit Instruments" in April (Ministry of Finance) and its connection with the outputs of ecosystem accounts was discussed.

• Classification of mapping units according to LULUCF: the correspondence of the areas presented in the report should be analyzed with land use account according to LULUCF (data submitted by KAUR to Statistics Estonia). It is important to describe to what extent the definitions used correspond / do not correspond to the LULUCF definitions (contact Allan Sims, KAUR). It was considered necessary to agree on a meeting to compare / analyze the classification of ecosystem types and crosswalk tables.

• KAUR raised a question about a reference to the use of the SFI plot database in the report. The Environmental Agency expressed its readiness that in the future KAUR, depending on the setting of the task, may perform the work based on SFI data for Statistics Estonia. Subsequent clarification by Statistics Estonia: Statistics Estonia did not use SMI source data, but models created on the basis of this database. Statistics Estonia also makes a clarification / correction in the report.

2. Treatment of ecosystem accounting development work plans for 2020-2021 and cooperation issues by topics was introduced, feedback and comments

2.1. Statistics Estonia continues to contribute to the development of the Ecosystem Accounting Standard of the United Nations Environmental Economic Accounting

2.2. Ecosystem extent account: compilation of the ecosystem map for a new period, time series, classification of changes, dimension of land users.

• Do the areas in the extent account compiled in 2019 (initial situation) coincide with other Estonian statistics? Do and to what extent do forest land and other ecosystem categories meet the LULUCF definition of land use? Statistics Estonia consults with KAUR in this regard (probably Allan Sims).

2.3. Urban thematic account was discussed. Statistics Estonia compiles the data layer of urban areas either according to administrative boundaries or population density. The question is also what the consumer needs. There is an option to create a hybrid in terms of population density and infrastructure.

Discussion

• The Environmental Agency referred to the layer of densely populated areas of Statistics Estonia from 2010, which is used in several surveys. Statistics Estonia has considered it obsolete and the plan is to create a new data layer for urban areas.

Information was shared that Evelyn Uuemaa (UT) deals with urban issues and suburbanisation.
• The definition of an urban ecosystem was discussed and the Ministry of the Environment referred to the European Commission's report on urban ecosystems. It was discussed which ecosystem services should be valued in the city and whether the choice of services provides requirements for the definition of urban areas. It was also discussed whether only an ecosystem within a densely populated area or also a neighborhood close to the city should be considered an urban ecosystem. For example, in the case of recreational services, the vicinity of the city is also important.
• An additional discussion on the definition of urban areas is planned with the Ministry of Finance, the Ministry of Economic Affairs, the Ministry of the Environment and ELME on 19.03.

2.4. Discussion on the implementation of the International Union for Conservation of Nature (IUCN) global ecosystem typology.
• KAUR provided information that there has been little information on this topic in Estonia. Kalev Sepp from the University of Life Sciences has shown interest.

2.5. Overview of monetary valuation of ecosystem services was given: inclusion of all terrestrial ecosystems, selection process of additional ecosystem services (in April Statistics Estonia will send a questionnaire to partners: representatives of the Ministry of Finance, the Ministry of the Economy, the Ministry of the Environment and the Ministry of Rural Affairs).

2.6. Discussion on accounting of ecosystem assets.
Methodological issues were discussed
• Statistics Estonia explained that an asset is a potential amount of services entering the economy, which has been assigned a value according to the value of the service calculated for a particular year.
• The Ministry of Economic Affairs provided information on the related project "Bioeconomy Value Chains" led by Jaan Kers from TUT.

2.7. Discussion on the ways and means of publishing the results. Statistics Estonia plans to publish maps of ecosystem services in the external map application (VKR) in 2021.

3. Conclusion: Feedback and cooperation issues
   3.1. We are waiting for feedback on the results of the ecosystem accounts conducted in 2019 and on the development activities of the ecosystem accounts for 2020-2021 by March 15 (questions are on the topics).
   3.2. Regarding the choice of ecosystem services, Statistics Estonia will ask for input from the representatives of the ministries in April.
   3.3. The first methodological seminar will be organized by Statistics Estonia between May and September 2020 (exact time to be decided).
   3.4. The analysis of the results and the final seminar are planned for April 2021.
   3.5. Suggestions and clarifications from field experts for the definitions in Estonian are very welcome, we are waiting for them throughout the project.

3.6. Statistics Estonia is waiting for opinions and proposals in the field of ecosystem services for new developments that can start in 2021 (the report identifies two possible areas: abiotic ecosystem services, marine and aquatic ecosystem services). Statistics Estonia makes proposals in writing and the Ministry of the Environment wishes that the process start as early as possible.

Summarized by Kätlin Aun, Kaia Oras

27.02.2020

ANNEX 2. Summary: Seminar on development of ecosystem accounting

Meeting 27th November 2020, Statistics Estonia, Skype for Business

Participants: Kaia Oras, Kätlin Aun, Grete Luukas, Helen Saarmets, Argo Ronk, Üllas Ehrlich, Allar Luik, Andra Ainsaar, Eleri Kautlenbach, Eneli Viik, Kadri Kask, Karel Lember, Madli Linder, Mati Valgepea, Merit Otsus, Sille Rebane

Presentation: Statistikaamet_eesti_ökosüsteemide arvepidamine_27_11 seminar.pdf

Report on grant work 2019: Aruanne ökosüsteemide ulatuse ja rohumaade ökosüsteemiteenuste konto arenduse 2019 kohta

Overview of ecosystem accounting and work done in 2020

Kaia Oras gave an overview of ecosystem accounting on international level (UN SEEA EEA) and a brief introduction to the work done by Statistics Estonia during the grant project in 2019. Tasks of the development of ecosystem accounting during 2020-2021 that include compiling ecosystem extent account, defining the extent of urban areas (urban ecosystems) and its relevant services, and analysing the applicability of IUCN Global Ecosystem Typology.

Comments:

- Ministry of the Environment was interested in the results and current state of IUCN GET.
- *SE (Statistics Estonia)* answer: *Statistics Estonia has presented the results of testing IUCN GET in Estonia in Virtual Expert Forum on SEEA Experimental Ecosystem Accounting 2020 in June, no news of progress and further guidance have been announced since then.*

Introduction to the determination of the relevance of ecosystem services (ES)

Inquiries from ministries and other relevant institutions about the relevance of monetary valuation of ecosystem services of forest, wetland and agricultural ecosystems were carried out in spring 2020. Kätlin Aun introduced the methodology of the determination of the relevance of monetary valuation of ecosystem services. The relevance was assessed in the scale: A- very important service (numerical score 3), B- important service (numerical score 2), C- service is not important to be valued in monetary terms (numerical score 1). After assigning a numerical score for the relevance, an average was calculated for every service in every ecosystem type (forest, wetland and agricultural ecosystems). Also additional criteria was applied to assess the relevance of the service such as whether the service is final or intermediate service, does it belong to EEA, and the feasibility of assessment. The majority of the services were assessed as very relevant and therefore included in the list of ecosystem services for monetary valuations. **The services included for monetary valuations are following:**

Provisioning services:

1. Animal feed;
2. Biomass for bioenergy;
3. Crops;
4. Wild berries, mushrooms etc., incl. wild game;
5. Timber;

6. Peat;
7. Seeds and spores;

Regulative services:

8. Flood protection
9. Climate regulation (carbon sequestration, carbon stock)
10. Regulation of air quality
11. Pollination;
12. Photosynthesis;
13. Soil fertility;
14. Maintenance of habitats;
15. Maintaining the reserve of clean water (the service was included in the list of services from the CVM questionnaire);

Cultural services:

16. Recreation;
17. Recreational hunting;
18. Nature education;
19. Landscape diversity (the service was included in the list of services from the CVM questionnaire).

Ecosystem services which were excluded from the list of ecosystem services for monetary valuations:

1. Medicinal herbs (assessed as not a very relevant service for monetary valuation);
2. Organic waste (assessed as not a very relevant service for monetary valuation);
3. Provision of ground- and surface water (outside of EEA, provided by water ecosystems, which are not under assessment in the current project);
4. Mediation of wastes or toxic substances (assessed as not a very relevant service for monetary valuation);
5. Regulation of microclimate (assessed as not a very relevant service for monetary valuation);
6. Controlling the spread of dust (assessed as not a very relevant service for monetary valuation);
7. Rainwater infiltration (outside of EEA, important in urban ecosystems, which are looked as a sub-account in the current project);
8. Visual screening (outside of EEA, important in urban ecosystems, which are looked as a sub-account in the current project);
9. Noise attenuation (outside of EEA, important in urban ecosystems, which are looked as a sub-account in the current project);
10. Groundwater recharge (intermediate or supporting service);
11. Pest control (valuation, incl. biophysical valuation, is complex);
12. Erosion control (valuation, incl. biophysical quantities, is complex);
13. Nature tourism (valuation, incl. biophysical quantities, is complex);
14. Aesthetic experience (valuation, incl. biophysical quantities, is complex);
15. Spiritual experience (valuation, incl. biophysical quantities, is complex).

Comments:

- No objections were given regarding the methodology of the determination of the relevance of monetary valuation of ecosystem services.

- Ministry of Economic Affairs and Communications are interested that nature tourism ecosystem service is included in the monetary valuations. Currently it is excluded because no data is available and therefore monetary valuation is complicated.
- Ministry of Rural Affairs and Ministry of Environment think that pest control is an important service which should be included in the monetary valuations.
- Ministry of Environment thinks that a majority of terrestrial ecosystems are connected with the provision of surface and groundwater and groundwater recharge. These are important services which should be included in the monetary valuations.
- There were questions why final ecosystem services are preferred over intermediate services. SE explained that the final user of an intermediate ecosystem service is not people (economic sector or activity in SNA) but the user is another ecosystem where the service contributes to the provisioning of other ecosystem services. Pollination is one of the intermediate services that is included in the monetary valuations, for other intermediate ecosystem services it is questionable.
- It was asked about the research papers on the dependence of crop yield on pollination. SE used, with local experts opinion, the methodology also used by Statistics Netherlands and the paper discussing the topic was *Klein, A.M., Vaissiere, B.E., Cane, J.H., Steffan-Dewenter, I., Cunningham, S.A., Kremen, C., Tscharntke, T. (2007). Importance of pollinators in changing landscapes for world crops. Proceedings of the Royal Society B 274, 303-313.*

Ecosystem services chosen for monetary valuation and their valuation methods

Grete Luukas and Kätlin Aun introduced potential monetary valuation methods and data for the valuation of ecosystem services included in the monetary assessment. Feedback on chosen methods and data were asked from participants.

Provisioning services:

1. Animal feed (rent price, resource rent methods);
2. Biomass for bioenergy (market price);
3. Crops (market price, resource rent, rent price);
4. Wild berries, mushrooms etc., incl. wild game (market price, CVM);
5. Timber (stumpage price,
6. Peat (market price);
7. Seeds and spores (market price, CVM);

Regulative services:

8. Flood protection (service is being analysed, it requires good data on biophysical quantities, CVM);
9. Climate regulation (carbon sequestration, carbon stock) (PES scheme, CVM);
10. Regulation of air quality (service is being analysed, it requires good data on biophysical quantities, CVM);
11. Pollination (avoided cost, CVM);
12. Photosynthesis (CVM);
13. Soil fertility (CVM);
14. Maintenance of habitats (CVM);
15. Maintaining the reserve of clean water (CVM);

Cultural services:

16. Recreation (cost-based method, time us, CVM);
17. Recreational hunting (cost-based method);

18. Nature education (cost based approach, CVM);
19. Landscape diversity (CVM).

Comments:

- When valuing the provision of timber, experts of forests should be included in the work. For example, there are uncertainties when valuing the yearly forest increment with the current method which experts could advise on how to improve.
- Regarding cost efficiency, it may not be sensible to value the services that result in low values (e.g. biomass for bioenergy). When there is no value or the service value is very low, it may be better not to value the service as the costs of the work would be higher than the result in return. At the same time, the service that may not be important or have a high value now, may be that in the future.

- Question: When the value of recreation service according to the costs of maintenance of hiking trails was valued 7.2 mln € and the value according to time use method was 51 mln €, can it be concluded that the costs made for maintenance of hiking trails are considered a good investment? Can it be concluded that hunting is more of a hobby when the value of game is 8 mln € but the value of recreational hunting is 16.1 mln €?
  SE answered that these results are not yet analysed and therefore concrete relationships cannot be drawn. However, at the first approximation, both statements seem to be correct. The purpose of ecosystem accounting is to identify ecosystems and their services that are valued by people. These data can be used in planning or economic analysis.
- Question: Can it be valued that when the costs of the maintenance of hiking trails are doubled, then the time spent there is also doubled?
  SE answered that there is no linear relation, but we think when the amount of hiking trails is increased, so is the time spent in nature increased. Another aspect of nature recreation is its positive effect on the health of people.
- Question: Was it considered that besides provisioning and cultural service, hunting also has a regulative effect by avoiding game damage and regulating population sizes, which could have a higher end value.
  SE answered that the regulative effect is more likely intermediate than final service. Game damage and additional feeding of game were considered as potential inputs in the valuation of the game provisioning service value but in the end, the approach was not applied.

Conclusion and addition work

Statistics Estonia asked feedback about the services chosen for monetary valuation, corresponding data and methods for 4th December 2020.

The final list of ecosystem services chosen for monetary valuation will be available after the calculations and testing. These will be introduced onwards of April 2021.

The memo of the meeting will be sent out in December.

Comments

- There is interest to form thematic groups for forest ecosystem services (Allar Luik, Andra Ainsaar and related people from the Ministry of Environment, Eleri Kautlenbach, Karel

Lember). Minimally it would include an in-depth meeting in January. Topics would also include indicators for forestry development plan and involving specialist on the services, e.g. in relation to hunting.

- There is interest to form a thematic group for agricultural ecosystem services (Kadri Kask, related people from the Land Use Policy Department of the Ministry of Rural Affairs). It could include an in-depth meeting in January.
- A certain amount of generalization is desirable when compiling accounts, otherwise the systems would become too detailed and complex and putting green accounting into framework would be postponed to indefinite future. Therefore, it is necessary to agree on which ecosystem services and how can be valued.

Summary of written comments received from participants on 4th December.

1. Participants wish that pest control (Ministry of Environment, Ministry of Rural Affairs), provision of medicinal herbs, provision of surface and groundwater, erosion control and nature tourism would be included in the monetary valuations.

SE takes the comment into consideration.

2. Participants introduced additional data sources:
    a. Nature tourism: Environmental Agency and Estonian University of Life Sciences research ecosystem services in relation to ELME project. Sustainable tourism is an important part in the agenda for future tourism, there are hints that foreigners who have travelled to Estonia appreciate Estonian nature.
    b. Medicinal herbs: Sellers in Estonia could give information about the quantities and prices of sold medicinal herbs.
    c. Surface and groundwater: the usage of groundwater could be assessed by the usage of water of the population
    d. Pest control: Eve Veromann (Estonian University of Life Sciences) is known to work on the topic.

SE takes the comments into consideration.

3. Ministry of Environment expressed their opinion that it is important to discuss the services that are valued using CVM because it is important how the questionnaire is constructed.

SE agrees with the comment.

4. Questions:
    a. What is behind the service "photosynthesis"? What is the difference between photosynthesis and climate regulation (carbon sequestration and storage)? If there is no photosynthesis there is no carbon sequestration.

       SE answer: Here the production of oxygen is meant under "photosynthesis". The process of photosynthesis is the same but under services a different end product is being looked at: the production of oxygen or sequestrated carbon. The terms and definitions are still open in ecosystem accounting, especially regarding regulating services. One of the objectives of our work is to define ecosystem services.

b. How can the contribution of important spawning grounds (alluvial meadows) to the formation of fish stocks be valued in monetary terms?

   SE answer: Such an ecosystem service is known as the nursery service. The service was not included in the preliminary list of ecosystem services and therefore the aspects related to it are not analysed. According to ESVD-TEEB or EVRI databases, there are several methods, such as direct market price, contingent valuation method, replacement cost, etc., that can be used to values the monetary equivalent of nursery service. As is the case with other ecosystem services, several of the monetary valuation methods rely on the biophysical data, which in this case would be the quantities of fish spawning in alluvial meadows. In the current project we value the ecosystem service habitat provision with CVM.

c. How do you plan to take into account the relationship between the supply of the service and the condition of the ecosystem asset? Is it possible to show how the assets of one ecosystem type (e.g. Nordic alvar) in various conditions contribute to the supply of ecosystem services in varying proportions? In general, there is no need to compare ecosystem types, but compare condition classes.

   SE answer: As of now, the assessment of ecosystem condition in Estonia is not yet available and therefore we do not know what the data shows. Taking condition into account is not part of the current project, it is planned for future work. However, when valuing the services, we try to use every meaningful data. At a first approximation, the condition classes can be used to (spatially) distribute the whole value, which was obtained by deductive methods, between ecosystem types.

d. Slide no 9. How can the higher value of recreation services on cultivated grasslands compared to semi-natural grasslands be explained? E.g. environmental sensitive permanent grassland vs Fennoscandian wooded meadows/ European dry heaths/ Boreal baltic coastal meadows?

   SE answer: The result depends on the monetary valuation method and the definition of the ecosystem service. The location of hiking and health trails gave us the supply of the service by ecosystem types which we matched with the use data. No in-depth analysis was carried out on the calculated results. However, one of the likely reasons is that the use of recreation service is higher on cultivated grasslands than on semi-natural grasslands as these are more abundant and accessible. It is possible to read further on the data and methodologies in our grant project report (2019) which is linked above.

e. Slide no 9. How can the higher value of recreation services on European dry heaths (4030) compared to Nordic alvars or coastal meadows be explained? Is the result dependent on the used methodology?

   SE answer: The result depends on the monetary valuation method and the definition of the ecosystem service. The location of hiking and health trails gave us the supply of the service by ecosystem types which we matched with the use data. No in-depth analysis was carried out on the calculated results. However, one of the likely reasons is that the use of recreation *service is higher on heaths as these are more accessible. It is possible to read further on the data and methodologies in our grant project report (2019) which is linked above.*

f. Slide no 9. What are the reasons behind the low value of nature education service on wooded meadows, coastal meadows, alvars, which are known to be one of the communities with highest biodiversity in Estonia? How is the result influenced by the used methodology? Which are other methodologies that could be used?

   SE answer: The result depends on the monetary valuation method and the definition of the ecosystem service. The valued nature ecosystem service was clearly defined as in-situ institutional nature education and the value was calculated based on which ecosystem types exist in the locations where nature education programs were carried out. When valuing ecosystem services, the demand for the service is as important as the supply and in these locations demand meets supply. Most likely the reasons are the same as the reasons behind the values of recreation service, that wooded meadows, coastal meadows and alvars are not as accessible or there are no study trails as the ecosystem types with higher values.
   It is possible to read further on the data and methodologies in our grant project report (2019) which is linked above. All suggestions to improve the valuations are appreciated.

Summarized by Kätlin Aun, Kaia Oras

17.12.2020

ANNEX 3. Summary: Seminar on development of ecosystem extent account and valuation of ecosystem services

June 11, 2021, Statistics Estonia

Memo

Zoom meeting, recording is available here.

1. Introduction
   1.1. Update on the progress and overview of Estonian ecosystem accounts, Kaia Oras
   Statistics Estonia (Kaia Oras) gave an overview of the work done in Estonia on ecosystem accounts in 2020-2021: compiled accounts and valued ecosystem services, treatment of the market and non-market ecosystem services and supply and use tables, asset account, urban thematic account and visualization efforts taken. The introduction to the future work programme was also given.

   1.2. State of the play in UN SEEA EA, Sjoerd Schenau, Kaia Oras
   International initiatives and developments were described.

2. Estonian ecosystem extent account
   2.1. Presentation of ecosystem extent account and map, Argo Ronk
   An overview of Estonia ecosystem extent account compilation and the details about underlying methodology with the main results was presented. Base map was compiled using most up to date and relevant spatial data concerning Estonia's ecosystems as of the beginning of 2020. The creation of the link between land owners and ecosystems was also introduced. State of the art regarding opening and closing extent account was described abd it was termed that final/detailed results will be presented in a methodological report.

   2.2. Urban thematic account, Argo Ronk, Kaia Oras
   Methodology for determining urban areas in Estonia and the reasoning behind the selection of the framework for urban thematic account was presented. Results were termed to be presented in a methodological report which should be finalized and approved during summer 2021.

   2.3. Ecosystem classification in Estonia, Kätlin Aun

   The need for unified ecosystem classification was described (compiled extent map included many map units such as Natura habitats, forest site types, land use and cover classes from different data sources, previously crosswalks to UNFCCC/IPCC land use classes (LULUCF) and EUNIS habitat classification were done but existing map units were difficult to delineate in these frameworks and the loss of detail was considered to be too large) and an attempt to develop a multi-level ecosystem classification for Estonia was created which includes 8 main ecosystem classes, 30 ecosystem sub types and 126 map units on the most detailed level was described. Proposed approach was considered to give a good layout for reporting results. It was explained how work was carried out in parallel - simultaneously with the testing of IUCN Global Ecosystem Typology.

2.4. IUCN Global Ecosystem Typology (IUCN GET) crosswalk results, Kätlin Aun, comment from Patrick Bogaart

The reasoning behind the task to test the crosswalks of Estonian ecosystem types to IUCN GET was described (the IUCN Global Ecosystem Typology offers a standardized, globally consistent, spatially explicit typology and terminology for managing the world's ecosystems and their services. It is a reference classification for UN System of Environmental-Economic Accounting –Ecosystem Accounting (SEEA EA) for ecosystem accounting). Those who participated in testing in spring 2020 with the help of external experts were thanked. The main results of testing of 30 respective ecosystem functional groups (EFG) identified in Estonia were described: One to one crosswalk of 39% of the cases was considered a good result. Preferred EFG was found for 78%, preferred EFG not found for 6% and ecosystem type was not fully described in 15% of the cases. Problems which arose with grouping Estonian forest sites, semi-natural grasslands and wetlands were described.

Patrick Bogaart offered a comment on the arisen issues and considered Estonia's efforts in IUCN testing very useful.

3. Presentation of the methods for the valuation of ecosystem services

3.1. Theoretical introduction on the valuation of services based on UN SEEA EA and some examples from Statistics Netherlands, Sjoerd Schenau

3.2. Selection of the services and introduction of the exchange value based monetary valuation methods, Kätlin Aun

Exchange value based monetary valuation methods were described briefly. Selection of the ecosystem services for monetary valuation was done based on the results of the questionnaires carried out in the beginning of 2020 to determine the importance of monetary valuation for ecosystem services in natural/seminatural ecosystems (grasslands, wetland, forest, cropland) and urban ecosystems. Additional criteria to the relevance and stakeholders' interest were data availability and feasibility of suitable valuation methods, possibility for regular production. Total of 16 services were chosen and valued with exchange value based methods in the project.

3.3. Overview of contingent valuation methods, Üllas Ehrlich

Overview of the method and main results was outlined.

4. Description of the valuation of the ecosystem services and results

4.1. Provisioning services, Grete Luukas, Kätlin Aun

The methods of monetary valuation and results of the value of the supply of the following provisioning ecosystem services divided between main ecosystem classes were presented: fodder and agricultural production, timber, wild berries and mushrooms, wild game, bioenergy, peat, forest seed, medicinal herbs. Applied details on methods were described. Chosen market price methods were justified regarding the choosing of the best method of valuation. For fodder and agricultural production rent price was used and for timber stumpage price, the supply of medicinal herbs was valued within willingness to pay questionnaire (CVM-contingent valuation method). Conclusion and open issues on the valuation of provisioning services was presented, including Eurostat proposal for the module of ecosystem accounts regarding provisioning services.

Merit Otsus from the Ministry of Environment asked if strictly protected forest are included in timber calculations (these are excluded) and whether the maturity of timber has been considered (it has not been considered).

4.2. Regulative services, Kätlin Aun

The methods of monetary valuation and results of the value of the supply of the following provisioning ecosystem services divided between main ecosystem classes were presented: climate regulation (valued with PES scheme method and also with CVM), regulation of air quality (benefit transfer, CVM), pollination (avoided cost, CVM), soil fertility (CVM) and habitat provisioning (CVM). Conclusion and open issues on the valuation of regulative services was presented, including Eurostat proposal for the module of ecosystem accounts regarding regulative services.

4.3. Cultural services, Grete Luukas, Kätlin Aun

The methods of monetary valuation and results of the value of the supply of the following provisioning ecosystem services divided between main ecosystem classes were presented: nature education (valuation based on expenditures, CVM), recreation (valuation based on time use, CVM), recreational hunting (consumer expenditures). Conclusion and open issues on the valuation of cultural services was presented, including Eurostat proposal for the module of ecosystem accounts regarding cultural services.

4.4. Urban ecosystem services

4.4.1.Services valued with exchange value based methods, Kätlin Aun

Details of the urban thematic account, namely urban ecosystems and the services they supply were explained. The monetary values of the services supplied by urban ecosystem assets were obtained using different approaches: as an extract from general ecosystem services valuation in case of both exchange values and welfare values; services specific to urban environment were valued separately (green waste, infiltration); CVM on urban ecosystem assets.

Services valued with exchange value based methods for urban ecosystem assets were Organic waste used for producing compost, which was valued with market price method and water infiltration which value was found using replacement cost method.

4.4.2.Overview of the non-market values of urban ecosystem services, Üllas Ehrlich

Overview of the method and main results was outlined.

Patrick Bogaart raised the discussion on the simultaneous application of exchange based methods and CVM for the characterization of the urban ecosystem services. Patrick asked whether considering CVM results on the same basis as results received by exchange based evaluation methods in urban ecosystems would open the door for considering CVM based valuations also on natural ecosystems when other evaluation methods are not feasible.

Üllas Ehrlich replied that monetary evaluation is not an ultimate goal and there are basic differences in values (services) valued by these two group of valuation methods. Only in case of perfect market these values could coincide (however this is hardly a case). In case of regulated services the question of the ecosystem contribution concerning the application of PES scheme is a question. Also in case of provisioning services the human input has a high share and it is difficult to entangle.

5. Supply and use tables. Assets. Visualisation of results

5.1. Supply and use tables of services, Grete Luukas

The logic and data of the supply and use tables of the selected services were presented and further plans were described. Logic was described how the users of ecosystem services have been determined (UN SEEA EA guidelines and SNA principles) in one hand the supply by ecosystem in another hand (spatial modelling). It was explained why and how the supply equals the use. Supply and use tables both for exchange and welfare based values were demonstrated and discussed. Calculated ecosystem services values filled in a supply and use tables were discussed. It was introduced why new achievement, the supply table is valuable, and which kind of information about supplied ecosystem services by ecosystem types it contains.

5.2. Treatment of non-market values, Kaia Oras, Üllas Ehrlich

As service values were both valued used market based and nonmarket valuation methods, the treatment of the values was discussed both from technical, and policy perspective. It was explained that many of the ecosystem services have no direct exchange value and therefore the monetary equivalent could not be obtained from the market. For example, among ecosystem services there are services related to walking in the forest (recreational value of the ecosystem), knowledge of the existence of biological species (psycho-social value) or enjoying the landscape view (aesthetic value). The question was raised whether these values without direct output having market price are in principle comparable to market values and what unites them. The goal to cover different types of values was discussed. Statistics Estonia worked together with Tallinn Technical University (who are in lead of environmental economics in Estonia) and found a common ground that all ecosystem services that increase welfare of individuals have value despite their participation in the market. Discussion points were handled under urban ecosystem services account. Statistics Estonia is expecting the further elaboration of these issues under UNSD research agenda of the valuation working group (TC), national accounts working group on valuation of non-market values (IWGNA), national evaluations and Eurostat TF of ecosystem accounts.

5.3. Asset accounts, Sjoerd Schenau, Grete Luukas

Ecosystem asset calculation logic was discussed and Estonian results of the selected ecosystem services was presented: in order to calculate asset values of ecosystems net present value (NPV) method was used. Three assumptions were presented and discussed: stream of future flow of ecosystem services values was considered constant, discount rate was 3% for provisioning services and 2% for regulative and cultural services (the scarcer the service the lower the discount rate) and the lifetime of all assets is 100 years.

Statistics Estonia welcomed possible thoughts and suggestions about the assumptions. Description of calculations were presented as well and future research needs in this area were highlighted.

5.4. Visualization of results via map/online platforms, Egert Indres

In addition to the maps created using ARC GIS. Egert Indres made and introduction to the developed interactive Arc GIS Online visualization tool. Both ecosystem extent account and ecosystem services display was presented. User has a possibility to choose the ecosystem type and follow the distribution and subtypes of this ecosystem type on a maps and the diagrams. Regarding the supply of the services user could select an ecosystem type and display the supply of the basket of the services per selected ecosystem type.

As a third feature user interface allows to pick a local municipality and display the ecosystem composition and provisioning of the services. Next phase of the work would be the testing of the user relevance, discussion the user aspects with the users in order to work further with most important features of the user interface.

5.5. Introduction to MAIA viewer, Patrick Bogaart

Patrick made an overview of the work done in MAIA viewer and the feasibility of displaying Netherlands ecosystem services accounts in MAIA interface.

Patrick emphasized that there are some very good features that have been developed in ARC GIS Publisher interface created by Statistics Estonia.

6. Future co-operation and closing of the meeting, Kaia Oras

Kaia Oras outline the timeline and the plans of co-operation considering the future development of the area, co-operation need in the light of the upcoming possible EU statistical regulation on ecosystem accounts and the tasks taken under next Eurostat grant for the years 2021-2023.

List of participants

Aija Kosk	Talltech
Ain Kull	Tartu University
Allar Luik	Estonian Private Forest Association
Andra Ainsaar	Ministry of Environment
Andres Levald	Ministry of Finance
Argo Ronk	Statistics Estonia
Aveliina Helm	Tartu University
Birgit Pai	Ministry of Rural Affairs
Bogaart P	Statistics Netherlands
Egert Indres	Statistics Estonia
Eleri Kautlenbach	Ministry of Finance
Ene Jurjens	Ministry of Economic Affairs and Communications
Evelyn Uuemaa	Tartu University
Grete Luukas	Statistics Estonia
Hannes Puu	Ministry of Rural Affairs
Helen Saarmets	Statistics Estonia
Kadri Kask	Ministry of Rural Affairs
Kadri Moller	Ministry of Environment
Kaia Oras	Statistics Estonia
Kaidi Jakobson	Estonian Environment Agency
Karel Lember	Ministry of Economic Affairs and Communications
Katrin Rannik	Ministry of Rural Affairs

Kristine Hindriks	Ministry of Rural Affairs
Kristjan Lepp	Ministry of Economic Affairs and Communications
Kätlin Aun	Statistics Estonia
Liina Remm	Tartu University
Madli Linder	Estonian Environment Agency
Margit Tennokene	Ministry of Environment
Marje Sarekanno	Agricultural Research Center
Marko Vainu	Tallina Ülikool
Mati Valgepea	Estonian Environment Agency
Meelis Seedre	Ministry of Environment
Merili Simmer	Ministry of Rural Affairs
Merit Otsus	Ministry of Environment
Olav Etverk	Estonian Environmental Board
Peep Siim	Estonian Environment Agency
Priit Põllumäe	Ministry of Environment
Schenau S	Statistics Netherlands
Sille Rebane	Ministry of Environment
Taimo Aasma	Estonian Environment Agency
Tambet Kikas	Agricultural Research Center
Tea Nõmmann	Private Expert
Timo Kark	Ministry of Environment
Veronika Vallner	Ministry of Rural Affairs
Üllas Ehrlich	Talltech

Summarized by Kätlin Aun, Kaia Oras

22.06.2021

ANNEX 4. Ecosystem Classification for ecosystem accounting in Estonia

Ecosystem map unit code	1. Ecosystem main class	2. Ecosystem type	3. Map unit
JO	Forest	Drained peatland forests	Oxcalis drained swamp forest site type
KS	Forest	Drained peatland forests	Drained swamp forest site type
MO	Forest	Drained peatland forests	Myrtillus drained swamp forest site type
JK	Forest	Mesotrophic boreal forests	Oxalis forest site type
SL	Forest	Mesotrophic boreal forests	Hepatica forest site type
KL	Forest	Eutrophic alvar forests and shrublands	Galamagrostis-alvar forest site type
LL	Forest	Eutrophic alvar forests and shrublands	Arctostaphylos-alvar forest site type
LU	Forest	Eutrophic alvar forests and shrublands	Sesleria-alvar forest site type
KN	Forest	Oligotrophic boreal heath forests	Calluna forest site type
SM	Forest	Oligotrophic boreal heath forests	Cladonia forest site type
JM	Forest	Oligo-mesotrophic boreal forests	Oxalis-Myrtillus forest site type
JP	Forest	Oligo-mesotrophic boreal forests	Oxalis-Rhodococcum forest site type
KM	Forest	Oligo-mesotrophic boreal forests	Polytrichum-Myrtillus forest site type
MS	Forest	Oligo-mesotrophic boreal forests	Myrtillus forest site type
PH	Forest	Oligo-mesotrophic boreal forests	Rhodococcum forest site type
KR	Forest	Oligotrophic paludifying forests	Polytrichum forest site type
SN	Forest	Oligotrophic paludifying forests	Vaccinium uliginosum forest site type
LD	Forest	Minerotrophic swamp forests	Alder (eutrophic) fen forest site type
MD	Forest	Minerotrophic swamp forests	Alder-birch (eutrophic-mesotrophic) swamp forest site type
ND	Forest	Eutrophic boreo-nemoral forests	Aegopodium forest site type
SJ	Forest	Eutrophic boreo-nemoral forests	Dryopteris forest site type
RB	Forest	Mixotrophic and ombrotrophic bog forests	Oligotrophic bog forest site type
SS	Forest	Mixotrophic and ombrotrophic bog forests	Transitional (mesotrophic) bog forest site type
AN	Forest	Eutrophic paludifying forests	Filipendula forest site type
OS	Forest	Eutrophic paludifying forests	Equisetum forest site type
TR	Forest	Eutrophic paludifying forests	Carex forest site type

Ecosystem map unit code	1. Ecosystem main class	2. Ecosystem type	3. Map unit
TA	Forest	Eutrophic paludifying forests	Carex-Filipendula forest site type
KP	Forest	Forest on reclaimed pits	Forest on reclaimed pits (gravel)
LP	Forest	Forest on reclaimed pits	Forest on reclaimed pits (sand)
MP	Forest	Forest on reclaimed pits	Forest on reclaimed pits (mineral)
SP	Forest	Forest on reclaimed pits	Forest on reclaimed pits (loam)
TP	Forest	Forest on reclaimed pits	Forest on reclaimed pits (peat)
Keskkonnatundlik püsirohumaa	Grassland	Cultivated grassland	Environmentally sensitive permanent grassland
Püsirohumaa	Grassland	Cultivated grassland	Permanent grassland
4030	Grassland	Heaths	European dry heaths (4030)
2330	Grassland	Heaths	Inland dunes with open Corynephorus and Agrostis grasslands (2330)
2320	Grassland	Heaths	Dry sand heaths with Calluna and Empetrum nigrum (2320)
6510	Grassland	Semi-natural grasslands	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis) (6510)
6270	Grassland	Semi-natural grasslands	Fennoscandian lowland species-rich dry to mesic grasslands (6270)
9070	Grassland	Semi-natural grasslands	Fennoscandian wooded pastures (9070)
6530	Grassland	Semi-natural grasslands	Fennoscandian wooded meadows (6530)
6210	Grassland	Semi-natural grasslands	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites) (6210)
5130	Grassland	Semi-natural grasslands	Juniperus communis formations on heaths or calcareous grasslands (5130)
Karjatamine väljaspool põllumaj. maad	Grassland	Semi-natural grasslands	Grazing outside of agricultural areas
6120	Grassland	Semi-natural grasslands	Xeric sand calcareous grasslands (6120)
1630	Grassland	Semi-natural grasslands	Boreal Baltic coastal meadows (1630)
Rohumaa	Grassland	Semi-natural grasslands	Grassland
6430	Grassland	Semi-natural grasslands	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels (6430)
8240	Grassland	Semi-natural grasslands	Limestone pavements (8240)
6450	Grassland	Semi-natural grasslands	Northern boreal alluvial meadows (6450)
6280	Grassland	Semi-natural grasslands	Nordic alvar and precambrian calcareous flatrocks (6280)

Ecosystem map unit code	1. Ecosystem main class	2. Ecosystem type	3. Map unit
6410	Grassland	Semi-natural grasslands	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae) (6410)
6130	Grassland	Semi-natural grasslands	Calaminarian grasslands of the Violetalia calaminariae (6130)
Põõsastik	Grassland	Shrubbery	Shrubbery
Aianduslik maa	Cropland	Horticultural land	Horticultural land
Lühiajaline rohumaa	Cropland	Crops	Short-term grassland
Mustkesa	Cropland	Crops	Fallow land
Põld	Cropland	Crops	Arable land
Põllukultuurid	Cropland	Crops	Crops
Tagasirajatud rohumaa	Cropland	Crops	Restored grassland
Püsikultuurid	Cropland	Permanent crops	Permanent crops
7230	Wetland	Fens	Alkaline fens (7230)
7160	Wetland	Fens	Fennoscandian mineral-rich springs and springfens (7160)
7210	Wetland	Fens	Calcareous fens with Cladium mariscus and species of the Caricion davallianae (7210)
Madalsoo	Wetland	Fens	Alder-birch (eutrophic-mesotrophic) swamp site type
7220	Wetland	Fens	Petrifying springs with tufa formation (Cratoneurion) (7220)
7140	Wetland	Transition mires	Transition mires and quaking bogs (7140)
Õõtsik	Wetland	Transition mires	Quaking bogs
7120	Wetland	Peat bogs	Degraded raised bogs still capable of natural regeneration (7120)
Laugas	Wetland	Peat bogs	Raised bog pools
3160	Wetland	Peat bogs	Natural dystrophic lakes and ponds (3160)
7110	Wetland	Peat bogs	Active raised bogs (7110)
7150	Wetland	Peat bogs	Depressions on peat substrates of the Rhynchosporion (7150)
Raba	Wetland	Peat bogs	Oligotrophic bog site type
Turbaväli	Wetland	Peat extraction sites	Peat extraction sites
Mahajäetud turbavä	Wetland	Abandoned peatlands	Abandoned peatlands
Haljasala	Artificial area	Green space	Green space
Kalmistu	Artificial area	Green space	Cemetery
Puuderida	Artificial area	Green space	Line of trees
Hoone	Artificial area	Buildings and other facilities	Building
Lennuväli	Artificial area	Buildings and other facilities	Airport
Rööbastee	Artificial area	Buildings and other facilities	Railroads
Sadam	Artificial area	Buildings and other facilities	Port

Ecosystem map unit code	**1. Ecosystem main class**	**2. Ecosystem type**	**3. Map unit**
Spordikompleks	Artificial area	Buildings and other facilities	Area used for sport activities
Tee	Artificial area	Buildings and other facilities	Roads
Tootmisõu	Artificial area	Buildings and other facilities	Production yard
Muu lage	Artificial area	Other artificial areas	Inland habitats with no vegetation
Jäätmaa	Artificial area	Other artificial areas	Wasteland
Elektriliin	Artificial area	Other artificial areas	Power lines
Karjäär	Artificial area	Other artificial areas	Excavation sites
Prügila	Artificial area	Other artificial areas	Landfill
Siht	Artificial area	Other artificial areas	Forest ride
Eraõu	Artificial area	Other artificial areas	Private Yard
1230	Coast	Shores	Vegetated sea cliffs of the Atlantic and Baltic Coasts (1230)
1130	Coast	Shores	Estuaries (1130)
Klibune ala	Coast	Shores	Coastal shingle
Liivane ala	Coast	Shores	Sandy shore
1640	Coast	Shores	Boreal Baltic sandy beaches with perennial vegetation (1640)
1620	Coast	Shores	Boreal Baltic islets and small islands (1620)
1110	Coast	Shores	Sandbanks which are slightly covered by sea water all the time (1110)
1220	Coast	Shores	Perennial vegetation of stony banks (1220)
1150	Coast	Shores	Coastal lagoons (1150)
1310	Coast	Shores	Salicornia and other annuals colonizing mud and sand (1310)
1210	Coast	Shores	Annual vegetation of drift lines (1210)
2110	Coast	Shores	Embryonic shifting dunes (2110)
2140	Coast	Shores	Decalcified fixed dunes with Empetrum nigrum (2140)
2120	Coast	Shores	Shifting dunes along the shoreline with Ammophila arenaria ('white dunes') (2120)
2130	Coast	Shores	Fixed coastal dunes with herbaceous vegetation ('grey dunes') (2130)
3140	Inland waterbodies	Lakes and ponds	Hard oligo-mesotrophic waters with benthic vegetation of Chara spp (3140)
Biotiik	Inland waterbodies	Lakes and ponds	Bio-pond
Järv	Inland waterbodies	Lakes and ponds	Lake

Ecosystem map unit code	1. Ecosystem main class	2. Ecosystem type	3. Map unit
3110	Inland waterbodies	Lakes and ponds	Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae) (3110)
3130	Inland waterbodies	Lakes and ponds	Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoeto-Nanojuncetea (3130)
Paisjärv	Inland waterbodies	Lakes and ponds	Reservoir
3150	Inland waterbodies	Lakes and ponds	Natural eutrophic lakes with Magnopotamion or Hydrocharition - type vegetation (3150)
Tehisjärv	Inland waterbodies	Lakes and ponds	Artificial lake
Tiik	Inland waterbodies	Lakes and ponds	Pond
Kraav	Inland waterbodies	Rivers and streams	Ditch
3260	Inland waterbodies	Rivers and streams	Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260)
Vooluveekogu	Inland waterbodies	Rivers and streams	River/stream/ditch
2190	Other	Other	Humid dune slacks (2190)
Muu	Other	Other	Other
8210	Other	Other	Calcareous rocky slopes with chasmophytic vegetation (8210)
8220	Other	Other	Siliceous rocky slopes with chasmophytic vegetation (8220)
Roostik	Other	Other	Reed bed
Soovik	Other	Other	Moist mesotrophic grassland

ANNEX 5. Comment on the preliminary testing of crosswalking the Estonian ecosystem types with the IUCN Global Ecosystem typology (V1.01)

June 2020, Tallinn

Prepared by Kaia Oras[1], Kätlin Aun[1], Aveliina Helm[2], Liina Remm[2], Ain Kull[2], Tambet Kikas[3], Madli Linder[4], Merit Otsus[5]

[1]Statistics Estonia, [2]University of Tartu, [3]Agricultural Research Centre, [4]The Estonian Environment Agency, [5]The Ministry of the Environment of Estonia

Introduction

In order to create a crosswalk between Estonian ecosystems and IUCN Global Ecosystem Typology, it was first necessary to create a uniform classification of Estonian ecosystems. The extent map of Estonian ecosystems has been compiled using information from different sources, such as information on habitat types, land use and management etc. Thereof ecosystem types were identified from the extent map with the help of experts in the corresponding fields and work undertaken in ELME project[71].

Currently the list of Estonian ecosystem types includes 80 ecosystem types mainly from terrestrial and freshwater and their transitional realms (forests, grasslands, heaths, outcrops, agricultural land, wetlands, coasts, artificial land and inland waterbodies). Further work on marine and inland waterbodies is being carried out under different projects.

The crosswalk between Estonian ecosystems and the IUCN Global Ecosystem Typology (IUCN GET) was done based on experts' opinion regarding the descriptions of Ecosystem Functional Groups (EFG) in The IUCN Global Ecosystem Typology v1.01[72]. Efforts were made to find the best available fit for each ecosystem type within existing ecosystem functional groups. However, in some cases the description of the existing EFG was not befitting even when we followed the general description of the EFG-s and did not consider minor deviations and individual detailed discrepancies with the EFG descriptions as important as to disregard the fit entirely. The comments for these cases are noted in the crosswalk table of accompanying Excel document and discussed below with the suggestions for descriptions and additional groups. The summary of the general fit of the Estonian ecosystem types within the IUCN Global Ecosystem Typology is also given.

Comments

We found that Ecosystem Functional Groups of IUCN GET offers a uniform fit for Estonian ecosystem types for 40% of the cases (32 cases out of 80). When two or more EFG-s were suitable, approximately

[71] „The nation wide assessment and mapping of ecosystem services". Project "Establishment of tools for integrating socioeconomic and climate change data into assessing and forecasting biodiversity status, and ensuring data availability" (ELME) http://www.keskkonnaagentuur.ee/elme

[72] Keith D.A, et al (2020) The IUCN Global Ecosystem Typology v1.01: Descriptive profiles for Biomes and Ecosystem Functional Groups, IUCN CEM, February 2020. https://iucnrle.org/static/media/uploads/references/research-development/keith_etal_iucnglobalecosystemtypology_v1.01.pdf

for 80% (30 cases out of 37) a preference towards one EFG existed (preferred EFG max>=0.6). In total a preferred EFG can be found for 78% of the Estonian ecosystem types.

For 12 cases IUCN GET did not offer means to fully characterize an ecosystem type (grassland types, heathland types, artificial area)

There are 5 cases (~6%) where no dominant EFG is identified, e.g. membership value between two or more candidate EFGs is 0.5/0.5. or 0.4/0.4/0.2. We are interested how to act in these cases and how the decision should be made when one-to-one crosswalk is needed, for example when the extent of ecosystem types is required to be reported using IUCN GET.

Based on our testing results, we give the following suggestions, which are described in more detail below:

- We propose a new EFG "Temperate mixed forests" that accounts forests with mixed canopy composition as well as cases where under one ecosystem type a site of deciduous forest or a site of needle-leaved forest can grow.
- Or as another solution it would benefit us when forests on mineral or organic soil and also on drained organic soil could be distinguished in the typology to better describe the ecological differences.
- We find that an EFG "Boreal forested wetlands" is missing from the typology but is needed.
- We support the idea that a new EFG T7.5 Semi-natural pastures and old fields has been added to the typology.
- We propose to widen the description of T3.3 to also include inland heathlands.
- There should be a way to account drained peatlands in the typology.
- The description of EFG T7.4 should be broadened regarding single large scale technogenic objects/landscapes where human activity is not present continuously.
- We propose a category(ies) "Other(s)" for unidentified areas to be included in the list which may not necessarily be described as an EFG but an additional item needed for statistical purposes.

Forests

IUCN Global Ecosystem Typology does not provide a good way to group Estonian forests. Estonian forests should be classified as T2.1 Boreal and temperate montane forests and woodland or T2.2 Temperate deciduous forests and shrublands but detailed distinction between these is difficult to make because the basis of the classification formations for Estonia and IUCN GET are different. The division between T2.1 and T2.2 is mainly based on canopy composition but the classification in Estonian system is based on soil (i.e. site types) and boreal, broad-leaved, also mixed forests can grow on one soil-type. Rough calculations were made based on the area of forests with main tree species to fit Estonian forest ecosystems under T2.2 and T2.1. Because these areas are changing the link between ecosystem types and IUCN EFG is not constant. To solve this issue of not forcibly grouping deciduous and needle-leaved forests we propose a new EFG "Temperate mixed forests" that accounts forests with mixed canopy composition as well as cases where under one ecosystem type a site of deciduous forest or a site of needle-leaved forest can grow.

Additionally, to support the proposal, the canopy composition in managed forests is determined by man and can be changed rapidly by cuttings and plantings, and therefore is not the same as it would be naturally. Grouping Estonian forest ecosystem types it appeared that the variation within the classes (T2.1 and T2.2) would be large and often larger than between the classes. For example birch and spruce woodlands on fertile mineral soil are more similar to each other than pine forest on deep peat and spruce forest on fertile mineral soil.

Or as another solution it would benefit us when forests on mineral or organic soil and also on drained organic soil could be distinguished in the typology to better describe the ecological differences.

In addition we identified a similar issue in Estonia as Canada indicates in their testing results that there are groups for temperate forests (EFG T2.2) and subtropical/temperate forested wetlands (EFG TF1.2) but there is no equivalent for boreal forests (EFG T2.1) in wetlands biome[73]. While trying to find the best fit, the decision was made to divide the membership value of forested wetlands types (e.g. Mixotrophic and ambrotrophic bog forests, Menerotrophic swamp forests) between groups in forest and wetlands biome but we do not think it is the best solution. A new EFG "Boreal forested wetlands" would give the best fit.

Grasslands and agricultural land

Estonian grasslands are semi-natural and low-intensity anthropogenic maintenance, such as grazing or mowing, is necessary for their existence. Fitting these under EFG T4.5 Temperate grasslands according to the EFG description will not be entirely correct. We find that linking habitat types Fennoscandian wooded pastures (9070) and Fennoscandian wooded meadows (6530) with the description of EFG T4.4 Temperate wooded savannas is also difficult. In the existing classification, these would fit better under T2.1 or T2.2 in the forest biome. We wish European wooded grasslands could be accounted in the typology as a new EFG: "Boreal wooded grasslands".

In the light of this we support the idea that a new EFG T7.5 Semi-natural pastures and old fields has been added to the typology, under which Estonian semi-natural grasslands and wooded pastures and meadows can be generally well- fitted.

Agricultural land can be used as cropland or grasslands and is well described by IUCN GET intensive land use systems. However we would like to point out that not all agricultural land is intensively managed. Distinguishing extensively used agricultural land is important in order not to neglect areas that may have a higher biodiversity.

Heathlands

Estonia has some heathlands and best fit for these is EFG T3.3 Cool temperate heathlands. However, they do not suit entirely to T3.3 and stay partly undescribed in the frame of IUCN GET because they are not in coastal areas in Estonia. To get a better fit we propose to widen the description of T3.3 to also include inland heathlands.

Wetlands

Estonian wetlands can be mostly well fitted under TF1.6 Boreal, temperate and montane peat bogs and/or EFG TF1.7 Boreal and temperate fens. However, due to the majority of Estonian peatlands being

[73] Preliminary exploration of ecosystem classifications proposed for use in ecosystem accounting: Canada's Ecological Land Classification, the USGS World Ecological Zones and IUCN Ecosystem Functional Groups .Prepared for consideration by the SEEA Experimental Ecosystem Accounting Revision 2020. January 2020. Ottawa, Ontario, Canada. Prepared by: Mark Henry, Ann-Helen Jean-Baptiste, Hugo Larocque and François Soulard. Environment Accounts and Statistics Program, Statistics Canada.

drained or influenced by draining, it can be argued that they do not fit the description of natural fens or peat bogs very well as ecological key drivers have changed because of lowered water table. There should be a way to account drained peatlands in the typology.

There is also the question how to fit forested wetlands and additionally forested drained wetlands into the typology which is also addressed under the section of forests in this document.

Artificial areas

Only areas defined as settlements should be fitted under EFG T7.4 Urban ecosystems according to its description. We have a combined ecosystem type of artificial areas which was mainly derived from topographic land use information. The group 'artificial areas' includes different site types such as excavation sites, airports, landfills, ports, sport facilities, roads, production yards etc. Some of these site types belong to the urban system and fit under the description of T7.4, but some may be single objects surrounded by natural ecosystems in which case fitting these under T7.4 is not fully satisfactory solution. It would give a better fit when the description of EFG T7.4 is broadened regarding single large scale technogenic objects/landscapes where human activity is not present continuously.

Inland waterbodies

Estonian lakes were fitted primarily under EFG F2.4 Freeze-thaw freshwater lakes, but they do not fit under the description entirely because lakes are covered with ice but it does not happen constantly every year for 40% or more time of the year, especially when considering recent years. For that reason we had to divide the membership value also between EFG F2.1 Large permanent freshwater lakes and F2.2 Small permanent freshwater lakes.

Unidentified areas

Due to combining different data sources, including topographic map, to create an ecosystem extent map, a so-called left-over category "Unidentified open area" was formed. Its composition is mainly unknown and cannot be identified using available data sources. This category may be ecologically irrelevant but is important in statistical sense when calculating the extent. In this light we propose to include a category(ies) "Other(s)" in the list.

Preliminary testing results of crosswalking the Estonian ecosystem types with the IUCN Global Ecosystem typology (V1.01)

Estonian ecosystem type biome	Estonian Ecosystem Type description	ctional group	T2.1 Boreal and temperate montane forests and woodlands	T2.2 Temperate deciduous forests and shrublands	T3.3 Cool temperate heathlands	T3.4 Rocky pavements, screes and lava flows	T4.4 Temperate wooded savannas	T4.5 Temperate grasslands	T7.1 Croplands	T7.2 Sown pastures and old fields	T7.3 Plantations	T7.4 Urban and infrastructure lands	S1.1 Aerobic caves	TF1.3 Permanent marshes	TF1.6 Boreal, temperate and montane peat bogs	TF1.7 Boreal and temperate fens	F1.1 Permanent upland streams	F1.3 Freeze-thaw rivers and streams	F2.1 Large permanent freshwater lakes	F2.2 Small permanent freshwater lakes	F2.4 Freeze-thaw freshwater lakes	F3.1 Large reservoirs	F3.2 Constructed lacustrine wetlands	F3.4 Freshwater aquafarms	FM1.3 Intermittently closed coastal lagoons	M1.7 Subtidal sandy bottoms	MT1.1 Rocky shores	MT1.2 Muddy shores	MT1.3 Sandy shores	MT1.4 Boulder-cobble shores	MT2.1 Coastal shrublands and grasslands	MFT1.1 Coastal river deltas	Tally check	max	#candidate EFGs	lower bound member-ship value (0-1)	upper bound member-ship value (0-1)	best estimate member-ship value (0-1)	confidence value (0-100)	bounds check	best est check	Notes
Forests	Drained peatland forests		0.5	0.5																													1	0.5	2	0.5	0.5	0.5	100	OK	OK	General comment on forests: Estonian forests should be classified as T2.1 or T2.2 or TF1.2. The division bet
Forests	Mesotrophic boreal forests		0.6	0.4																													1	0.6	2	0.6	0.6	0.6	100	OK	OK	General comment on forests: Estonian forests should be classified as T2.1 or T2.2 or TF1.2. The division bet
Forests	Eutrophic alvar forests and shrublands		0.8	0.2																													1	0.8	2	0.8	0.8	0.8	100	OK	OK	General comment on forests: Estonian forests should be classified as T2.1 or T2.2 or TF1.2. The division bet
Forests	Oligotrophic boreal heath forests		1																														1	1	1	1	1	1	100	OK	OK	General comment on forests: Estonian forests should be classified as T2.1 or T2.2 or TF1.2. The division bet
Forests	Oligo-mesotrophic boreal forests		0.8	0.2																													1	0.8	2	0.8	0.8	0.8	100	OK	OK	General comment on forests: Estonian forests should be classified as T2.1 or T2.2 or TF1.2. The division bet
Forests	Reclamationed pits forest site type		0.7	0.3																													1	0.7	2	0.7	0.7	0.7	100	OK	OK	General comment on forests: Estonian forests should be classified as T2.1 or T2.2 or TF1.2. The division bet
Forests	Oligotrophic paludifying forests		0.9	0.1																													1	0.9	2	0.9	0.9	0.9	100	OK	OK	General comment on forests: Estonian forests should be classified as T2.1 or T2.2 or TF1.2. The division bet
Forests	Menerotrophic swamp forests		0.2	0.4										0.4																			1	0.4	3	0.4	0.4	0.4	100	OK	OK	General comment on forests: Estonian forests should be classified as T2.1 or T2.2 or TF1.2. The division bet
Forests	Eutrophic boreo-nemoral forests		0.2	0.8																													1	0.8	2	0.8	0.8	0.8	100	OK	OK	General comment on forests: Estonian forests should be classified as T2.1 or T2.2 or TF1.2. The division bet
Forests	Mixotrophic and ambrotrophic bog forests		0.8												0.2																		1	0.8	2	0.8	0.8	0.8	100	OK	OK	General comment on forests: Estonian forests should be classified as T2.1 or T2.2 or TF1.2. The division bet
Forests	Eutrophic paludifying forests		0.2	0.8																													1	0.8	2	0.8	0.8	0.8	100	OK	OK	General comment on forests: Estonian forests should be classified as T2.1 or T2.2 or TF1.2. The division bet
Coasts	Coastal shingle																													1			1	1	1	1	1	1	90	OK	OK	
Coasts	Sandy shore																												1				1	1	1	1	1	1	90	OK	OK	
Unidentified c	Unidentified open area									0.2		0.8																					1	0.8	2	0.8	0.8	0.8	50	OK	OK	Specific ecosystem type cannot be identified, left-over category. There should be a place for such left-over
Grasslands	Fennoscandian wooded pastures (9070)						0.3																										0.3	0.3	1	0.3	0.3	0.3	70	OK	OK	Grazed areas with trees and shrubs. Suggestion for a new group: Semi-natural wooded grasslands.
Grasslands	Fennoscandian wooded meadows (6530)						0.3																										0.3	0.3	1	0.3	0.3	0.3	90	OK	OK	Grazed areas with trees and shrubs. Suggestion for a new group: Boreal wooded grasslands
Grasslands	Boreal Baltic coastal meadows (1630)																														1		1	1	1	1	1	1	100	OK	OK	Semi-natural grassland
Heathlands	European dry heaths (4030)				0.7			0.3																									1	0.7	2	0.7	0.7	0.7	90	OK	OK	Heathlands
Grasslands	Juniperus communis formations on heaths or calcareous grasslands (5130)						0.3	0.7																									1	0.7	2	0.7	0.7	0.7	80	OK	OK	Semi-natural grassland alternating with shrubland
Grasslands	Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites) (6210)							0.3																									0.3	0.3	1	0.3	0.3	0.3	100	OK	OK	Semi-natural grassland
Grasslands	Fennoscandian lowland species-rich dry to mesic grasslands (6270)							0.3																									0.3	0.3	1	0.3	0.3	0.3	100	OK	OK	Semi-natural grassland
Grasslands	Nordic alvar and precambrian calcareous flatrocks (6280)							0.3																									0.3	0.3	1	0.3	0.3	0.3	100	OK	OK	Semi-natural grassland
Grasslands	Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae) (6410)							0.3																									0.3	0.3	1	0.3	0.3	0.3	100	OK	OK	Semi-natural grassland
Grasslands	Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels (6430)							0.3																									0.3	0.3	1	0.3	0.3	0.3	100	OK	OK	Semi-natural grassland
Grasslands	Northern boreal alluvial meadows (6450)							0.3																									0.3	0.3	1	0.3	0.3	0.3	100	OK	OK	Semi-natural grassland
Grasslands	Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis) (6510)							0.3																									0.3	0.3	1	0.3	0.3	0.3	100	OK	OK	Semi-natural grassland
Grasslands	Grassland							0.5		0.5																							1	0.5	2	0.5	0.5	0.5	70	OK	OK	Pooled group of open grassland habitats with differing land-use and origin
Grasslands	Limestone pavements (8240)					1																											1	1	1	1	1	1	100	OK	OK	Formations on calcareous bedrock outcrops
Grasslands	Xeric sand calcareous grasslands (6120)				0.2			0.8																									1	0.8	2	0.8	0.8	0.8	80	OK	OK	Rare habitat type in Estonia that is rather considered to match with heathland than grassland
Grasslands	Calaminarian grasslands of the Violetalia calaminariae (6130)							1																									1	1	1	1	1	1	80	OK	OK	Almost non-existent habitat type in Estonia, could be considered as grassland
Outcrops	Calcareous rocky slopes with chasmophytic vegetation (8210)					1																											1	1	1	1	1	1	90	OK	OK	
Outcrops	Siliceous rocky slopes with chasmophytic vegetation (8220)					1																											1	1	1	1	1	1	90	OK	OK	
Outcrops	Caves not open to the public (8310)												1																				1	1	1	1	1	1	100	OK	OK	
Crops	Crops: grassland									1																							1	1	1	1	1	1	100	OK	OK	Intensive use
Crops	Crops								0.8	0.1	0.1																						1	0.8	3	0.8	0.8	0.8	100	OK	OK	
Crops	Permanent crops										1																						1	1	1	1	1	1	100	OK	OK	
Crops	Long-term grassland									1																							1	1	1	1	1	1	100	OK	OK	Can be intensively used.
Crops	Horticultural land										1																						1	1	1	1	1	1	70	OK	OK	Permanent, semi-permanent or cropped agricultural land-use.
Crops	Species-rich long-term grassland							0.5		0.5																							1	0.5	2	0.5	0.5	0.5	70	OK	OK	Less intensive agricultural use, more similar to semi-natural grasslands
Coasts	Boreal Baltic sandy beaches with perennial vegetation (1640)																														1		1	1	1	1	1	1	100	OK	OK	
Coasts	Fixed coastal dunes with herbaceous vegetation ('grey dunes') (2130)																														1		1	1	1	1	1	1	100	OK	OK	
Coasts	Sandbanks which are slightly covered by sea water all the time (1110)																									1							1	1	1	1	1	1	80	OK	OK	Can be perhaps considered also as sandy shores? No tides in Baltic sea!
Coasts	Annual vegetation of drift lines (1210)																												0.2	0.2	0.6		1	0.6	3	0.6	0.6	0.6	80	OK	OK	Divided between different EFG-s according to description of Estonian habitats in Paal 2000.
Coasts	Perennial vegetation of stony banks (1220)																													0.2	0.8		1	0.8	2	0.8	0.8	0.8	80	OK	OK	Divided between different EFG-s according to description of Estonian habitats in Paal 2000.
Coasts	Vegetated sea cliffs of the Atlantic and Baltic Coasts (1230)																										0.2				0.8		1	0.8	2	0.8	0.8	0.8	80	OK	OK	Divided between different EFG-s according to description of Estonian habitats in Paal 2000.
Coasts	Salicornia and other annuals colonizing mud and sand (1310)																											0.5	0.3		0.2		1	0.5	3	0.5	0.5	0.5	80	OK	OK	Divided between different EFG-s according to description of Estonian habitats in Paal 2000.
Coasts	Boreal Baltic islets and small islands (1620)																											0.2	0.2	0.2	0.4		1	0.4	4	0.4	0.4	0.4	80	OK	OK	Divided between different EFG-s according to description of Estonian habitats in Paal 2000.
Coasts	Embryonic shifting dunes (2110)																												0.9		0.1		1	0.9	2	0.9	0.9	0.9	80	OK	OK	Divided between different EFG-s according to description of Estonian habitats in Paal 2000.
Coasts	Shifting dunes along the shoreline with Ammophila arenaria ('white dunes') (2120)																												0.8		0.2		1	0.8	2	0.8	0.8	0.8	80	OK	OK	Divided between different EFG-s according to description of Estonian habitats in Paal 2000.
Coasts	Decalcified fixed dunes with Empetrum nigrum (2140)																												0.2		0.8		1	0.8	2	0.8	0.8	0.8	80	OK	OK	Divided between different EFG-s according to description of Estonian habitats in Paal 2000.
Coasts	Coastal lagoons (1150)																								1								1	1	1	1	1	1	80	OK	OK	Divided between different EFG-s according to description of Estonian habitats in Paal 2000.
Heathlands	Dry sand heaths with Calluna and Empetrum nigrum (2320)				0.3																												0.3	0.3	1	0.3	0.3	0.3	50	OK	OK	Do not suit well to T3.3, not in coastal areas in Estonia
Heathlands	Inland dunes with open Corynephorus and Agrostis grasslands (2330)				0.3																												0.3	0.3	1	0.3	0.3	0.3	50	OK	OK	Do not suit well to T3.3, not in coastal areas in Estonia
Water bodies	Natural dystrophic lakes and ponds (3160)														0.6						0.4												1	0.6	2	0.6	0.6	0.6		OK	OK	
Wetlands	Active raised bogs (7110)														1																		1	1	1	1	1	1		OK	OK	
Wetlands	Degraded raised bogs still capable of natural regeneration (7120)														1																		1	1	1	1	1	1		OK	OK	
Wetlands	Transition mires and quaking bogs (7140)														0.6	0.4																	1	0.6	2	0.6	0.6	0.6		OK	OK	
Wetlands	Depressions on peat substrates of the Rhynchosporion (7150)														1																		1	1	1	1	1	1		OK	OK	
Wetlands	Fennoscandian mineral-rich springs and springfens (7160)															0.9	0.1																1	0.9	2	0.9	0.9	0.9		OK	OK	
Wetlands	Calcareous fens with Cladium mariscus and species of the Caricion davallianae (7210)															1																	1	1	1	1	1	1		OK	OK	
Wetlands	Petrifying springs with tufa formation (Cratoneurion) (7220)															0.9	0.1																1	0.9	2	0.9	0.9	0.9		OK	OK	
Wetlands	Alkaline fens (7230)															1																	1	1	1	1	1	1		OK	OK	
Wetlands	Eutrophic to meso-eutrophic (minerotrophic) fens															1																	1	1	1	1	1	1		OK	OK	
Wetlands	Abandoned peatlands														1																		1	1	1	1	1	1		OK	OK	Abandoned peatlands
Wetlands	Peatland, extraction site														0.9	0.1																	1	0.9	2	0.9	0.9	0.9		OK	OK	
Urban	Urban grey space											1																					1	1	1	1	1	1	100	OK	OK	Urban
Urban	Urban green space											1																					1	1	1	1	1	1	100	OK	OK	Urban
Artificial areas	Artificial areas											0.7																					0.7	0.7	1	0.7	0.7	0.7	100	OK	OK	The land use group of artificial areas includes different site types such as excavation sites, airports, landfills,
Water bodies	Artificial water bodies																						1										1	1	1	1	1	1	100	OK	OK	Artificial wetlands
Coasts	Estuaries (1130)																															1	1	1	1	1	1	1	100	OK	OK	Only one region in Estonia (Kasari estuary)
Water bodies	Oligotrophic waters containing very few minerals of sandy plains (Littorelletalia uniflorae) (3110)																			0.4	0.6												1	0.6	2	0.6	0.6	0.6	80	OK	OK	Difficult to find the right EFG. Some years not under ice for 40% of the time, sometimes less.
Water bodies	Oligotrophic to mesotrophic standing waters with vegetation of the Littorelletea uniflorae and/or of the Isoeto-Nanojuncetea (3130)																			0.4	0.6												1	0.6	2	0.6	0.6	0.6	80	OK	OK	Difficult to find the right EFG. Some years not under ice for 40% of the time, sometimes less.
Water bodies	Hard oligo-mesotrophic waters with benthic vegetation of Chara spp (3140)																			0.4	0.6												1	0.6	2	0.6	0.6	0.6	80	OK	OK	Difficult to find the right EFG. Some years not under ice for 40% of the time, sometimes less.
Water bodies	Natural eutrophic lakes with Magnopotamion or Hydrocharition -type vegetation (3150)																			0.4	0.6												1	0.6	2	0.6	0.6	0.6	80	OK	OK	Difficult to find the right EFG. Some years not under ice for 40% of the time, sometimes less.
Water bodies	Water courses of plain to montane levels with the Ranunculion fluitantis and Callitricho-Batrachion vegetation (3260)																	1															1	1	1	1	1	1	100	OK	OK	
Water bodies	Lakes																		0.2	0.2	0.6												1	0.6	3	0.6	0.6	0.6	80	OK	OK	Difficult to find the right EFG. Some years not under ice for 40% of the time, sometimes less.
Water bodies	Reservoir																					0.5	0.5										1	0.5	2	0.5	0.5	0.5		OK	OK	
Water bodies	Artificial water bodies																						1										1	1	1	1	1	1	100	OK	OK	Artificial wetlands
Water bodies	Small lakes																						0.9	0.1									1	0.9	2	0.9	0.9	0.9		OK	OK	Artificial wetlands, some used for aquafarming
Water bodies	Rivers																	1															1	1	1	1	1	1	100	OK	OK	

ANNEX 6. Details of data sources and accompanying attributes for the data used in order of compiling ecosystem unit map.

Priority refers to ordering, how data layers were prioritized in case of overlaps

Priority	Data	Source	Classification	Number of classes	Data Type	Date accessed	Link
1	Agricultural land and semi-natural habitats (Support bases)	Estonian Agricultural Registers and Information Board	Original/local	8	Vector	21.01.2020	https://kls.pria.ee/kaart/
2	Forest types	Forest registry of Estonia	Original/local	32	Vector	02.02.2020	https://register.metsad.ee/#/
3	Wetlands	Estonian Nature Foundation	Natura 2000 habitats	57	Vector	23.01.2020	EELIS (Eesti Looduse infosüsteem – Keskkonnaregister): Keskkonnaagentuur
4	Semi-natural habitats which are eligible for support	Estonian Nature Information System	Natura 2000 habitats	15	Vector	21.01.2020	EELIS (Eesti Looduse infosüsteem – Keskkonnaregister): Keskkonnaagentuur
5	Natura 2000 habitats (Annex I habitats)	Estonian Nature Information System	Natura 2000 habitats	60	Vector	23.01.2020	EELIS (Eesti Looduse infosüsteem – Keskkonnaregister): Keskkonnaagentuur
6	Meadows	Estonian Seminatural Community Conservation Association	Natura 2000 habitats	12	Vector	23.01.2020	EELIS (Eesti Looduse infosüsteem – Keskkonnaregister): Keskkonnaagentuur
7	Estonian Topographic Database	Land Board of Estonia	Original/local	34	Vector	03.01.2020	https://geoportaal.maaamet.ee/est/Ruumiandmed/Eesti-topograafia-andmekogu-p79.html

ANNEX 7. Willingness to pay questionnaires

7.1. WTP questionnaire for forests

……. conducts a study on forest ecosystem services. The aim of the study is to find out the demand of the Estonian population for the forest protected from clear-cutting and its ecosystem services. In addition, we also ask for the demographics of the respondents so that generalizations can be made. The survey is anonymous and its results are used only in a generalized form.

Before answering the questions, please read the information about the Estonian forests.

Estonia is geographically located in a forest zone. Therefore, many of the natural biological species living in Estonia are historically related to the forest in its natural state, where forest parts of different ages and containing different tree species are located close to each other.

The share of forested land in the territory of Estonia is almost 50 percent, but the share of old forests, which are valuable habitats, has been constantly decreasing in recent decades as a result of intensive management. Some forest types that are particularly valuable as habitats for the species (eg old spruces) are almost extinct or disappearing. Protecting forests of economic value is often difficult and meets with opposition by forest owners. The reason for this situation is the lack of compensation systems for lost income that would satisfy forest owners.

A situation is developing in which Estonia is unable to preserve forests for future generations and also to fulfill its obligations to the European Union for the protection of valuable forest habitats. In order to sustainably preserve the species richness associated with forest habitats, the share of protected forests should be 25 percent of the total forest area, according to some natural scientists (eg Matti Masing). It is quite obvious that the current situation is unsatisfactory in terms of biodiversity and does not guarantee the sustainable existence of valuable forest habitats and associated species.

So far, it has not been studied what Estonian inhabitants think about restricting economic activities in forests, taking old forests under nature protection and what is the population's demand for forest ecosystem services. This questionnaire has been developed to find it out.

Please answer following questions about the Estonian forests!

1. How often do you go to the forest?

at least once a week once a month once a year I do not go to the forest

☐ ☐ ☐ ☐

2. Do you think that forests are being cut down in Estonia

too much optimally too few

☐ ☐ ☐

3. Which should be the main goal of forest management

economic benefit good state of the environment creation of recreational opportunities

☐ ☐ ☐

4. **Do you think that the area of forests under nature protection in Estonia is**

too small optimal too big

☐ ☐ ☐

5**. Should the state compensate the forest owner for the lost economic income due to nature conservation restrictions?**

certainly should should not I do not know

☐ ☐ ☐

6. The following is a list of important ecosystem services provided by forests. Please rank them according to how important one or another service is to you by writing the numbers in the boxes after the services (1- most important, 5-least important).

a) Ensuring landscape diversity ☐
b) Providing recreation and leisure opportunities ☐
c) Habitat supply for biological species ☐
d) Climate regulation (carbon sequestration) ☐
k) Supply of mushrooms and berries ☐

7. If you think that part of the Estonian forest should be protected from clear-cutting, where the services of the forest ecosystem can be expressed, then how much would you personally be willing to pay for it per year?

NB! Although the answer does not require actual payment, please try to answer as faithfully as possible and within your financial means.

I would agree to pay for the maintenance of a forest protected from clear-cutting ……… Euros per year.

Now some questions about you:

GENDER (please underline your answer):
man
woman

EDUCATION (please underline your answer):

basic (incl. initial)
secondary
higher

AGE (please underline your answer):

18-23
24-29
30-39
40-49
50-59
60-69
üle 70

AVERAGE MONTHLY INCOME (NET) (in EUR) (please underline your answer):

less than 500
501-800
801-1000
1001-1300
1301-2000
over 2000

Thank you for completing the questionnaire!

7.2. WTP questionnaire for wetlands

… .. carry out a study on the value of bog ecosystem services. The aim of the study is to find out the demand of the Estonian population for the preservation and restoration of bogs and for the services of the bog ecosystems. In addition, we also ask for the demographics of the respondents so that generalizations can be made. The survey is anonymous and its results are used only in a generalized form.

Before answering the questions, please read the information about Estonian bogs.

Bogs began to form in Estonia immediately after the ice receded 11 thousand years ago. Thus, the bogs are as old as Estonia's first inhabitants, hunters and fishermen. For centuries, people in Estonia have been related with swamps, fighting against them and draining them. But bogs have been also as a refuge from the enemy. Herbs and berries have been obtained from bogs throughout the ages, many legends and folklore are associated with swamps, and swamps have given substance to writers and artists. At present, people moving in nature come into contact with bogs mainly on hiking trails built in the bogs by the State Forest Management Center (RMK), for example, the nature trail through Viru bog is visited by thousands of people a year.

However, the value of the bog is not only to offer nature experiences, recreational opportunities and cranberries. Bogs are also valuable and complex ecosystems, huge reservoirs of clean water, oxygen producers and carbon sink, which is particularly important in the fight against global warming.

However, bogs are not always valued, in different periods of history they have seen as wasted land that must be reclaimed for agriculture and forestry. Especially during the period of large-scale agriculture in the Soviet Union, an extensive land improvement program was launched, as a result of which the area of bogs decreased more than three times, However, the drained bogs did not become a fertile field or a timber productive forest, they only became wasted peat area, from which huge amounts of greenhouse gas carbon dioxide began to be released into the atmosphere. Thus, the restoration of bogs, which started at the national level in 2016, is especially important for slowing down global warming. Restoration of bogs consists of filling the former drainage ditches and building dams to stop the outflow of water from the bog. The matter of swamp restoration is to restore the natural situation that existed before the drainage. To date, 1,200 hectares of marshes have been restored in Ida-Virumaa, and at least 6,000 hectares are planned to be restored in the coming years. When ditches are closed, bog ecosystems do not recover immediately, but over many years. The maintenance and restoration of bogs is costly and in some cases hinders forestry, but is of great importance from the point of view of climate, global conservation, habitats and also recreation.

If you are interested in the future of Estonian bogs and the ecosystem services offered by bogs, then please answer the following questionnaire.

1**. How often do you go to the bog (for example, on the hiking trail of Viru bog, etc.)?**

at least once a week ☐ once a month ☐ once a year ☐ never ☐

2**. Do you think that the area of bogs currently being restored in Estonia is**

too small ☐ sufficient ☐ too large ☐

3. Which is most important to you in the preservation and restoration of bogs?

economic benefit ☐ good condition of the environment ☐ creation of recreation opportunities ☐

4. The following is a list of important ecosystem services provided by bogs. Please rank them according to how important one or another service is to you by writing the numbers in the boxes after the services (1- most important, 10-least important).

a) Ensuring landscape diversity ☐
b) Providing opportunities for environmental education ☐
c) Providing recreation and leisure opportunities ☐
d) Habitat supply for biological species ☐
e) Urban microclimate regulation and carbon sequestration ☐
f) Maintaining clean water resources ☐
g) Air and water purification ☐
h) Photosynthesis (oxygen production) ☐
i) Provision of genetic and resources and medicinal plants ☐
k) Provision of berries, mushrooms and other bog products ☐

5. **If you think that existing bogs in Estonia should be preserved and drained bogs restored so that ecosystem services can be expressed there, then how much would you personally be willing to pay for it per year?**

NB! Although the answer does not require actual payment, please try to answer as faithfully as possible and within your financial means.

I would agree to pay for the maintenance and restoration of the bogs (please underline your answer)

0 € /per year	1€/per year	5€/per year	10€/per year
15€/per year	30€/per year	50€/per year	more than 50€/per year

Now some questions about you:

GENDER (please underline your answer):
man
woman

EDUCATION (please underline your answer):

basic (incl. initial)
secondary
higher

AGE (please underline your answer):

18-23
24-29
30-39
40-49
50-59
60-69
üle 70

AVERAGE MONTHLY INCOME (NET) (in EUR) (please underline your answer):

less than 500
501-800
801-1000
1001-1300
1301-2000
over 2000

Thank you for completing the questionnaire!

7.3. WTP questionnaire for urban ecosystems

.... is conducting a study on the socio-economic value of urban green spaces. The aim of the study is to find out the population's monetary demand for urban green spaces and the ecosystem services they provide. The questionnaire below has been prepared for this purpose. In addition, we also ask for the demographic data of the respondents so that generalizations can be made. The survey is anonymous and its results are used only in a generalized form.

Before answering the questions, please read the information about the green areas of the city.

Green spaces are invaluable in creating the identity of cities and ensuring the quality of the living environment. Is it possible to imagine Tallinn without Kadriorg, Tartu without Toomemäe or Pärnu without the beach park? With this in mind, we understand the important role that green spaces play in shaping the unique urban environment as well as in the everyday life of urban inhabitants. The green areas provide shade, recreational and sports opportunities for both children and adults. In addition, green spaces improve the urban environment by reducing noise, cleaning the air and providing habitat for birds and squirrels.

Urban green spaces are very diverse, including urban forests, such as Stroomi Forest, Nõmme Forest, Pirita Forest; parks such as Kadriorg and Glehn Park; smaller green areas in the city center, such as Tammsaare Park, Police Garden and Deer Park. In addition, the city's green areas include formations with a smaller area than parks, such as lawns and alleys formed by rows of trees, lawns separating traffic lanes and flower beds. The city's green areas are not limited to public space, but also include gardens belonging to private houses (for example, the Nõmme and Pirita districts in Tallinn). In short, when driving around the city or walking, a person is exposed to landscaping almost all the time. Landscaping is such a natural part of urban space that it is often overlooked. However, you will definitely notice and react when the trees are removed or on the green area is being built.

Although the existence of green spaces in cities seems to be taken for granted, green spaces in public spaces do not arise or persist in themselves, but require constant maintenance, which is financed from the city budget. Green areas also need protection, because land in the city is expensive and the pressure from real estate developers to build green areas is strong. With the mandate of the residents, the city authorities must prevent it and ensure the preservation of green areas and their remaining in public use.

The study on the socio-economic value of city green areas, of which this questionnaire is a part, will help to identify the role of urban green spaces and the monetary value of the ecosystem services they provide. However, the recognized value is the best guarantee for the sustainability of city green spaces.

Please fill in this questionnaire!

1. How often do you visit the green areas of the city?

almost every day ☐ at least once a week ☐ once a month ☐ I do not visit green areas ☐

2. Do you think that there are green areas in Estonian cities

too many ☐ optimally ☐ too few ☐

3. If you think that there are too few green spaces, what types of green spaces should be added as a matter of priority?

parks ☐ lawns and flower buds ☐ gardens ☐ tall landscaping and alleys ☐

4. Do you consider it permissible to build houses in public green areas?

certainly not ☐ yes, if the buildings are beautiful ☐ yes, if the developer pays the city enough ☐

5. The following is a list of different green areas in Tallinn. Please rank them according to how important one or another type of green area is to you by writing the numbers in the boxes after the services (1- most important, 7-least important).

a) Big parks (e.g. Kadriorg, Glehni park) ☐
b) Small parks in the City centre (e.g. Tammsaare park, Hirvepark) ☐
c) Tall landscaping (trees, alleys) by the road ☐
d) Lawn strips by the road and between lanes (e.g. Sõpruse av.) ☐
e) Lawn strips and flower pots by the sidewalks ☐
f) Privately owned gardens (näit Nõmmel, Meriväljal) ☐
g) Forests within the city borders (e.g. Nõmme forest, Stroomi forest) ☐

6. The following is a list of important ecosystem services provided by urban green areas. Please rank them according to how important one or another service is to you by writing the numbers in the boxes after the services (1- most important, 10-least important).

e) Ensuring the diversity of urban space ☐
f) Providing opportunities for environmental education ☐
g) Providing recreation and leisure opportunities ☐
h) Habitat supply for biological species (e.g. birds) ☐
i) Urban microclimate regulation and carbon sequestration ☐
j) Providing shade for people (e.g. from wind and sun) ☐
k) Traffic noise reduction ☐
l) City air purification ☐
m) Photosynthesis (oxygen production) ☐
n) Offering aesthetic pleasure (flower buds, alleys) ☐

7. If you think that green spaces in Estonian cities are important and you consume the services of urban green space ecosystems, how much would you personally be willing to pay for the preservation and maintenance of urban green spaces per year?

NB! Although the answer does not require actual payment, please try to answer as faithfully as possible and within your financial means.

I would agree to pay for the preservation and maintenance of urban green spaces (please underline your answer)

0 € /per year	1€/per year	5€/per year	10€/per year
15€/per year	30€/per year	50€/per year	more than 50€/per year

Now some questions about you:

GENDER (please underline your answer):
man
woman

EDUCATION (please underline your answer):

basic (incl. initial)
secondary
higher

AGE (please underline your answer):

18-23
24-29
30-39
40-49
50-59
60-69
üle 70

AVERAGE MONTHLY INCOME (NET) (in EUR) (please underline your answer):

less than 500
501-800
801-1000
1001-1300
1301-2000
over 2000

Thank you for completing the questionnaire!