Statistics Estonia

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Development of environmental accounts

Activity 2. Developing and refining ecosystem accounts

D1.8 Description of the methodology for advancing ecosystem accounts, methodology

Methodological report

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1 Introduction

Current methodological report outlines the work carried out under Activity 2. Developing and refining ecosystem accounts. The main goal of this activity (activity 2) was the development and refining of ecosystem accounts. One of the main expected outcomes was that the proposed Eurostat module for the ecosystem accounts would be tested. Another goal was to contribute to the development of the nationwide system, which would provide desired outputs for the planned new module of ecosystem accounts under the regulation 691/2011. Work on the condition account is presented as a separate deliverable (D1.7 Description of the feasibility of compilation of the ecosystem condition accounts) but for the sake of integrity and cross references, condition account is also included in this deliverable.

Work on ecosystem accounts in Estonia started under Eurostat grants already in 2019. Ecosystem accounts were now developed further by widening the scope to comply with the needs of upcoming amendment of regulation 691/2011 regarding the introduction of the new module on ecosystem accounting. Planned components of ecosystem accounts in the new module which have been proposed as an amendment under the regulation 691/2011 were tested.

In order to test the the new planned ecosystem account, analysis on the scope of statistics of Eurostat's proposal for legal base was first carried out. The scope, methodologies and definitions were regularly discussed and refined on Eurostat Task Force of Ecosystem Accounting. In addition to the already arranged work on compilation of the ecosystem extent account (closing stock 2020 and 2021) new activities related to the testing of EU typology, which included conversion from national typology to EU typology, filling in reporting tables on ecosystem extent, analyzing and compiling the methodology for the ecosystem services and condition components were carried out. Respective subchapters provide the results and observations.

Valuation of ecosystem services included both biophysical and monetary assessment. The range of the services were selected based on the proposed amendment to EU Regulation 691/2011. The methodologies for biophysical assessment were mainly based on the guidance notes prepared by Eurostat. The methods for biophysical and monetary valuation of the ecosystem services were applied and supply and use account was compiled based on the results obtained. Advice and consultation on valuation methods for ecosystem services and quality insurance of the compiled accounts was essential. National experts were consulted to integrate the knowledge generated in the field of ecosystem services valuation in Estonia for assessments in both physical and monetary terms. The analyses and interpretation of the results by the experts who are experienced and qualified on international level but also in Estonia on national scale on current issues was needed and useful.

It was initially foreseen to attempt to compile an opening stock for ecosystem condition account in sense of SEEA EA draft table 5.4. During the project the scope of the condition accounts and included indicators changed due to the development of the proposal for amendment of regulation EU 691/2011 and the advancements of the work in Eurostat Task Force. The grant agreement was amended, and the proposed ecosystem condition account of the ecosystem accounts proposal was tested instead. Defining the scope of the foreseen work and also the compilation of ecosystem condition account comprised a lot of co-operation with other institutions in Estonia.

While testing the feasibility to produce ecosystem accounts, Statistics Estonia contributed to the work of the Eurostat Task Force on Ecosystem Accounts. The experiences and knowledge gained in testing were communicated to the Task Force. In addition to Statistics Estonia's involvement in the Task Force, Estonia's partners were also involved with discussions and comments.

The analysis of the possible outputs (indicators) of ecosystem accounting was carried out as much as possible and was considered useful. Work carried out is described in respective subchapter.

The main international partner in the development of the ecosystem accounts was Statistics Netherlands. The cooperation covered the advice on valuation methods for ecosystem services, the compilation of the ecosystem services supply and use, approaches for the condition indicators, quality insurance of the compiled accounts and the sharing the knowhow on setting up a system for regular data production. A study visit was organized to Statistics Netherland where among other topics (related to other activities of the grant) advancement of ecosystem accounts and problems were handled.

Statistics Estonia worked together with Estonian partners for establishing partner-inclusive system for national ecosystem accounting. The work focused on the new proposed module of ecosystem accounts and the design of the potential regular cooperation for the compilation of ecosystem accounts in Estonia was initiated. Main partners are Estonian Environment Agency, Environmental Ministry but also other ministries as stakeholders, agencies providing relevant information and scientific institutions (universities, experts) contributing with knowledge. At the end of the project seminar involving all partners was organized where all main project achievements were presented and at the end of the session, a panel was organized to discuss the results and development of the system for ecosystem accounting where main partners, main bottlenecks and opportunities, also the alignment and use of ecosystem accounts in policy were discussed. The logic of the partnership is described in respective subchapter.

Statistics Estonia has devoted energy for making the knowledge gained available to others as well. Statistics Estonia has contributed to the work of the 28th meeting of the UN Environmental Accounts London Group[1] submitting and discussing the outputs of the methodological work on ecosystem services on nature recreation in 2022 and participating in the panel for discussing output indicators based on ecosystem accounting. In late 2021 Statistics Estonia discussed on the 27th[2] UN Environmental Accounts London Group meeting the methodological articles on nature education ecosystem service and the one on compilation of the aggregated indicator (GEP) based on ecosystem services. Statistics Estonia has presented the work and shared the experience gained on international methodological seminars: Workshop on ecosystem accounts and land accounts in Eurostat[3] in 2022 and also in Joint OECD-UNECE Seminar on the Implementation of the SEEA[4] in 2023.

Statistics Estonia participated on MAIA seminars organized virtually on relevant topics and on the final physical conference[5] to discuss the valuation issues and indicators derived from ecosystem accounts.

Statistics Estonia provided the consultation to the Statistical Office of Slovenia on the compilation and methodologies on ecosystem accounts. The consultation, however, was not covered with the finances of the current grant.

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1 https://seea.un.org/events/london-group-environmental-accounting-28th-meeting
2 https://seea.un.org/events/london-group-environmental-accounting-27th-meeting
3 (26.01.2022)
4 https://unece.org/statistics/documents/2023/03/presentations/ecosystem-accounts-estonia-progress-so-far
5 https://maiaportal.eu/storage/app/media/maia-final-project-conferenceupdatedv6.pdf

2 Ecosystem extent

2.1 Overview of ecosystem extent account compilation for 2020 and 2021

Ecosystem extent accounts are the cornerstone for ecosystem accounting as this account is basis for the compilation of ecosystem services and ecosystem condition accounts. During this grant the ecosystem extent accounts were compiled for years 2020 and 2021. Compilation of these accounts was based on the experience and knowledge obtained from previous projects (831254 — 2018-EE-ECOSYSTEMS[6] and 881542 — 2019-EE-ECOSYSTEMS[7]) where accounts were developed as fully spatial approach - a GIS based opening extent accounts for years 2018 and 2019. Often key decision is if a vector or raster ecosystem extent maps are produced. In our case, we have chosen a vector approach (throughout 2018-2021 for extent accounts) as vector maps are better in dealing with linear landscape elements and hence data isn't dependent on grid size thereby giving higher geographic accuracy.

For ecosystem extent maps (for years 2020 and 2021), we used same methods as in previous projects where the Estonian topographic database[8] served as a basis for the creation ecosystem extent 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 (e.g., overlapping) but also making some records outdated. Therefore, it was questionable what the actual state of these older records is. Therefore, also in current grant we used a decision tree in order decide prioritization of the different data layers when overlaps did occur between two or more detailed data layers.

For both years we preferred and therefore gave more weight to data layers which were most up to date and likely more precisely mapped (due to local inventories). Different data sources reflect their status based on access date (ANNEX 5). Main 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 and this got the highest priority. In this dataset only the lands which are under support bases are 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

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[6] 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/2021-07/Methodological%20report_831254_2018_EE_ECOSYSTEMS_revised_version_31_03%20%281%29.pdf

[7] Statistics Estonia, 2021. Development of the ecosystem accounts (Eurostat Grant Agreement NUMBER — 881542— 2019-EE-ECOSYSTEMS) https://www.stat.ee/sites/default/files/2021-07/D1.1%20Final%20methodological%20report_July_2021.pdf

[8] Estonian Land Board, https://geoportaal.maaamet.ee/est/Ruumiandmed/Eesti-topograafia-andmekogu-p79.html

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[9]). 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 mainly obtained from Estonian Fund for Nature (ELF). 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 consists of spatial information about Estonia's semi-natural habitats which are eligible to support, and it was obtained from Estonian Environment Agency. Similarly, to previous datasets, most of the data is within ten years' time frame and uses Natura 2000 habitat types 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 therefore questionable, what is the actual state of these 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 neighbouring polygons within the dataset.

5. Natura 2000 habitats

This dataset consists 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 yearly. 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 neighbouring polygons within the dataset.

6. Meadows

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[9] Lõhmus, E. 1984. Eesti metsakasvukohatüübid. Lisad, tabel 1. Metsamuldade klassifikatsiooniüksused ja nendele vastavad kasvukohatüübid

This dataset consists 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 of 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 neighbouring polygons within the dataset.

Our methods for ecosystem extent map compilation follow the proposed principal steps in Iterative classification process as suggested in guidance note for ecosystem extent accounts[10]. By defining priority orderings, it ensures that area once classified as such cannot become a something else later in the classification process, which ensures that classification will be mutually exclusive and exhaustive.

We did a manual verification on the combined dataset and decided that some classes: the roads, inland waters, peatlands, quarries, and private yards needed to separately overlay with combined 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, 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 forests.

Merging different data layers into one layer creates additional artifacts (sliver polygons) due to fact that different ecosystem assets borders do not coincide with each other perfectly. Therefore, to simplify the combined dataset, it was first decided to apply “circle method”. In other words, if 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 result was still not satisfactory and had some drawbacks, we separately dealt ecosystem assets which were relatively “narrow” and at the same time relatively long causing sometime remarkable polygon area (sliver polygons). Using polygon buffering tool, we decided to test most of the ecosystem assets based on formula: log (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 then subdivided into 20x20 meters grids and randomly merged to neighboring polygons within the dataset. For the last step we excluded urban areas as whole 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 around 80% of ecosystem accounting area for both years. For the remaining 20% of the area, Estonian Topographic Database was the only source of information we could use.

For the year 2020, final ecosystem extent map consisted of ca. 4.6 million polygons covering 126 different mapping units (ANNEX 5). Altogether, area of 43 465 km2 (whole Ecosystem accounting area

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[10] Eurostat – Unit E2. Guidance note on ecosystem extent accounts - final draft version. Revised based on outcomes of the test in Q4 2022. Version February 2022

without lakes Võrtsjärv and Peipsi järv) was mapped (Figure 1). The forest land covered most of the Estonia (54.8%) followed by cropland (19.3%), grassland (11.7%), wetland (6.4%), artificial area (5.7%), inland waterbodies (2%), other and coast both (< 0.1%).

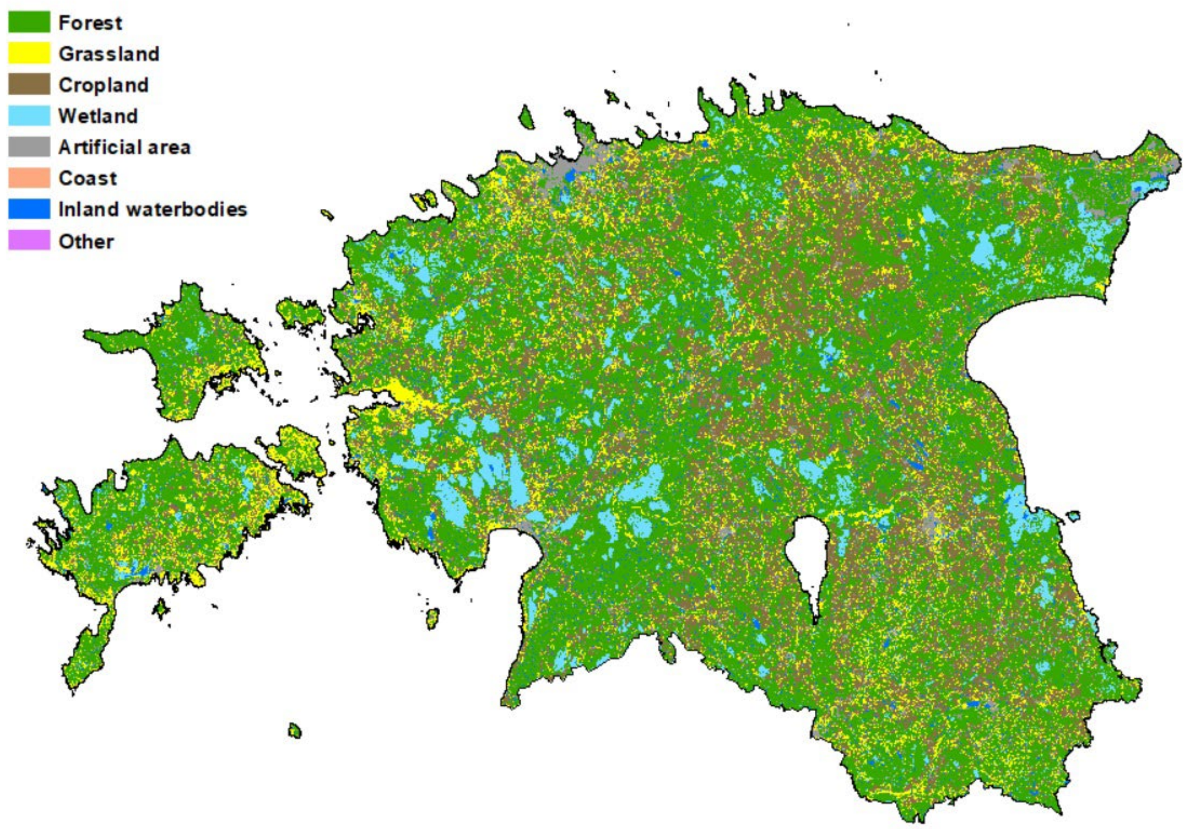

Figure 1. Estonian ecosystem extent map aggregated to main ecosystem types for year 2020

For the year 2021, final ecosystem extent map consisted also of ca. 4.6 million polygons covering 126 different mapping units (ANNEX 5). Altogether, area of 43 465 km2 (whole Ecosystem accounting area without lakes Võrtsjärv and Peipsi järv) was mapped (Figure 2). As expected, the forest land covered most of the Estonia (54.9%) followed by cropland (19.3%), grassland (11.5%), wetland (6.3%), artificial area (5.8%), inland waterbodies (2%), other and coast both (< 0.1%).

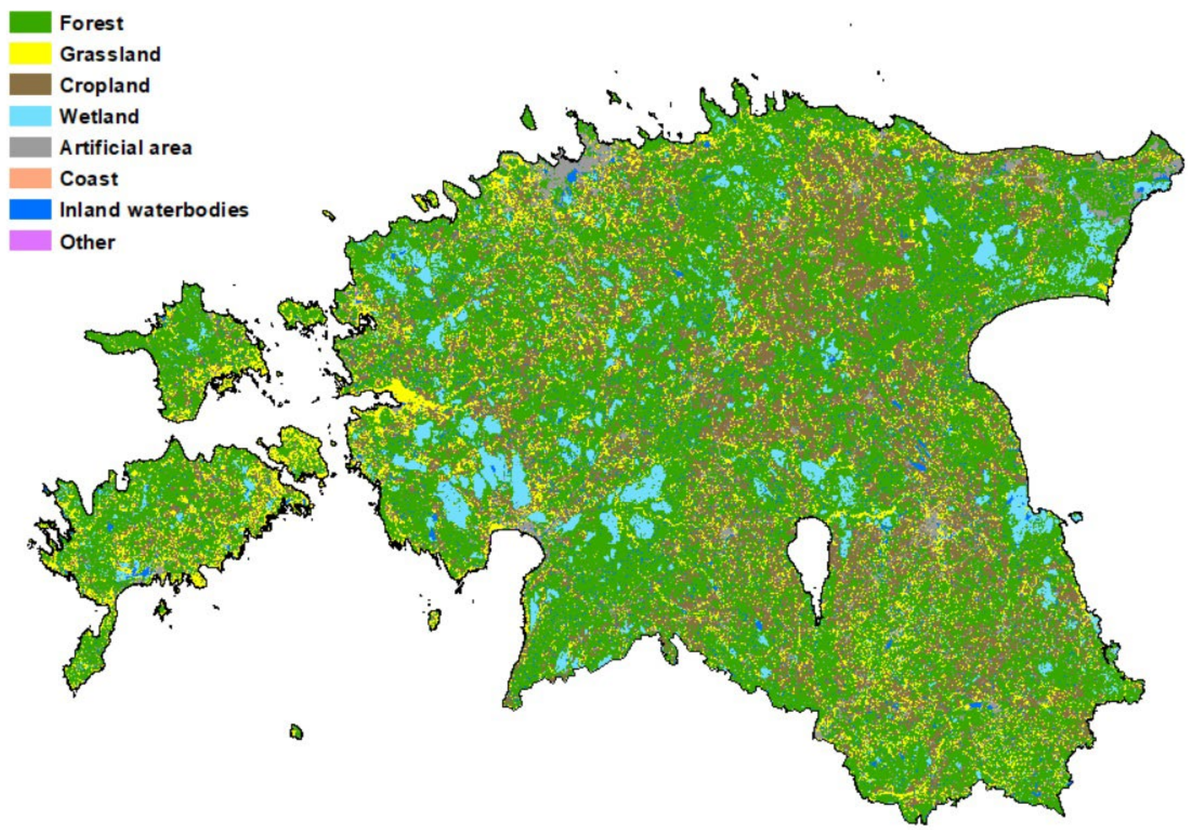

Figure 2. Estonian ecosystem extent map aggregated to main ecosystem types for year 2021

Results of the extent account for both years are also included in excel format in project deliverable D1.5. Dataset on ecosystem extent account 101022852_2020-EE-ENVACC.

Similarly, to compiled previous ecosystem accounts (831254 — 2018-EE-ECOSYSTEMS[11] and 881542 — 2019-EE-ECOSYSTEMS[12]) one of the tasks was adding an ownership dimension to extent account linking ecosystem assets 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 tested for both years by using ecosystem extent map of corresponding year and by adding an owner's dimension.

In order to determine the institutional sector and economic activity of the landowner we primarily used information from Land Register. 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 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 or SPI information the State Forest Management Centre information

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[11] 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/2021-07/Methodological%20report_831254_2018_EE_ECOSYSTEMS_revised_version_31_03%20%281%29.pdf

[12] Statistics Estonia, 2021. Development of the ecosystem accounts (Eurostat Grant Agreement NUMBER — 881542— 2019-EE-ECOSYSTEMS) https://www.stat.ee/sites/default/files/2021-07/D1.1%20Final%20methodological%20report_July_2021.pdf

was used if available. 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 was selected. 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. Ecosystem types, classified by NACE and institutional sector categories can be seen in Table 1 and Table 2.

For the year 2020, the owner of most (55%) of the ecosystems are non-financial corporations (Table 1a). They own also more than half of forest extent (67%), wetlands (82%), coasts (59%) and inland waterbodies (57%). Second largest owner are households (36% of total extent) and they own more than half of grass- and croplands (58% of total grasslands and 57% of 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 81.5% 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 (58 % of corporations total cropland extent). Results are presented in Table 5.

For the year 2021, also owner of most (55%) of the ecosystems are non-financial corporations (Table 1b). Similarly, to year year 2020, they own also more than half of forest extent (67%), wetlands (82%), coasts (61%) and inland waterbodies (57%). Second largest owner are households (36% of total extent) and they own more than half of grass- and croplands (57% of total grasslands and 56% of 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 4. The biggest extent of corporation's cropland is allocated under crop and animal production activity (58 % of corporations total cropland extent). Results are presented in Table 6.

Table 1. Opening extent account (2020), classified by most 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		1 600 276	141 802	282 392	226 932	75 304	1 795	49 785	2 114	2 380 400	54.8
..Agriculture, forestry and fishing	A	1 537 122	111 171	214 930	224 575	45 710	1 624	45 960	1 848	2 182 940	91.7
..Crop and animal production, hunting and related service activities	A.1	32 047	35 428	163 913	609	7 862	2	2 974	83	242 919	11.1
..Forestry and logging	A.2	1 504 988	75 565	50 966	223 963	37 734	1 621	42 897	1 765	1 939 498	88.8
..Fishing and aquaculture	A.3	86	178	50	3	114	1	89	1	523	0.0
..Mining and quarrying	B	1 601	468	711	389	1 527		122	3	4 821	0.2
..Manufacturing	C	7 306	1 914	2 916	97	4220	8	249	17	16 726	0.7
..Electricity, gas, steam and air conditioning supply	D	2 576	1 671	951	293	2 224	22	681	13	8 431	0.4
..Water supply; sewerage, waste management and remediation activities	E	362	394	88	17	756	0	268	9	1 895	0.1
..Construction	F	3 326	1 884	1 859	98	1 780	11	168	16	9 142	0.4
..Wholesale and retail trade; repair of motor vehicles and motorcycles	G	9 032	1 929	1 963	191	2 135	5	214	28	15 497	0.7
..Transportation and storage	H	2 922	925	2 641	190	5 119	9	111	11	11 928	0.5
..Accommodation and food service activities	I	2 775	886	717	97	533	10	140	9	5 168	0.2
..Information and communication	J	637	306	331	12	152	0	21	4	1 463	0.1
..Real estate activities	L	24 611	16 069	51 263	784	8 239	74	1 436	112	102 588	4.3
..Professional, scientific and technical activities	M	3 034	1 588	1 948	96	1 078	18	142	16	7 919	0.3
..Administrative and support service activities	N	2 452	991	1 110	36	599	2	94	8	5 292	0.2
..Education	P	261	152	90	4	78	4	6	0	594	0.0
..Human health and social work activities	Q	112	33	23	1	102	0	4	1	275	0.0
..Arts, entertainment and recreation	R	452	387	217	9	396	4	62	5	1 533	0.1
..Other service activities	S	357	293	241	9	130	1	23	5	1 058	0.0
..Other corporations		1 338	740	395	34	525	3	86	8	3 130	0.1
Financial corporations		427	253	203	12	167	4	18	1	1 085	0.0
General government		113 097	58 935	66 414	34 091	57 838	263	12 025	543	343 206	7.9
Households		645 676	293 699	479 652	15 053	102 329	622	23 022	1 652	1 561 705	35.9
Non-profit institutions serving households		3 100	1 778	1 574	147	1 666	4	223	12	8 503	0.2
Rest of the world		14 253	7 811	5 659	550	3 638	79	443	97	32 530	0.7
Not specified		3 744	4 509	2 629	286	5 031	264	2 474	204	19 140	0.4
TOTAL		2 380 574	508 786	838 524	277 073	245 972	3 030	87 990	4 623	4 346 570	100
Share, %		54.8	11.7	19.3	6.4	5.7	0.1	2.0	0.1	100	

Table 2. Closing extent account (2021), classified by most 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		1 606 843	139 319	286 108	226 170	76 014	2 115	49 926	2 387	2 388 883	55
..Agriculture, forestry and fishing	A	1 543 386	109 819	220 125	223 868	45 879	1 904	46 157	2 110	2 193 246	91.8
..Crop and animal production, hunting and related service activities	A.1	26 172	33 922	166 175	516	8 211	5	2 882	89	237 972	10.9
..Forestry and logging	A.2	1 517 112	75 744	53 742	223 346	37 536	1 898	43 181	2 021	1 954 580	89.1
..Fishing and aquaculture	A.3	102	153	207	5	132	1	93	0	694	0
..Mining and quarrying	B	1 076	491	709	293	866	0	68	1	3505	0.1
..Manufacturing	C	7 611	2 092	3 359	100	4 316	9	270	18	17 775	0.7
..Electricity, gas, steam and air conditioning supply	D	3 177	1 785	1 223	447	3 228	20	746	18	10 645	0.4
..Water supply; sewerage, waste management and remediation activities	E	371	403	91	15	770	0	258	10	1 917	0.1
..Construction	F	2 904	1 500	1 604	76	1 780	12	173	16	8 064	0.3
..Wholesale and retail trade; repair of motor vehicles and motorcycles	G	10 296	2 085	2 397	217	2 145	14	251	52	17 458	0.7
..Transportation and storage	H	2 496	890	1 376	185	5 152	29	95	9	10 231	0.4
..Accommodation and food service activities	I	2 796	947	487	87	533	10	130	8	4 998	0.2
..Information and communication	J	648	347	355	14	179	2	24	4	1 573	0.1
..Real estate activities	L	24 785	15 046	50 879	697	8 398	77	1 395	101	101 377	4.2
..Professional, scientific and technical activities	M	3 095	1 630	1 480	90	1 129	22	136	18	7 600	0.3
..Administrative and support service activities	N	2 266	900	1 130	36	671	4	89	4	5098	0.2
..Education	P	234	146	103	5	68	4	6	0	566	0
..Human health and social work activities	Q	120	32	28	1	105	0	4	0	290	0
..Arts, entertainment and recreation	R	445	456	225	11	338	5	59	9	1 547	0.1
..Other service activities	S	300	202	256	6	142	1	23	4	934	0
..Other corporations		837	549	282	22	314	4	45	6	2 059	0.1
Financial corporations		394	303	194	21	138	4	31	1	1 087	0
General government		114 139	57 481	65 206	33 559	59 098	282	12 294	593	342 653	7.9
Households		636 489	286 555	472 801	14 523	104 019	698	22 878	1 730	1 539 692	35.4
Non-profit institutions serving households		3 331	1 907	1 660	132	1 737	4	231	23	9 025	0.2
Rest of the world		13 970	7 686	5 622	514	3 676	107	446	112	32 132	0.7
Not specified		9 182	7 061	7 991	335	5 580	283	2 411	249	33 093	0.8
TOTAL		2 384 348	500 312	839 584	275 255	250 262	3 494	88 217	5 094	4 346 567	100
Share, %		54.9	11.5	19.3	6.3	5.8	0.1	2	0.1	100	

Table 3. Opening extent account (2020), 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%	34%	82%	31%	59%	57%	46%	55%
Financial corporations	0%	0%	0%	0%	1%	0%	0%	0%	0%
General government	5%	12%	8%	12%	24%	9%	14%	12%	8%
Households	27%	58%	57%	5%	42%	21%	26%	36%	36%
Non-profit institutions serving households	0%	0%	0%	0%	1%	0%	0%	0%	0%
Rest of the world	1%	2%	1%	0%	1%	3%	1%	2%	1%
Not specified	0%	1%	0%	0%	2%	9%	3%	4%	0%
Share of ecosystem type in total	55%	12%	19%	6%	6%	0%	2%	0%	100%

Table 4. Closing extent account (2021), 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%	34%	82%	30%	61%	57%	47%	55%
Financial corporations	0%	0%	0%	0%	0%	0%	0%	0%	0%
General government	5%	11%	8%	12%	24%	8%	14%	12%	8%
Households	27%	57%	56%	5%	42%	20%	26%	34%	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%	1%	2%	1%
Not specified	0%	1%	1%	0%	2%	8%	3%	5%	1%
Share of ecosystem type in total	55%	12%	19%	6%	6%	0%	2%	0%	100%

Table 5. Distribution of ecosystem types with categories of non-financial corporations by economic activities (2020)

	NACE	Forest	Grassland	Cropland	Wetland	Artificial area	Coast	Inland waterbodies	Other	TOTAL	Share from ecosystem extent	Share from corporations extent
Non-financial corporations total		1 600 276	141 802	282 392	226 932	75 304	1 795	49 785	2 114	2 380 400	54.8%	
..Crop and animal production, hunting and related service activities	A.1	2.0%	25.0%	58.0%	0.3%	10.4%	0.1%	6.0%	3.9%	242 918	5.6%	10.2%
..Forestry and logging	A.2	94.0%	53.3%	18.0%	98.7%	50.1%	90.3%	86.2%	83.5%	1 939 498	44.6%	81.5%
..Fishing and aquaculture	A.3	0.0%	0.1%	0.0%	0.0%	0.2%	0.1%	0.2%	0.0%	522	0.0%	0.0%
..Mining and quarrying	B	0.1%	0.3%	0.3%	0.2%	2.0%	0.0%	0.2%	0.1%	4 820	0.1%	0.2%
..Manufacturing	C	0.5%	1.3%	1.0%	0.0%	5.6%	0.4%	0.5%	0.8%	16 726	0.4%	0.7%
..Electricity, gas, steam and air conditioning supply	D	0.2%	1.2%	0.3%	0.1%	3.0%	1.2%	1.4%	0.6%	8 431	0.2%	0.4%
..Water supply; sewerage, waste management and remediation activities	E	0.0%	0.3%	0.0%	0.0%	1.0%	0.0%	0.5%	0.4%	1 894	0.0%	0.1%
..Construction	F	0.2%	1.3%	0.7%	0.0%	2.4%	0.6%	0.3%	0.7%	9 141	0.2%	0.4%
..Wholesale and retail trade; repair of motor vehicles and motorcycles	G	0.6%	1.4%	0.7%	0.1%	2.8%	0.3%	0.4%	1.3%	15 496	0.4%	0.7%
..Transportation and storage	H	0.2%	0.7%	0.9%	0.1%	6.8%	0.5%	0.2%	0.5%	11 928	0.3%	0.5%
..Accommodation and food service activities	I	0.2%	0.6%	0.3%	0.0%	0.7%	0.6%	0.3%	0.4%	5 167	0.1%	0.2%
..Information and communication	J	0.0%	0.2%	0.1%	0.0%	0.2%	0.0%	0.0%	0.2%	1 463	0.0%	0.1%
..Real estate activities	L	1.5%	11.3%	18.2%	0.3%	10.9%	4.1%	2.9%	5.3%	102 587	2.4%	4.3%
..Professional, scientific and technical activities	M	0.2%	1.1%	0.7%	0.0%	1.4%	1.0%	0.3%	0.7%	7 919	0.2%	0.3%
..Administrative and support service activities	N	0.2%	0.7%	0.4%	0.0%	0.8%	0.1%	0.2%	0.4%	5 291	0.1%	0.2%
..Education	P	0.0%	0.1%	0.0%	0.0%	0.1%	0.2%	0.0%	0.0%	594	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%	0.0%	275	0.0%	0.0%
..Arts, entertainment and recreation	R	0.0%	0.3%	0.1%	0.0%	0.5%	0.2%	0.1%	0.2%	1 532	0.0%	0.1%
..Other service activities	S	0.0%	0.2%	0.1%	0.0%	0.2%	0.0%	0.0%	0.2%	1 057	0.0%	0.0%
.Other corporations		0.1%	0.5%	0.1%	0.0%	0.7%	0.2%	0.2%	0.4%	3 130	0.1%	0.1%

Table 6. Distribution of ecosystem types with categories of non-financial corporations by economic activities (2021)

	NACE	Forest	Grassland	Cropland	Wetland	Artificial area	Coast	Inland waterbodies	Other	TOTAL	Share from ecosystem extent	Share from corporations extent
Non-financial corporations total		1 60 6843	139 319	286 108	226 170	76 014	2 115	49 926	2 387	2 388 883	55	
..Crop and animal production, hunting and related service activities	A.1	1.63%	24.35%	58.08%	0.23%	10.8%	0.22%	5.77%	3.72%	237 972	5.48%	9.96%
..Forestry and logging	A.2	94.42%	54.37%	18.78%	98.75%	49.38%	89.74 %	86.49%	84.65 %	1 954 580	44.97%	81.82%
..Fishing and aquaculture	A.3	0.01%	0.11%	0.07%	0%	0.17%	0.05%	0.19%	0.02%	694	0.02%	0.03%
..Mining and quarrying	B	0.07%	0.35%	0.25%	0.13%	1.14%	0%	0.14%	0.04%	3 505	0.08%	0.15%
..Manufacturing	C	0.47%	1.50%	1.17%	0.04%	5.68%	0.45%	0.54%	0.74%	17 775	0.41%	0.74%
..Electricity, gas, steam and air conditioning supply	D	0.20%	1.28%	0.43%	0.2%	4.25%	0.96%	1.49%	0.76%	10 645	0.24%	0.45%
..Water supply; sewerage, waste management and remediation activities	E	0.02%	0.29%	0.03%	0.01%	1.01%	0%	0.52%	0.41%	1 917	0.04%	0.08%
..Construction	F	0.18%	1.08%	0.56%	0.03%	2.34%	0.55%	0.35%	0.67%	8 064	0.19%	0.34%
..Wholesale and retail trade; repair of motor vehicles and motorcycles	G	0.64%	1.50%	0.84%	0.1%	2.82%	0.65%	0.5%	2.18%	17 458	0.4%	0.73%
..Transportation and storage	H	0.16%	0.64%	0.48%	0.08%	6.78%	1.38%	0.19%	0.36%	10 231	0.24%	0.43%
..Accommodation and food service activities	I	0.17%	0.68%	0.17%	0.04%	0.7%	0.46%	0.25%	0.35%	4 998	0.11%	0.21%
..Information and communication	J	0.04%	0.25%	0.12%	0.01%	0.24%	0.1%	0.05%	0.15%	1 573	0.04%	0.07%
..Real estate activities	L	1.54%	10.80%	17.78%	0.31%	11.05%	3.63%	2.8%	4.23%	101 377	2.33%	4.24%
..Professional, scientific and technical activities	M	0.19%	1.17%	0.52%	0.04%	1.49%	1.03%	0.27%	0.75%	7 600	0.17%	0.32%
..Administrative and support service activities	N	0.14%	0.65%	0.39%	0.02%	0.88%	0.19%	0.18%	0.15%	5 098	0.12%	0.21%
..Education	P	0.01%	0.1%	0.04%	0%	0.09%	0.18%	0.01%	0.02%	566	0.01%	0.02%
..Human health and social work activities	Q	0.01%	0.02%	0.01%	0%	0.14%	0%	0.01%	0.01%	290	0.01%	0.01%
..Arts, entertainment and recreation	R	0.03%	0.33%	0.08%	0%	0.45%	0.22%	0.12%	0.36%	1 547	0.04%	0.06%
..Other service activities	S	0.02%	0.15%	0.09%	0%	0.19%	0.03%	0.05%	0.17%	934	0.02%	0.04%
..Other corporations		0.05%	0.39%	0.1%	0.01%	0.41%	0.17%	0.09%	0.24%	2 059	0.04%	0.09%

2.2 Urban areas

Similarly to compiled earlier compiled ecosystem accounts, as a part of ecosystem extent account we also paid special attention to urban areas. To best to our knowledge there is no universal or single criteria in order to define urban areas that would suit in every case. One option is to use already existing administrative borders of urban areas for defining urban areas for ecosystem extent account, but in case of Estonia some of those areas are relatively large, meaning these areas would include many natural ecosystems (e.g., forests, grasslands, wetlands). As urban areas can be charactered both by large share of infrastructure and high human population density, it was decided to define urban areas based on infrastructure and human population density in Estonia. Urban areas were defined separately for year 2020 and 2021.

For spatial analyses we used one hectare grid. For every single grid cell, we determined both human population density (data managed by Statistics Estonia) and the share of the infrastructure. As a part of the infrastructure, we regarded: residential or community buildings, buildings under construction, greenhouses, production buildings, other buildings, ruins, production yards, bus stations, pedestrian areas, the runways, traffic areas, parking lots, sport facilities, other roads, light traffic roads, side roads, other national roads, main roads, ramps and connecting roads, the streets and support roads. Data was obtained from the Estonian topographic database[13]. We also calculated the share of landmass in every grid cell and weighted both human population density and the share of the infrastructure with it in order to take account that there is less terrestrial land in coastal grids.

Preliminary every grid cell was determined either urban or rural based on if human population density was greater than or equal to 200 people per square kilometer or the share of infrastructure is greater than or equal to 10%. For the next step, all the grids were dissolved based on urban/rural status and reassigned if necessary. Newly created objects were given final status based on the area. As a third criteria we used total area, as urban areas needed to be at least 1 km2 in size in order to exclude smaller villages or larger farms which could have locally high share of infrastructure.

In 2020 total area of urban areas was 727.3 km^2 (Figure 3) and in 2021 720.6 km^2 in Estonia (Figure 4).

[13] Estonian Land Board, https://geoportaal.maaamet.ee/est/Ruumiandmed/Eesti-topograafia-andmekogu-p79.html

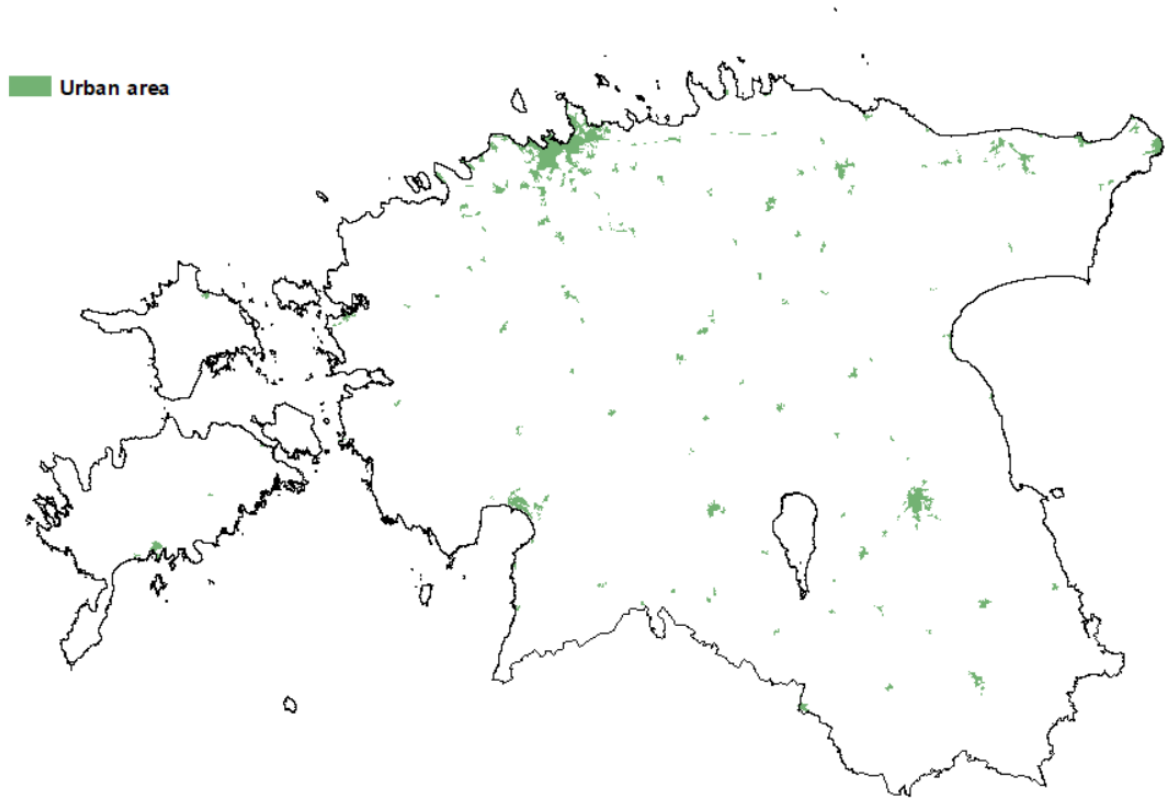

Figure 3. Distribution of urban area in Estonia (2020)

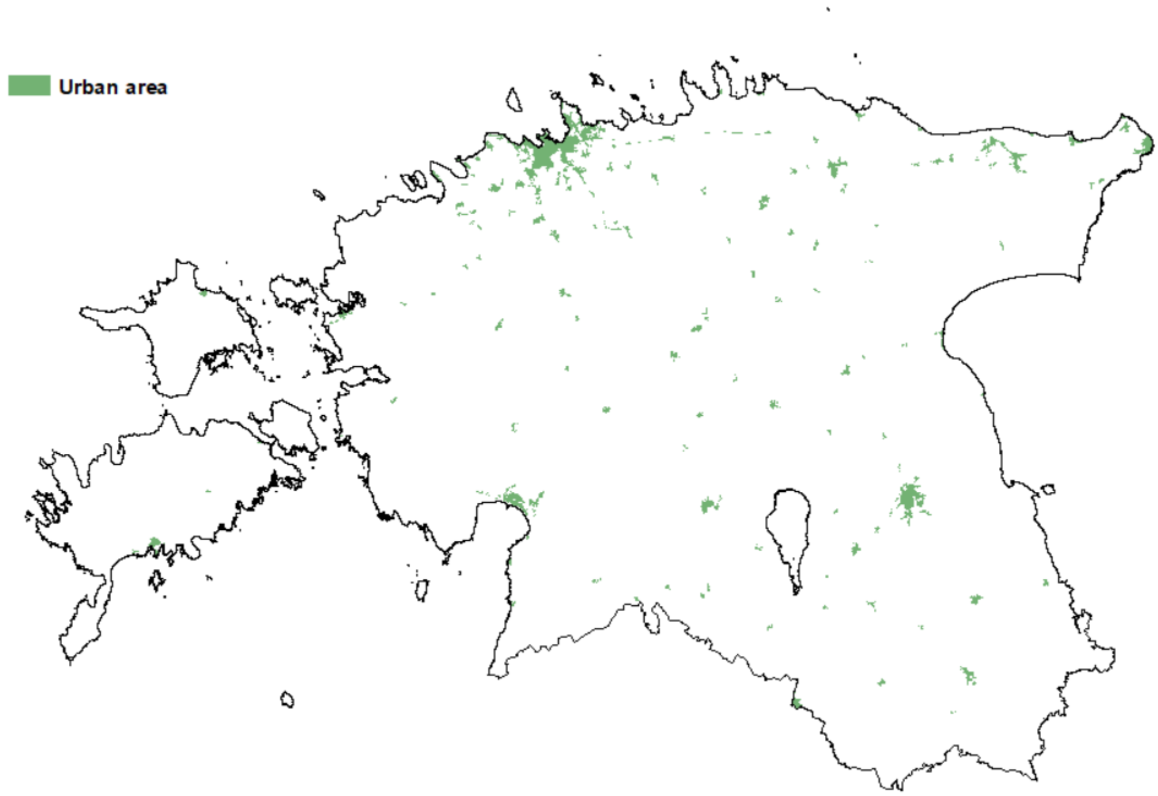

Figure 4. Distribution of urban area in Estonia (2021)

2.3 Evaluation of the changes in ecosystem extent account

In the current grant work two separate ecosystem extent accounts (extent maps) were created for years 2020 as opening extent and 2021 as closing extent. 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 grid cell. Spatial analyses were carried out for both opening and closing extents (Table 5). Although changes were relatively small in area in the timeframe of one-year, using level I classification it shows that grasslands decreased the most in total area and artificial area increased the most within one year (Table 7). Using level II classification to zoom in into area changes, it is seen that (Table 8) the largest changes occurred in the areas of cultivated grassland and Eutrophic alvar forests and shrublands which both decreased. Other artificial areas and Drained peatland forests areas were both largest increases in area.

Table 7. Ecosystem extent account, opening extent for year 2020 and closing extent for year 2021 for Estonia (whole EAA) by main ecosystem types, km2

	2020		2021
Ecosystem type	Opening extent	Net change in extent	Closing extent
Forest	23805.74	37.74	23843.48
Other	46.23	4.71	50.94
Grassland	5087.86	-84.74	5003.12
Cropland	8385.24	10.60	8395.84
Coast	30.30	4.65	34.94
Wetland	2770.72	-18.17	2752.55
Artificial area	2459.76	42.90	2502.66
Inland waterbodies	879.90	2.27	882.17

Table 8. Ecosystem extent account (km2), opening extent for year 2020 and closing extent for year 2021 for Estonia (whole EAA)

	2020		2021
Ecosystem type	Opening extent	Net change in extent	Closing extent
Horticultural land	36.06	-0.36	35.70
Green space	113.79	1.49	115.28
Buildings and other facilities	868.68	8.96	877.64
Abandoned peatlands	57.36	-0.20	57.16
Drained peatland forests	3279.27	19.36	3298.63
Cultivated grassland	2540.50	-71.94	2468.56
Mesotrophic boreal forests	3921.10	19.09	3940.18
Eutrophic alvar forests and shrublands	500.66	-9.65	491.01
Fens	497.05	-9.99	487.06
Forest on reclaimed pits	138.90	1.42	140.32
Other	46.23	4.71	50.94
Other artificial areas	1477.29	32.45	1509.74
Heaths	3.95	-0.97	2.98
Oligotrophic boreal heath forests	199.69	-3.32	196.38
Oligo-mesotrophic boreal forests	4856.94	17.79	4874.73
Crops	8315.71	11.75	8327.46
Semi-natural grasslands	2394.21	-8.90	2385.32
Shrubbery	149.19	-2.93	146.26
Permanent crops	33.46	-0.79	32.68
Peat bogs	1610.53	-7.35	1603.18
Oligotrophic paludifying forests	411.75	-6.68	405.07
Shores	30.30	4.65	34.94
Minerotrophic swamp forests	730.13	-8.91	721.22
Eutrophic boreo-nemoral forests	2073.94	18.02	2091.96
Mixotrophic and ombrotrophic bog forests	1407.08	-3.92	1403.16
Lakes and ponds	317.10	1.70	318.80
Transition mires	424.96	-0.97	423.99
Eutrophic paludifying forests	6286.28	-5.46	6280.83
Peat extraction sites	180.81	0.35	181.16
Rivers and streams	562.80	0.57	563.37
Total	43465.7		43465.7

We also created ecosystem type change matrix to illustrate ecosystem conversions in Estonia (Table 9, also in accompanying Excel file "D1_5_ Dataset on ecosystem extent account"). The largest ecosystem conversions between opening and closing extent occurred between cultivated grassland which were converted to crops (16 397 ha change). At same time also 9 130 ha 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 3 094 ha of crops were converted into other artificial area indicating growing importance about the share of infrastructure in landscapes. Also eutrophic paludifying forests were converted to oligo-mesotrophic boreal forests (2 986 ha change) and eutrophic boreo-nemoral forests (3 055 ha change). These changes could indicate that these changes are due to reappraisals. Altogether there was 3% (112 648 ha) of Estonia total area that experienced some kind of ecosystem conversions in the timeframe of one-year.

Table 9. Ecosystem type change matrix (for year 2020 and 2021) to show ecosystem type conversions in Estonia

Opening area (ha) \ **Closing area (ha)**	Horticultural land	Green space	Buildings and other facilities	Abandoned peatlands	Drained peatland forests	Cultivated grassland	Mesotrophic boreal forests	Eutrophic alvar forests andshrublands	Fens	Reclamationed pits forest site type	Other	Other artificial areas	Heaths	Oligotrophic boreal heath forests	Oligo-mesotrophic boreal forests	Crops	Semi-natural grasslands	Shrubbery	Permanent crops	Peat bogs	Oligotrophic paludifying forests	Shores	Menerotrophic swamp forests	Eutrophic boreo-nemoral forests	Mixotrophic and ambrotrophic bog forests	Lakes and ponds	Transition mires	Eutrophic paludifying forests	Peat extraction site	Rivers and streams	**TOTAL**
Horticultural land	0	8	17	1	0	11	3	0	0	0	0	35	0	0	0	40	37	0	20	0	0	0	0	6	0	0	0	2	0	0	**180**
Green space	3	0	129	0	0	9	5	4	0	0	0	66	0	2	8	8	47	2	0	0	0	0	0	0	0	3	0	6	0	0	**292**
Buildings and other facilities	2	80	0	0	9	37	28	3	0	1	8	226	0	1	16	86	158	0	0	0	0	2	3	11	2	3	0	31	0	2	**709**
Abandoned peatlands	1	0	1	0	2	0	0	0	0	1	0	0	0	0	0	1	0	0	0	35	0	0	0	0	3	0	0	0	15	0	**59**
Drained peatland forests	0	0	16	1	0	93	478	6	114	28	3	176	0	7	765	152	124	14	0	71	51	4	702	317	1171	12	194	1678	4	2	**6183**
Cultivated grassland	4	6	80	0	103	0	260	21	35	1	3	579	0	0	63	16397	2340	34	28	0	0	3	11	122	4	12	3	282	0	15	**20406**
Mesotrophic boreal forests	4	24	30	0	353	188	0	231	33	45	6	441	1	6	2089	531	502	25	0	1	4	21	72	1543	54	28	6	1276	0	9	**7523**
Eutrophic alvar forests andshrublands	0	2	25	0	11	29	858	0	18	20	1	86	0	2	49	26	218	13	1	0	0	1	8	51	3	1	1	380	0	0	**1804**
Fens	0	0	2	0	209	142	72	19	0	2	32	61	0	2	34	28	622	18	0	6	4	49	303	28	95	27	563	227	0	6	**2551**
Reclamationed pits forest site type	0	0	1	0	30	2	17	0	0	0	0	22	0	3	10	2	15	0	0	0	2	0	0	0	2	0	0	7	0	0	**113**
Other	0	1	0	0	0	4	3	3	10	0	0	106	0	0	4	2	25	3	0	0	2	33	1	5	0	2	3	24	0	0	**231**
Other artificial areas	10	123	383	0	84	267	260	43	31	46	628	0	0	6	188	601	1108	41	4	4	8	148	19	118	12	86	2	258	0	16	**4494**
Heaths	0	0	0	0	0	2	0	0	0	0	0	1	0	0	0	1	85	0	0	0	0	19	0	0	0	0	0	0	0	0	**108**
Oligotrophic boreal heath forests	0	0	2	0	5	0	5	2	0	3	1	18	0	0	467	0	7	0	0	5	53	6	0	0	5	1	1	13	0	0	**594**
Oligo-mesotrophic boreal forests	1	3	25	0	802	49	1771	15	29	18	3	317	1	158	0	147	143	2	1	7	325	7	57	731	174	29	21	2518	1	5	**7360**
Crops	35	39	435	0	166	9130	1465	35	29	5	4	3094	0	0	270	0	2158	69	132	1	2	1	17	530	13	22	3	518	0	16	**18189**
Semi-natural grasslands	4	65	292	0	294	2454	1177	176	288	7	26	1259	0	1	325	1473	0	211	24	0	5	210	68	541	15	48	94	1395	0	56	**10508**
Shrubbery	0	0	10	0	30	56	59	31	18	3	1	62	0	0	11	66	176	0	0	0	1	1	11	17	3	2	0	121	0	0	**679**
Permanent crops	70	0	4	1	1	8	7	1	0	0	0	6	0	0	1	155	9	0	0	0	0	0	0	1	0	0	0	0	0	0	**264**
Peat bogs	0	0	0	4	233	0	4	0	9	12	0	34	0	0	26	0	0	0	0	0	10	0	6	4	1361	3	269	13	77	0	**2065**
Oligotrophic paludifying forests	0	0	7	0	152	1	19	0	4	0	0	23	0	21	867	2	4	0	0	5	0	0	8	16	110	0	6	151	0	0	**1396**
Shores	0	0	0	0	0	3	4	2	0	0	0	20	0	5	6	0	43	1	0	0	0	0	0	0	0	3	0	1	0	0	**88**
Menerotrophic swamp forests	0	0	3	0	1731	11	93	4	63	8	1	34	0	0	82	11	41	3	1	6	14	4	0	66	240	3	11	709	0	1	**3140**
Eutrophic boreo-nemoral forests	3	4	8	0	222	94	1317	29	10	6	2	135	0	3	621	237	241	10	3	1	3	5	42	0	17	4	2	2215	0	11	**5245**
Mixotrophic and ambrotrophic bog forests	0	0	8	3	2028	8	73	2	35	36	0	21	0	7	320	6	20	0	0	912	145	0	250	26	0	4	79	157	7	0	**4147**
Lakes and ponds	0	1	2	0	4	5	3	0	2	2	4	17	0	0	8	7	52	1	0	0	2	9	3	3	1	0	9	9	0	0	**144**
Transition mires	0	0	0	0	107	3	16	1	553	0	7	7	0	0	14	4	48	1	0	202	6	0	54	3	335	11	0	15	0	0	**1387**
Eutrophic paludifying forests	0	6	28	1	1710	218	1696	150	158	6	13	398	1	10	2986	450	901	52	5	5	79	7	501	3055	124	19	15	0	0	8	**12602**
Peat extraction site	0	0	0	31	3	0	0	0	0	0	0	1	0	0	0	0	0	0	0	13	0	0	0	0	4	0	1	1	0	0	**54**
Rivers and streams	0	2	3	0	3	8	2	0	38	0	1	17	0	0	2	11	25	2	0	0	0	0	5	2	1	1	2	8	0	0	**133**
TOTAL	**137**	**364**	**1511**	**42**	**8292**	**12832**	**9695**	**778**	**1477**	**250**	**744**	**7262**	**3**	**234**	**9232**	**20444**	**9149**	**502**	**219**	**1274**	**716**	**530**	**2141**	**7196**	**3749**	**324**	**1285**	**12015**	**104**	**147**	**112648**

2.4 Testing of ecosystem extent account guidance note

As part of Eurostat taskforce on ecosystem accounting, we took part in the testing of ecosystem extent account guidance note. The test took place from the end of October 2022 till early January 2023. The objective of the test was to fill in the questionnaire[14] on ecosystem extent and changes matrix based on EU typology. The results of the test would reflect how well the instructions in the guidance note on ecosystem extent accounts[15] can be applied for compiling ecosystem extent and whether ecosystem types defined in EU typology[16] are suitable for reporting.

Testing included following tasks:

a) crosswalking between our local ecosystem classification and newly proposed EU typology (both on level I and II),
b) filling in the extent of different ecosystem types (both on level I and II),
c) filling in conversion matrix for ecosystem types.

Data from year 2019 as an opening extent and data from 2020 as a closing extent which we had compiled in prior years using national datasets were used for testing.

As ecosystem extent had already been compiled in Estonia, the main work concerned delineating ecosystem types as how they are defined in EU ecosystem typology. This included crosswalking ecosystem types used in the “Classification of ecosystems for ecosystem accounting in Estonia” and “EU ecosystem typology”.

EU Typology was developed 2021-2022 with the purpose to harmonize EU ecosystem accounting reporting. It is based on the most important existing ecosystem classifications: MAES, EUNIS, IUCN Global Ecosystem Typology (GET). The typology consists of three levels where the first level is an updated MAES ecosystem typology, it is most generalized and foreseen to be the basis for ecosystem accounts reporting. EU level 2 ecosystem types are differentiated in a manner that is relevant for ecosystem service and condition modelling and reporting. Majority of EU L2 ecosystem types align with EUNIS habitat level 2 classification. EU level 3 ecosystem types are most detailed, these may be adjusted for national level analysis and their purpose is to support ecosystem service and condition modelling rather than reporting. Majority of EU L3 ecosystem types align with EUNIS habitat level 3 classification.

Classification of ecosystems for ecosystem accounting in Estonia was developed during previous grant work on ecosystem accounts (881542— 2019-EE-ECOSYSTEMS)[17] The creation of the classification began with the testing of the IUCN Global Ecosystem Typology (IUCN GET) in 2020 and was built up tiered as the most detailed level 3 would be placed at the lowest level of the IUCN GET or other international classification, but higher levels (1,2) follow common ecosystem types. The grouping of ecosystem types was done mainly on the basis of existing Estonian classifications (Paal habitat

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[14] Eurostat – Unit E2. Ecosystem extent accounts - draft questionnaire (v. October 2022 for testing). (Annex to the Guidance note on extent accounts). Supplementary document 1 to Doc. ENV/EA/TF/2022_4/2.

[15] Eurostat – Unit E2. Guidance note on ecosystem extent accounts - final version for TF discussion before the testing. ENV/EA/TF/2022_4/2. Task force on ecosystem accounting 15-16 September 2022

[16] Eurostat – Unit E2. Annex 3. Description of the EU ecosystem typology (Annex to the Guidance note on extent accounts). Supplementary document 1 to Doc. ENV/EA/TF/2022_4/2. Task force on ecosystem accounting 15-16 September 2022

[17] Statistics Estonia, 2021. Development of the ecosystem accounts (Eurostat Grant Agreement NUMBER — 881542— 2019-EE-ECOSYSTEMS) https://www.stat.ee/sites/default/files/2021-07/D1.1%20Final%20methodological%20report_July_2021.pdf

types, Habitats Directive Annex I habitats). The classification was crosswalked to several existing habitat or ecosystem classifications: LULUCF land cover types, EUNIS, IUCN GET.

Therefore, in most cases the crosswalking between “EU ecosystem typology” and “Classification of ecosystems for ecosystem accounting in Estonia” was rather straightforward thanks to the already established links between EUNIS and IUCN classifications for both classifications.

Generally, filling in the areas of different ecosystem types was straightforward (ecosystem type areas and net changes between two years), especially on level I using EU typology (Table 10, also in accompanying Excel file “D1_5_ Dataset on ecosystem extent account). We encountered some drawbacks on level II where we did not have one to one relationship between classes using different classification systems. For example, distinguishing continuous settlement areas and discontinuous settlement areas needed some extra GIS analyses as these areas were not distinguished as such before. Similarly, class forest and woodlands needed some extra work on level II to classify forests into broadleaved, coniferous and mixed forest in Estonia. Due to time constraints, we were able to fill out the corresponding areas in table for settlements and other artificial areas and forest and woodlands classes on level II for year 2020, but principally it can be carried out also for year 2019. Marine ecosystems on level II were the most problematic class to us currently (due to lack of data) as the focus has been mainly on terrestrial ecosystems (including smaller lakes and rivers) when compiling ecosystem extent accounts in prior years. Therefore, this ecosystem type needs further work in coming years.

Results show that marine ecosystems have the largest area in Estonia followed by forest/woodlands and cropland. This holds true both for year 2019 and 2020. Net change within class was largest in grassland class (which decreased) and smallest in marine ecosystems which basically remained the same (Table 8).

Filling out the ecosystem conversion matrix for different ecosystem types (how and if ecosystem type has changed into another ecosystem type during reference period) was also relatively straightforward as reporting was needed on level I using EU typology (Table 11). In terms of area (ha), grasslands changed the most, which were converted into croplands (19 159 ha). In the same time 13 964 ha of cropland was also converted into grassland. Compared to other ecosystem types, we did not detect any changes in marine ecosystems in terms of area.

Results are also included in excel format in project deliverable D1.5. Dataset on ecosystem extent account 101022852_2020-EE-ENVACC.

Table 10. Ecosystem extent accounts using EU ecosystem typology. Different ecosystem type areas in 2019 and 2020 with net changes during reference period

Reporting unit =			**1000 ha**				
Reference year =			**2020**				
Previous reference year =			**2019**				
Items in bold are mandatory to be reported.							
EU ecosystem typology: level 1		**EU ecosystem typology: level 2**	**Opening area (Extent in the previous reference year)**	**Additions**	**Reductions**	Net changes (additions less reductions; +/-)	**Closing area (Extent in the current reference year)**
1. Settlements and other artificial areas		1.1 Continuous settlement area					8.39
		1.2 Discontinuous settlement area					93.52
		1.3 Infrastructure	94.48			3.08	97.56
		1.4 Urban greenspace	6.29			0.34	6.62
		1.5 Other artificial areas	1.09			0.11	1.20
	Total (level 1)		**203.56**			**3.74**	**207.29**
2. Cropland		2.1 Annual cropland	826.81			1.50	828.30
		2.2 Rice fields	0.00			0.00	0.00
		2.3 Permanent crops	3.32			0.02	3.34
		2.4 Agro-forestry areas	0.00			0.00	0.00
		2.5 Mixed farmland	2.97			0.10	3.07
		2.6 Other farmland	0.00			0.00	0.00
	Total (level 1)		**833.10**			**1.61**	**834.71**
3. Grassland		3.1 Sown pastures and fields (modified grasslands)	259.06			-5.68	253.38
		3.2 Natural and semi-natural grasslands	234.37			-1.08	233.30
	Total (level 1)		**493.43**			**-6.75**	**486.68**
4. Forest and woodlands		4.1 Broadleaved deciduous forest					964.09
		4.2 Coniferous forests					842.59
		4.3 Broadleaved evergreen forest	0.00			0.00	0.00
		4.4 Mixed forests					552.29
		4.5 Transitional forest and woodland shrub	13.60			0.25	13.85
		4.6 Plantations	0.00			0.00	0.00
	Total (level 1)		**2370.65**			**2.17**	**2372.82**
5. Heathlands and shrub		5.1 Tundra	0.00			0.00	0.00
		5.2 Heathland and (sub-) alpine shrub	14.87			0.09	14.96
		5.3 Sclerophyllous vegetation	0.00			0.00	0.00
	Total (level 1)		**14.87**			**0.09**	**14.96**
6. Sparsely vegetated ecosystems		6.1 Bare rocks	0.07			0.00	0.07
		6.2 Semi-desert, desert and other sparsely vegetated areas	57.94			1.72	59.66
		6.3 Ice sheets, glaciers and perennial snowfields	0.00			0.00	0.00
	Total (level 1)		**58.01**			**1.72**	**59.73**
7. Inland wetlands		7.1 Inland marshes on mineral soil	53.35			-0.62	52.73
		7.2 Mires, bogs and fens	228.07			-0.72	227.35
	Total (level 1)		**281.43**			**-1.34**	**280.08**
8. Rivers and canals		8.1 Rivers	10.76			-0.03	10.73
		8.2 Canals, ditches and drains	45.19			-0.37	44.82
	Total (level 1)		**55.95**			**-0.40**	**55.55**
9. Lakes and reservoirs		9.1 Lakes	206.88			-0.01	206.87
		9.2 Artificial reservoirs	8.42			0.07	8.49
		9.3 Geothermal pools and wetlands (Iceland)	0.00			0.00	0.00
	Total (level 1)		**215.30**			**0.06**	**215.35**
10. Marine inlets and transitional waters (lagoons, fjords)		10.1 Coastal lagoons	0.49			-0.33	0.16
		10.2 Estuaries and bays	0.14			-0.01	0.13
		10.3 Intertidal flats	0.00			0.00	0.00
		10.4 Deepwater coastal inlets (fjords)	0.00			0.00	0.00
	Total (level 1)		**0.63**			**-0.34**	**0.29**
11. Coastal beaches, dunes and wetlands		11.1 Artificial shorelines	0.00			0.00	0.00
		11.2 Coastal dunes, beaches and sandy and muddy shores	2.87			-0.20	2.67
		11.3 Rocky shores	0.03			0.00	0.03
		11.4 Coastal saltmarshes and salines	0.73			-0.33	0.40
	Total (level 1)		**3.63**			**-0.53**	**3.10**
12. Marine ecosystems		12.1 Marine macrophyte habitats					0.00
		12.2 Coral reefs					0.00
		12.3 Shellfish beds and reefs					0.00
		12.4 Subtidal sand beds and mud plains	0.03			0.03	0.06
		12.5 Subtidal rocky substrates					0.00
		12.6 Continental and island slopes					0.00
		12.7 Deepwater benthic and pelagic ecosystems					0.00
		12.8 Sea ice					0.00
	Total (level 1)		**2523.09**			**0.03**	**2523.12**

Table 11. Ecosystem type conversion matrix. Ecosystem types areal changes during reference period (2019 - 2020). Changes larger than 10 ha are shown. Larger changes are indicated in red and smaller changes in green.

Reporting unit = ha

Reference period (year n to year n+3) = 2019-2020

Category	Ecosystem type (Opening area)	Settlements and other artificial areas	Cropland	Grassland (pastures, semi-natural and natural grasslands)	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems (coastal waters, shelf and open ocean)
		Closing area											
1	Settlements and other artificial areas		722	1038	718	10	358	11		27			
2	Cropland	1487		13964	4510	107	490	57	24	26			
3	Grassland (pastures, semi-natural and natural grasslands)	1399	19159		6587	405	623	956	68	87	87		
4	Forest and woodland	1310	2393	4450		293	1483	2114	50	121	29		
5	Heathland and shrub	33	74	250	570		140	89					
6	Sparsely vegetated ecosystems	550	243	755	1178	65		82		39	124		
7	Inland wetlands	21	46	1372	3383	62	179			35	11		
8	Rivers and canals	14	17	62	54		12	14					
9	Lakes and reservoirs	19	19	80	92	28	79	142					
10	Marine inlets and transitional waters			76			140	97		11			
11	Coastal beaches, dunes and wetlands			174	83		556						
12	Marine ecosystems (coastal waters, shelf and open ocean)												

3 Ecosystem condition account

The possibility to compile ecosystem condition account was tested. The compilation of the condition account was mainly guided by the development of the amendment of EU regulation 691/2011 regarding the new proposed module of ecosystem accounts. Ecosystem account description is also presented as a separate deliverable "D1_7_ Description of the feasibility of compilation of the ecosystem condition accounts _101022852_2020-EE-ENVACC" but due to the desired integrity and cross-references to other chapters on ecosystem accounting it is also presented as chapter 3 in current report.

Currently it has been agreed upon to include the following condition indicators for mandatory reporting in the proposed amendment of EU regulation 691/2011:

1. For settlements and other artificial areas:
- green areas in cities and adjacent towns and suburbs shall be reported in % of total area, calculated for the entire area of the cities and adjacent towns and suburbs, including all ecosystem types in that area;
- concentration of particulate matter, with a diameter up to 2.5 μm in cities, shall be reported in μg/m3 as a national average for the reporting period.
2. For cropland:
- soil organic carbon stock in topsoil shall be reported in tonne/ha, as a national average for the reporting period.
3. For grassland:
- soil organic carbon stock in topsoil shall be reported in tonne/ha, as a national average for the reporting period.
4. For cropland and grassland together:
- common farmland bird index shall be reported as a national aggregate index for the reporting period.
5. For forest and woodland:
- dead wood shall be reported in m3/ha, as a national average for the reporting period;
- tree cover density shall be reported in %, as a national average for the reporting period.
6. For coastal beaches, dunes and wetlands:
- the share of artificial impervious area cover, present in coastal area that includes ecosystem type coastal beaches, dunes and wetlands shall be reported in % as a national average for the reporting period.

Therefore the work focused on the aforementioned condition indicators. The methods from guidance note on condition indicators prepared by Eurostat[18] were analysed and were followed as much as possible. Also experts' opinions about solutions that suit local conditions were taken into account.

The format of the reporting table for condition indicators has not yet been provided. The condition account was compiled for the year 2020 where possible. Table 12 gives an overview of ecosystem condition indicators and their values which represent the national average according to the approach and data described in the guidance document. Detailed description of the methodology and alternative approaches are given in the respective subchapters.

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[18] Eurostat – Unit E2. Doc. ENV/EA/TF/2023_1/6. Ecosystem condition accounts – guidance note. Second proposal. (February 2023)

Table 12. Ecosystem condition indicators

Ecosystem	Indicator	**Value**
Settlements and other artificial areas	Green areas in cities and adjacent towns and suburbs (% of total area)	44 – 60
Settlements and other artificial areas	Concentration of Particulate Matter (PM) with a diameter up to 2.5 µm (annual average µg/m3 2020)	5.71
Croplands	Soil organic carbon stock in topsoil (kg C/ha)	665 140
Grasslands	Soil organic carbon stock in topsoil (kg C/ha)	849 577
Croplands and grassland together	Common farmland birds index – LPI (2020)	58.12
Forests and woodlands	Deadwood (m3/ha, 2020)	17.3
Forests and woodlands	Tree cover density (%, 2022)	70.4
Coastal wetlands, beaches and dunes	Share of artificial impervious area cover (% of total area)	9 – 16

3.1 Green areas in cities and adjacent towns and suburbs

The work was carried out in collaboration with Estonian Environment Agency. The aim was to adapt the methodology and calculate the condition indicator for settlements and other artificial areas "Green areas in cities and adjacent towns and suburbs based" on the latest version of amendment proposal of Regulation (EU) 2017/2391 and guidance material prepared by Eurostat (latest version: February 2023).

3.1.1 Method and results

For settlements and other artificial areas the condition indicator would be: green areas in cities and adjacent towns and suburbs that shall be reported in % of total area, calculated for the entire area of the cities and adjacent towns and suburbs, including all ecosystem types in that area.

The guidance note also suggests: 'Urban green space' is the proportion of existing green areas in an urban area. Green areas can be defined as the ensemble of the following categories of the CLC Classification: 'green urban areas', 'broad-leaved forests', 'coniferous forests', 'mixed forests', 'natural grasslands', 'moors and heathlands', 'transitional woodland-shrubs' and 'sparsely vegetated areas'.

According to the guidance note, for the spatial delineation of urban areas, cities, and their adjacent towns and suburbs are considered local administrative units, categorized according to the degree of urbanization typology set out under Regulation (EU) 2017/2391. Relevant LAUs in Estonia are the following cities: Tallinn, Tartu, and Narva. Administrative borders[19] of these cities were used.

As suggested in the guidance note, Copernicus Urban Atlas data (corresponding roughly to the ecosystem extent account level 2) to define green areas were used (2018)[20]. In addition to this, Estonian Topographic Database data (2023)[21] were tested.

[19] Borders of cities: Estonian Land Board, https://geoportaal.maaamet.ee/eng/Spatial-Data/Administrative-and-Settlement-Division-p312.html. Validity date 5.04.2023.
[20] https://land.copernicus.eu/local/urban-atlas/urban-atlas-2018?tab=download
[21] https://geoportaal.maaamet.ee/eng/Spatial-Data/Estonian-Topographic-Database-p305.html

Classes that can be considered as urban green in these two datasets[22] were chosen to calculate the indicator. Then, national average share of urban green areas and the share in different cities was calculated using standard GIS-programs (ArcGIS, MapInfo).

It could be argued how to define urban area. In this case, the analysis was carried through within the local administrative units (LAUs) in DEGURBA level 1 administrative units that are Tartu, Tallinn, and Narva. It would be more appropriate of urban areas were spatially delineated according to areas functioning as urban ecosystems. We are proposing an approach for delineating urban areas that has been worked out during Estonian MAES project ELME (methodology enclosed in separate document). One of several possibilities has been presented here: ETAK (ETD) green areas within ELME urban areas within administrative borders. According to this approach, the share of the green areas was the lowest. It might be useful to also present the share of the green areas within the whole ELME urban (functionally whole) area, i.e., without delimiting it with the LAU level 1 unit's administrative borders.

Different approaches gave different results (Table 13). More detailed results are provided in attached tables and layers.

Table 13. Urban green – % of the area of the administrative unit according to two different data sets (Estonian Topographic Database and Urban Atlas). In addition, areas functioning as whole urban ecosystems were selected inside administrative borders of the cities to assess the share of (ETAK) green areas.

	ETAK (Estonian Topographic Database) green (%) within city administrative borders		Urban Atlas green (%) within city administrative borders			ETAK urban green (%) within ELME urban area (within city administrative borders)
	non-artificial in total	without waterbodies	non-artificial in total (incl. arable land with annual crops)	without arable land (annual crops); waterbodies included	without arable land and waterbodies	
Tallinn	45	37	43	42	34	25
Tartu	47	45	78	57	55	31
Narva	57	49	58	58	52	33
NATIONAL AVERAGE	50	44	60	53	47	30

In conclusion, national average share of urban green areas varies from 44 to 60% depending on the used dataset and classes included as urban green.

3.2 Concentration of particulate matter, with a diameter up to 2.5 μm in cities

The aim was to adapt the methodology and calculate the condition indicator for settlements and other artificial areas "Concentration of particulate matter, with a diameter up to 2.5 μm in cities" on the latest version of amendment proposal of Regulation (EU) 2017/2391 and guidance material prepared by Eurostat (latest version: February 2023).

[22] Classes defined as urban green in this analysis, are listed in respective attached tables and layers.

3.2.1 Method and results

The ecosystem condition characteristic is defined in the proposal for legal text as concentration of particulate matter, with a diameter up to 2.5 µm in cities, shall be reported in µg/m3 as a national average for the reporting period.

Guidance note lists several good data sources for PM2.5, such as Copernicus CAMS PM2.5 (2018), EMEP (2000-2018), Annual AQ statistics from Environment Agencies.

For assessing the indicator annual air quality statistics for 2020 was used. Estonian Environmental Research Centre (EKUK) has produced a map of PM2.5 concentrations in resolution of 1000x1000m based on national emissions and meteorological data in Airviro modeling system. The same data was used as an input for the air filtration ecosystem service and is further described in paragraph 4.5.

For delineating cities, two different approaches were tested:

1) local administrative units, categorised as cities according to the degree of urbanisation typology set out under Regulation (EU) 2017/2391[23] was the proposed approach in the guidance note. It includes three major cities in Estonia: Tallinn, Tartu, Narva within their administrative borders (Estonian Land Board, 2023).
2) Urban areas on ecosystem extent map (year 2020). This approach includes all urban areas with dense infrastructure and population. Read more in chapter 2.

PM2.5 map was combined with the different data used for delineating cities and the (spatial) average concentration of PM2.5 was found. It is 5.71 µg/m3 for LAU (Tallinn, Tartu, Pärnu) and 5.58 µg/m3 for all urban areas ().

Table 14. Concentration of PM2.5

	LAU (Tallinn, Tartu, Narva)	Urban areas from ecosystem extent map
Concentration of PM2.5 in cities (µg/m3)	5.71	5.58

3.3 Soil organic carbon stock in topsoil in grasslands and croplands

3.3.1 Method and results

The aim was to adapt the methodology and calculate the condition indicator "Soil organic carbon stock in topsoil in grasslands and croplands" based on the latest version of amendment proposal of Regulation (EU) 2017/2391 and guidance material prepared by Eurostat (latest version: February 2023).

The ecosystem condition characteristic is defined in the proposal for the legal text as soil organic carbon stock in topsoil shall be reported in tonne/ha, as a national average for the reporting period.

23 https://ec.europa.eu/eurostat/web/degree-of-urbanisation/background

The soil carbon map created during ELME project based on national soil map with high spatial resolution (Estonian Land Board) and literature. The data is described as follows[24]:

> The soil carbon reserve is a rather stable indicator over time, therefore based on the soil texture and the name of the soil derived from soil map an approximate estimation of the soil carbon reserve can be made, which has also been confirmed by the soil science professor of The Estonian University of Life Sciences (EMÜ) A. Astover. Also, the approximate soil carbon reserves of forests by habitat type have been published by EMÜ scientists (Lutter et al., 2019) and by scientists of the University of Tartu (UT) Geography Department (Kmoch et al., 2021) to estimate carbon reserves, a model using a soil map as a basis has been created, which covers all ecosystems throughout Estonia.

The soil carbon map includes all carbon stock with no depth limit. It was discussed and an assumption was made that in croplands and grasslands the whole stock describes the stock in top layer of the soil because of its natural depth which rarely falls under 30 cm. The issue could rise on crop- or grasslands on deep peat soils. It was also noted that even when the top layer limit is applied, the whole supply is ecologically important.

For the spatial delineation cropland and grasslands as defined in the ecosystem extent account was used. The average organic carbon stock was 665 140 kg/ha in croplands and 849 577 in grasslands (Table 15).

Table 15. Soil organic carbon stock in topsoil (kg C/ha) for cropland and grassland.

	Soil organic carbon stock (kg C/ha)
Croplands	665 140
Grasslands	849 577

[24] „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
Lutter, R., Kõlli, R., Tullus, A., Tullus, H. (2019). Ecosystem carbon stocks of Estonian pre-mature and mature managed forests: effects of site conditions and overstorey tree species. European Journal of Forest Research, 138, 125–142.10.1007/s10342-018-1158-4
Kmoch, A., Kanal, A., Astover, A., Kull, A., Virro, H., Helm, A., Pärtel, M., Ostonen, I., Uuemaa, E. (2021). ESSDD - EstSoil-EH v1.0: An eco-hydrological modelling parameters dataset derived from the Soil Map of Estonia, Earth System Science Data, 13, 83–97, 2021. https://doi.org/10.5194/essd-13-83-2021. https://essd.copernicus.org/articles/13/83/2021/

Further division between detailed ecosystem types could be made for the indicator (Table 16).

Table 16. Soil organic carbon stock in topsoil (kg C/ha) for detailed cropland and grassland ecosystem types.

Ecosystem type	Soil organic carbon stock (kg C/ha)
Cropland total	665 140
Short-term grassland	697 788
Crops	651 314
Fallow land	767 053
Restored grassland	931 038
Permanent crops	641 356
Arable land	665 237
Horticultural land	631 987
Grassland total	849 577
Boreal Baltic coastal meadows (1630)	817 538
Dry sand heaths with Calluna and Empetrum nigrum (2320)	728 153
Inland dunes with open Corynephorus and Agrostis grasslands (2330)	587 258
European dry heaths (4030)	773 442
Juniperus communis formations on heaths or calcareous grasslands (5130)	809 282
Xeric sand calcareous grasslands (6120)	760 307
Calaminarian grasslands of the Violetalia calaminariae (6130)	714 774
Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia) (* important orchid sites) (6210)	771 882
Fennoscandian lowland species-rich dry to mesic grasslands (6270)	748 385
Nordic alvar and precambrian calcareous flatrocks (6280)	795 782
Molinia meadows on calcareous, peaty or clayey-silt-laden soils (Molinion caeruleae) (6410)	1 046 397
Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels (6430)	1 148 219
Northern boreal alluvial meadows (6450)	1 191 177
Lowland hay meadows (Alopecurus pratensis, Sanguisorba officinalis) (6510)	766 916
Fennoscandian wooded meadows (6530)	752 479
Limestone pavements (8240)	839 134
Fennoscandian wooded pastures (9070)	745 762
Grazing outside of agricultural areas	772 488
Environmentally sensitive permanent grassland	1 654 780
Shrubbery	892 836
Permanent grassland	869 468
Grassland habitat	752 466

3.4 Farmland and Forest bird indices of Estonia

The work was carried out in collaboration with Estonian Environment Agency. The aim was to adapt the methodology and calculate bird indices for croplands and grassland based on the latest version of amendment proposal of Regulation (EU) 2017/2391 and guidance material prepared by Eurostat (latest version: February 2023).

3.4.1 Introduction

Multi-species indices (MSI) are complex ecological indicators that are used to combine relative abundance estimates of a set of species. The objective of a multi-species index is to summarise the status and trends of the set of species. The choice of species is often motivated by the demand to inform different environmental policies. Farmland bird index and forest bird index are two most widely used multi-species indices that are used to summarise the status of birds that breed in farmlands and forests.

3.4.2 Method and results

Multi-species indices are usually estimated by calculating geometric mean of species relative abundance estimates, known as population indices. Population index is a time-series that presents the abundance of a species, relative to a base year (e.g. abundance at 1984 equals 100%). The indices of other years are expressed as percentage of abundance of base year. Population indices and standard errors are calculated using a tailor-made implementation of loglinear regression models known as TRIM (Trends and Indices for Monitoring) software (Pannekoek and Van Strien, 2005). For estimating multi-species indices and confidence intervals, an algorithm using Monte Carlo simulation is used (Soldaat et al., 2017).

As Eurostat Guidance proposes, common farmland bird index summarises population trends of common and widespread birds in farmland habitats and is intended as a proxy to assess the biodiversity status of agricultural landscapes in Europe. Three alternatives can be presented to assess common farmland index: **FBI** (the farmland bird index), **NE-FBI** (North-Europe common farmland bird index) and the common farmland bird index (**LPI**) (Table 17). The Farmland bird index (FBI) is calculated by the Estonian Environment Agency (the Agency) to explain national and international indicators describing biodiversity and agriculture. The Agency does not calculate FBI for PECBMS, since the latter uses calculations for EU and pan-European levels and for sub-regions but not on national level. Species choice for farmland bird index (FBI) is based on 39 species listed in PECBMS species lists (PECBMS, 2022). Source data is gathered according to the Estonian Environmental Monitoring act and it`s sub-programmes: point census of breeding birds (PR0065), monitoring of predatory birds (PR0029) and monitoring of piciformes (PR0069). PR0065 and PR0029 data is used calculating FBI, since monitoring of piciformes is not carried out in cultural landscapes. In 2020 214 out of 1080 census points were located in grassland or cropland (incl. mixed farmland).

From the 39 species, 23 of them breed in Estonia and for about 15 species there is sufficient data for estimating population indices. Species choice for forest bird index (FoBI) is based on 34 species listed in PECBMS species lists (PECBMS, 2022). From the 34 species, 26 of them breed in Estonia. It should be noted that this list does not include some abundant forest species for Estonia (e.g. willow warbler *Phylloscopus trochilus*). Species list of Estonian forest bird index (EST-FoBI) is based on expert choice and includes almost all abundant forest specialists (53 species). In June 2022, the proposal for Nature Restoration Law was introduced by European Commission (DG Environment, 2022). The proposal includes also species lists to assess the status of farmland birds in different member states. For Estonia, this list contains 14 species. This new index is referred as common farmland bird index or in short LPI ("levinud põllulindude indeks").

Table 17. Common farmland indeces: LPI - the common farmland bird index, FBI (the farmland bird index), NE-FBI (North-Europe common farmland bird index) and their upper and lower confidence levels.

Year	LPI	Lower CL LPI	Upper CL LPI	FBI	Lower CL FBI	Upper CL FBI	NE_FBI	Lower CL NE_FBI	Upper CL NE_FBI
2020	58.12	33.55	100.65	62.06	44.06	87.41	65.81	46.35	93.47
2021	67.28	38.35	118.06	68.76	48.09	98.29	67.97	46.62	99.10
2022	63.30	35.38	113.25	65.23	44.11	96.46	61.13	41.21	90.69

3.4.3 References

Directorate-General for Environment. 2022. Proposal for a Nature Restoration Law. https://environment.ec.europa.eu/publications/nature-restoration-law_en

Pannekoek, J., van Strien, A.J., 2005. TRIM 3 manual. TRends and Indices for Monitoring data. Research paper no. 0102. Voorburg, The Netherlands. Available freely at: https://www.cbs.nl/en-gb/society/nature-and-environment/indices-and-trends-trim

Pan-European Common Bird Monitoring Scheme. 2023-02-15. What species is habitat classification used for PECBMS data? https://pecbms.info/methods/questions-and-answers/question-4-1

Soldaat, L.L., Pannekoek, J., Verweij, R.J.T., van Turnhout, C.A.M., van Strien, A.J. 2017. A Monte Carlo method to account sampling error in multi-species indicators. Ecological Indicators. 81, 340-347. https://doi.org/10.1016/j.ecolind.2017.05.033

3.5 Deadwood

The work was carried out in collaboration with Estonian Environment Agency. The aim was to adapt the methodology and calculate the condition indicator on deadwood in forest and woodland ecosystems based on the latest version of amendment proposal of Regulation (EU) 2017/2391 and guidance material prepared by Eurostat (latest version: February 2023).

3.5.1 Method and results

The estimates of deadwood volume are based on data measured in the process of the National Forest Inventory (NFI).

Design of the Estonian NFI is a systematic sample without pre-stratification. The network of sample plots covers the whole country and is planned as a five-year cycle. The sampling intensity is the same throughout the whole country. The sample (cluster) distribution is based on a national 5-km x 5-km quadrangle grid, determined by the L-EST co-ordinates system. Sample plots are concentrated into clusters to increase the efficiency of the survey. Approximately 370 clusters (ca 5 500 sample plots) measured each year i.e. the permanent plots will be re-measured in every 5 years.

An observation unit is an individual field plot that is the centre of sample circles with defined radii. The method of sampling with partial replacement is used. Plots are divided into permanent clusters and temporary clusters that form 800 x 800 metre squares. The sample plot radius depends on the assessed variables, as well as their values (e.g., tree diameter). In addition to plots with the main radii of 10 m and 7 m, where the land-use category is determined, plots of other radii are also used. All population units have an equal probability of being selected into the sample. The result is point estimates of multiple population parameters based on the measurement data. Although all NFI estimates are based on sampling, they are not absolute. Therefore, each estimate of a general parameter is always accompanied with a sampling error. The sampling scheme and design are described in more detail by Adermann (2010)[25].

NFI forest estimates are the basis for national[26] and international statistical reporting: e.g. United Nations/FAO Forest Resources Assessment[27], the Ministerial Conference on the Protection of Forests in Europe (Forest Europe aka MCPFE[28]), information on forest carbon pools and changes for the LULUCF sector in the GHG inventory[29].

3.5.2 Definition and data

NFI provides deadwood volume estimates about standing and lying deadwood of stemwood:

- with utilisation value (at least for fuelwood) and
- without utilisation value (at least for fuelwood) i.e. decaying wood or snags and notches.

In Estonia, usually the standing and lying deadwood with utilization value (at least for fuelwood) is being reported. Same approach is valid in case of Pan-European reporting: Forest Europe process defines deadwood as *non-living woody biomass either standing or lying on the ground, exceeding specified thresholds*. UNFAO FRA includes deadwood estimates indirectly in the form of volume of biomass and stored carbon in deadwood. In case of FRA reporting and GHG LULUCF reporting (of net emissions in CO2 eq) the stem wood volume is expanded with biomass expansion factors to include the non-stemwood and below-ground deadwood.

3.5.3 Data availability and periodicity

NFI is able to provide all mentioned estimates for forest land according to Estonian or international (FRA) forest definition. NFI yearly estimates are available since 1999. Data for the previous year become available in June of the next year. Note that all NFI basic estimates are compiled from the measurements of the 5 most recent years and attributed to the latest year of measurement.

In 2020, the total deadwood was estimated 17.3 m3/ha (Table 18).

Table 18. Deadwood (m3/ha)

	With utilisation value			Without utilisation value			Total deadwood
	standing deadwood	lying deadwood	total	standing deadwood	lying deadwood	total	
	m3/ha						
2020	6.0	8.9	14.9	0.5	1.9	2.4	17.3
2021	6.1	8.8	15.0	0.5	1.9	2.4	17.4

[25] Adermann, V. (2010). Estonia. *In*: Tomppo, E., Gschwantner, T., Lawrence, M., McRoberts, R. (eds). National forest inventories: Pathways for common reporting. Dordrecht: Springer, pp. 171–184.
[26] https://keskkonnaportaal.ee/sites/default/files/Teemad/Mets/Mets2020.pdf
[27] https://www.fao.org/forest-resources-assessment/en/
[28] https://foresteurope.org/state-of-europes-forests/
[29] https://unfccc.int/documents/461808

3.6 Forest tree cover density

The work was carried out in collaboration with Estonian Environment Agency. The aim was to adapt the methodology and calculate the condition indicator on forest tree cover density for forest and woodland ecosystems based on the latest version of amendment proposal of Regulation (EU) 2017/2391 and guidance material prepared by Eurostat (latest version: February 2023).

3.6.1 Method

The estimates of canopy cover are based on airborne laser scanning (ALS) data. The data is collected from airplanes, using a laser scanner which operates in near infra-red (NIR) wavelength. The pulses emitted by the scanner are timed and the position of the reflection (echo) is calculated through the aircrafts GNSS (global navigation satellite system), inertial measurement unit (IMU) and scan angle. The end result is a three-dimensional pointcloud which can be used to describe the whole vertical structure of a forest and the ground beneath. The point cloud formed by the ground reflections is an elevation dataset that allows topographic, hydrological, etc. analyses.

ALS data is processed to distinguish the ground from the pointcloud and canopy cover is then calculated as the ratio of echoes above 1.3 m to all echoes. Those points are considered to represent the crown coverage of woody vegetation. Average forest tree crown coverage is calculated for every pixel of 10x10m of scanned area. To obtain the tree cover density of forest land only those pixels have to be considered which remain inside the perimeter of the designated forest land area. According to the tree cover estimates of the pixels remaining on forest land the average forest tree cover density estimate is then calculated.

The ALS data were processed using FUSION/LDV freeware. The raster maps were processed with QGis and zone statistics using forest land mask of Estonian Topographic Database (ETAK). According to the described method the estimate of tree cover density for 2022 is 70.4%. ALS data is from years 2019-2022, forest land mask of ETAK is as published current status by Estonian Land Board.

Similar method can be used with other types of remote sensing data (e.g. satellite images). ALS method was chosen by remote sensing experts as most accurate and handy available method at present in Estonia. The detailed general description of the methodological approach by Tauri Arumäe and Mait Lang is available in article "Estimation of canopy cover in dense mixed-species forests using airborne lidar data"[30].

3.6.2 Definition and data

"EU-wide methodology to map and assess ecosystem condition[31]" defines tree cover density as follows: "*Tree cover density is defined as the 'vertical projection of tree crowns to a horizontal earth's surface*". Forest tree cover density is mostly used in describing the bushlands in stand-wise forest inventory. Number of trees per ha in case of reforestation areas/young stands and stocking level in case of other stands are used to describe the use of habitat space by woody vegetation on forest land. There is no everyday use of forest tree cover estimates in forestry.

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[30] Available at: https://www.tandfonline.com/doi/full/10.1080/22797254.2017.1411169
[31] Available at: file://sise.envir.ee/Kasutajad$/KAUR/37109292732/Downloads/eu-wide%20methodology%20to%20map%20and%20assess%20ecosystem%20condition-KJNA31226ENN.pdf

ALS measurements are carried out yearly by the Estonian Land Board. Data[32] from flights made in summertime (so-called summer flights or forestry mapping flights) were used for canopy cover estimation. The data for the whole country was gathered from 2019 to 2022. Forest land data from the Estonian Topographic Database (ETAK) by Estonian land Board is used as the basis of the forest land.

3.6.3 Data availability and periodicity

LiDAR elevation data from forestry mapping by the Estonian Land Board is publicly available at: https://geoportaal.maaamet.ee/est/Ruumiandmed/Korgusandmed/Aerolaserskaneerimise-korguspunktid/ALS-IV-ring-2021-2024-p855.html (in Estonian); https://geoportaal.maaamet.ee/eng/Maps-and-Data/Topographic-Data/Elevation-data-p308.html (in English).

Forest land data from the Estonian Topographic Database (ETAK) by Estonian land Board is publicly available at Board's web-site: map layer of woody vegetation (E_305) subtype „Mets", see more https://geoportaal.maaamet.ee/eng/Spatial-Data/Estonian-Topographic-Database-p305.html.

3.7 Share of artificial impervious area cover in coastal areas

The work was carried out in collaboration with Environment Agency and State Forest Management Centre. The aim was to adapt the methodology and calculate the condition indicator "Share of artificial impervious area cover in coastal areas" based on the latest version of amendment proposal of Regulation (EU) 2017/2391 and guidance material prepared by Eurostat (latest version: February 2023).

3.7.1 Method and results

For coastal areas, the share of artificial impervious area cover (% as a national average) is planned to be reported as an indicator describing the condition of coastal ecosystems.

According to the guidance note, original (semi-) natural land cover or water surface in coastal areas with an artificial, impervious cover is considered as an indicator for ecosystem condition degradation.

According to the guidance note, coastal areas are the local administrative units (LAUs) that are bordering or close to the coastline (at least 50% of their surface area within a distance of 10 km from the coastline). A total of 25 municipalities are considered as coastal according to this approach in Estonia. However, two more municipalities having less than 50% of their area within the 10 km zone (Lüganuse and Lääne-Nigula) were also included in the analysis because they are located on the coast. A total of 27 municipalities[33] were thus involved.

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[32] LiDAR data with average pulse density 0.8 p/m^2, distance between pulses 1.64 m,
[33] Borders of local municipalities: Estonian Land Board, https://geoportaal.maaamet.ee/eng/Spatial-Data/Administrative-and-Settlement-Division-p312.html. Validity date 5.04.2023.

Three data sets were tested to calculate the indicator: Corine Land Cover (CLC; 2018[34]; suggested in the guidance note), Estonian Topographic Database (ETD; 2023[35]), and Copernicus imperviousness layer (2019, based on 2018 data[36]). The first two are the so-called pre-classified datasets.

After the delineation of the coastal area (choosing the municipalities) and defining the classes that can be considered as artificial in ETD and CLC datasets[37], the total share of the artificial area (national average) and the share in different municipalities was calculated using standard GIS-programs (ArcGIS, MapInfo). Overlapping phenomena in the ETD dataset were combined before calculations.

All these three datasets gave different results (Figure 1). According to the ETD, the average share of the artificial area in the 27 municipalities is 9%. ETD is the most accurate regarding the topology of the phenomena and the dataset we used was the most up to date, but the dataset is updated irregularly. The result from CLC data was 16% which is much higher value, but it is well known that CLC tends to smooth smaller patches of habitats and other phenomena, including green areas in settlements which are together defined as continuous or discontinuous urban areas in CLC. Thus, CLC tends to overestimate the share of artificial areas compared to the other datasets we used. We also tested the high resolution (10 m) imperviousness layer[4] suggested by European Environment Agency[38] and describing soil sealing and how impervious the surfaces are. According to this data set, the average sealed area (we considered all pixels with an imperviousness value of 1% to 100% as sealed) in these 27 municipalities is 9% that is the same as in the case of ETD data. If the imperviousness data were more up to date, it could possibly be considered the most accurate in terms of assessing the share of impervious land cover, while pre-classified layers like CLC of ETD don't give the full information of how impervious the objects are (e.g., the class comprising sport fields might comprise objects with very variable imperviousness).

It might be useful to test the NDVI-based indices. Copernicus imperviousness layer is also NDVI-based, but the input data is a bit outdated and newer information would be useful. The imperviousness layer enables a methodological comparison with CLC while the datasets are based on the satellite data from the same year (2018).

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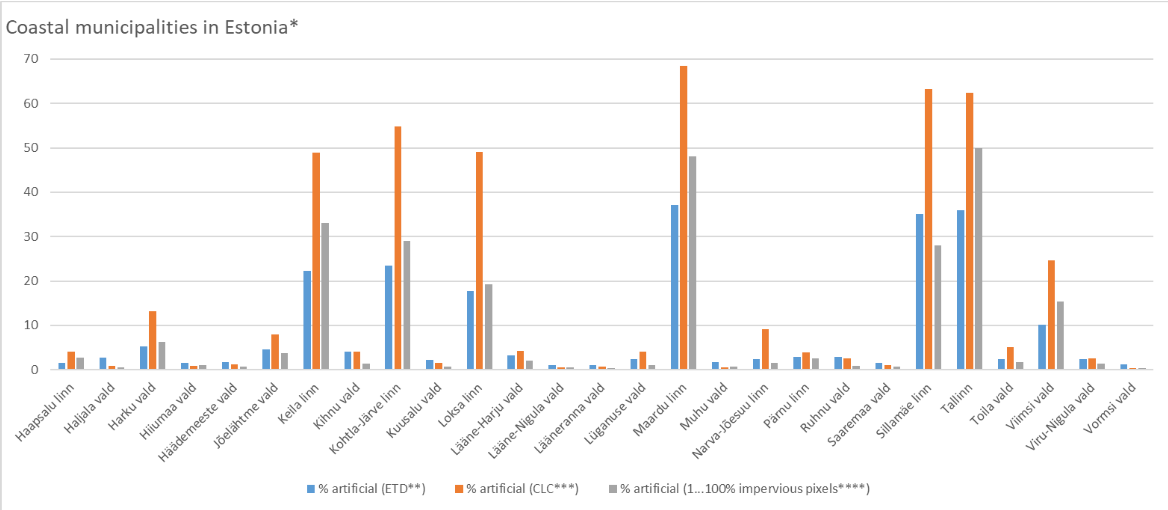
[34] https://land.copernicus.eu/pan-european/corine-land-cover/clc2018
[35] https://geoportaal.maaamet.ee/eng/Spatial-Data/Estonian-Topographic-Database-p305.html
[36] Imperviousness Density 2018 — Copernicus Land Monitoring Service (https://land.copernicus.eu/pan-european/high-resolution-layers/imperviousness/status-maps/imperviousness-density-2018?tab=metadata)
[37] Classes that were considered artificial in this analysis, are listed in respective attached tables and layers.
[38] https://www.eea.europa.eu/publications/soil-monitoring-in-europe



** According to the current definition in the guidance note*
*** ETD – Estonian Topographic Database*
**** CLC – Corine Land Cover*
***** Copernicus imperviousness data*

Figure 5. The share (%) of artificial and impervious areas in 27 coastal municipalities in Estonia.

It should be decided how to define the coastal area. It can be argued whether the current definition of coastal areas is adequate (50% of the municipality within 10 km from the coastline).

We also used 200 m buffer from coastline as a coastal area for comparison. In this case, 25 municipalities are comprised (the cities of Kohtla-Järve and Keila are excluded while they are located further inland) with their 200 m shoreline buffer. According to the Copernicus imperviousness layer 3% of the 200 m wide coastal zone is covered with impervious areas in Estonia. This is significantly less than in the case of the zone defined in the guidance note. The result seems sound while 200 m is generally (but with possibilities for exceptions) the width of the shore building exclusion zone on the seacoast. For comparison, ETD artificial areas cover 11% of the 200 m zone of the coastal 25 municipalities. It should be further analysed (by combining different data sets) why the difference in ETD data and imperviousness data is so large here. It might be the case that the ETD data we used are newer but other reasons should also be investigated in further testing with ancillary data and combined datasets. We did not calculate the areas of the artificial CLC classes in the 200 m zone because of the low possible relevance (the coarseness of the dataset).

Similar calculations can be provided for 100 m (as being currently discussed in EUROSTAT task force) and 500 m buffers (as has been done before in Estonia, in the case of marine ecosystem services mapping process).

In conclusion, national average share of artificial areas on the coast varies from 9 to 16% if the whole area of the coastal municipalities is included in the analysis, and from 3 to 11% in the 200 m wide coastal zone.

3.8 Discussion

The possibility to compile ecosystem condition account was tested. The work showed that condition account can be compiled using the proposed indicators with relative ease in case of availability of relevant knowledge and data. However, it can be discussed whether national (spatial) average is the best representation for describing the condition of ecosystems and what is the deeper meaning behind the obtained results (see ANNEX 1 for discussion).

Using spatial average as a reporting unit may not be the best interpretation of condition. For example tree cover density averaged out over the entire country and over all forest types would not be adequate in Estonia for characterizing the condition of forests. Some forest types in Estonia have naturally lower tree cover density than the others but it does not mean that the previous have worse condition than the latter A forest stand with tree cover density of 30% might be ecologically in a condition as good as one with density of 90% - it depends on the forest type.

Several definitions regarding input data for calculating condition indicators were open for free interpretation in the guidance document. Thus, it was currently up to account compilers to decide which data to use, regarding for example, how to delineate green or impervious areas, which common bird index (LPI, FBI, NE_FBI) or deadwood type to report. These should be agreed upon for harmonized reporting.

Also, connection between ecosystem extent and condition account is rather weak. There are indicators that are calculated for areas that do not include all ecosystem area (cities vs urban area, coastal zone vs coastal ecosystems). Whereas it is not a problem as different data can be combined, attention must be paid how these results are presented as to not create misunderstanding.

In addition, some indicators that are required and defined for other reporting systems (farmland bird index and deadwood) by default use different definition and extent of respective ecosystem classes. That either requires that ecosystem types and extent is compiled in accordance with these reporting guidelines or changing the already set methodology for calculating the indicators. The deeper connection between extent and proposed condition indicators however was not analysed in the work.

4 Ecosystem services

4.1 Overview

The objective of the work was to first compile the list of clearly defined ecosystem services according to the national and international interests of what should be recorded in the ecosystem accounts in biophysical and monetary values. Main idea was to identify the ecosystem services that were left out from previous works in 2019 and 2020 by Statistics Estonia but which were now considered important by Eurostat according to the proposed amendment of the regulation EU 691/2011. Based on the new knowledge and previous experience, the validation of the input data and monetary assessment methods for ecosystem services valuation was carried out as well. Regarding analyzing monetary valuation methods, the objective to find the most suitable method among alternatives. Following chapters provide the results for the services where both applying physical and monetary valuation methods were tested.

Analysis on the list of the services of Eurostat's proposal for legal base (new module of the regulation 691/2011) was carried out. The considered ecosystem services and their definitions according to the proposal for the amendment of Regulation (EU) 691/2011 were:

(a) Provisioning services

– Crop provision, defined as the ecosystem contribution to plant growth as approximated by the amount of harvested crops for different uses. This includes food and fibre production, fodder and energy, and grazed biomass, as set out under Annex III, Table A, Section 1.1 and Section 1.2.

– Pollination, defined as the ecosystem contribution by wild pollinators to the production of the crops above. The contributions shall be reported in tonnes of pollinator-dependent crops that can be attributed to wild pollinators, by type of crop for the main types of pollinator-dependent crops comprising fruit trees, berries, tomatoes, oilseeds and 'other'.

– Wood provision, defined as the ecosystem contribution to the growth of trees and other woody biomass, shall be reported as net increment as defined in Annex VII in over-bark, in thousand m3.

(b) Regulating and maintenance services

– Air filtration is defined as the ecosystem contribution to filtering air-borne pollutants through the deposition, uptake, fixing and storage of pollutants by ecosystem components (particularly trees). This mitigates the harmful effects of the pollutants. The contributions shall be reported in tonnes of particulate matter adsorbed.

– Global climate regulation is defined as the ecosystem contribution to reducing concentrations of greenhouse gases in the atmosphere through the removal (net sequestration) of carbon from the atmosphere and the retention (storage) of carbon in ecosystems. The contributions shall be reported in terms of tonnes of net sequestration of carbon and tonnes of organic carbon stored in terrestrial ecosystems, including above ground and below ground stock.

– Local climate regulation is defined as the ecosystem contribution to regulating ambient atmospheric conditions in urban areas through vegetation that improves the living conditions of people and supports economic production. It shall be expressed and reported as the reduction of temperature in cities, due to the effect of urban vegetation, in degrees Celsius on days exceeding 25 degrees Celsius.

(c) Cultural services

– Nature-based tourism-related services are defined as the ecosystem contribution, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use and enjoy the environment through direct, in-situ, physical and experiential interactions with the environment. These contributions shall be reported in number of overnight stays in hotels, hostels, camping grounds, etc. that can be attributed to visits to ecosystems.

Following ecosystem services were valued and tested both in physical and monetary terms: crop provision, wood provision, pollination, global climate regulation, nature-related tourism services. We also tested the feasibility to compile microclimate regulation for which specific skills and knowledge were needed but were not known before the start of the project.

We tried to find the methods which use validated input data (data gaps found and filled where possible) and the most optimal assessment methods selected for the ecosystem service valuations.

Ecosystem services supply and use account was compiled (2020) and is displayed in chapter 4.9 and in Annex "D1_6_ Dataset of the supply and use tables of ecosystem services_101022852_2020-EE-ENVACC" as MS EXCEL file.

It was also foreseen to include welfare values in addition to exchange values in the process of valuation of ecosystem services where relevant. In following chapters results for the welfare values are discussed in the valuation of air filtration, local climate regulation and nature-related toyrism and recreation services.

Results of monetary assessment of ecosystem services in Estonia was compared with the results of other countries. These values were used as a background information for valuation of ecosystem services (and as a possible candidates for the value transfer method).

Consultations were carried out with Statistics Netherlands but also with Statistics Slovenia.

4.2 Crop provision

According to the definition of the proposal for the amendment of Regulation (EU) 691/2011, the ecosystem service crop provision is defined as the ecosystem contribution to plant growth as approximated by the amount of harvested crops for different uses. This includes food and fibre production, fodder and energy, and grazed biomass, as set out under Annex III, Table A, Section 1.1 and Section 1.2.

In addition to using the preferred method of using data obtained from MFA (material flow accounts) for physical ecosystem service account, the other two approaches mentioned in the guidance note for crop provision[39] were looked into and data available from agriculture statistics and national geo-spatial data on crop production areas and/or data from national registries of agricultural parcels were analysed.

For monetary valuation, the service was valued with rent price method and alternative in the form of resource rent was used. The best method taking into consideration the compatibility with the physical indicator of the service and best approximation to ecosystem contribution was analysed.

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

The service is included in both physical and monetary supply and use tables. These tables are displayed in chapter 4.9 and in Annex "D1_6_ Dataset of the supply and use tables of ecosystem services_101022852_2020-EE-ENVACC" (MS EXCEL file) more detailed distribution by ecosystem types and users is given. Result obtained by rent price is included in SUT out of the other tested alternative monetary valuation methods for the service.

4.2.1 MFA as data source

The supply of crop is found by using the amount of harvested crops in the MFA (material flow accounts) breakdown, sections 1.1 and 1.2. In MFA, the amount of harvested crops is recorded under characteristics 'Domestic extraction'. It is suggested in the guidance note for crop provision that when compiling the supply side of crop provision, 'Domestic extraction' of all reporting items of MFA sections 'Crops' (1.1), 'Crop residues' (1.2.1) and 'Fodder crops including biomass harvest from grassland' (1.2.2.1) is to be recorded as a supply from ecosystem type 'Cropland'. 'Domestic extraction' of MFA item 'Grazed biomass' (1.2.2.2) is to be reported as a supply from 'Grassland'. However, grassland ecosytem types includes permanent grassland which also contributes to fodder production, therefore it would be more correct to attribute MF.1.2.2.1 Fodder crops (including biomass harvest from grassland) to grasslands than croplands. It is also supported by PM0821 data where production from permanent pastures and meadows is recorded The results in the format of the draft reporting table from the guidance note Annex 2a with added final row "total" can be seen in Table 19.

The use of the crop provision ecosystem service is to be attributed to intermediate consumption by industries (agriculture sector). The results in the format of the draft reporting table from the guidance note Annex 2b with added final row "total" can be seen in Table 20.

Table 19. Supply of crop production according to MFA (material flow accounts), thousand tons, 2020

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

.. - data not published

Table 20. Use of crop production according to MFA (material flow accounts), thousand tons, 2020

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

.. - data not published

4.2.2 Agriculture statistics and agricultural register (geospatial data) as data source

With the aim to also find spatial distribution of crop provision ecosystems service the supply of crops was found also by using agricultural statistics, which includes data on area under cultivation (ha), production area(ha), production (tons) and yield (kg(ha) divided by counties.

The guidance note denotes that results obtained using the advanced approaches must be aligned with MFA reporting. Data for the items of MFA section 1.1 crops can be cross walked easily. For MFA 1.2 Crop residues (used), fodder crops and grazed biomass conversions are needed:

1. Items of section 1.2.1 'Crop residues (used)' represent residues of certain common crops included in section 1.1. These residues are not reported in crop statistics, but their amounts further used in the economy can be estimated and the MFA handbook suggests methods (pages 42-46).
2. Data for 'Fodder crops' are collected in crop statistics in EU standard humidity (i.e. 65%; see Table 3, page 14 in Annual crop statistics Handbook, 2020 edition). They need to be converted to 15% humidity.
3. For 1.2.2.2 'Grazed biomass', the MFA handbook provides methods to estimate these data based on agriculture statistics and suggests conversion parameters (e.g. harvest rate, pasture yield, etc.), if these are not available nationally (see MFA handbook, pages 42-46).

Considering the possibilities of data from Agricultural Registers and Information Board which includes agricultural fields and crops grown in the field, the additional data on crop residues that is included in MFA was not included to the data from agriculture statistics.

In order to distribute crop provision on map, crop yields from agriculture statistics were combined with geospatial field data from Agricultural Registers and Information Board and additional grassland and field units from extent map. Only crops and crazed biomass was mapped (Figure 6).

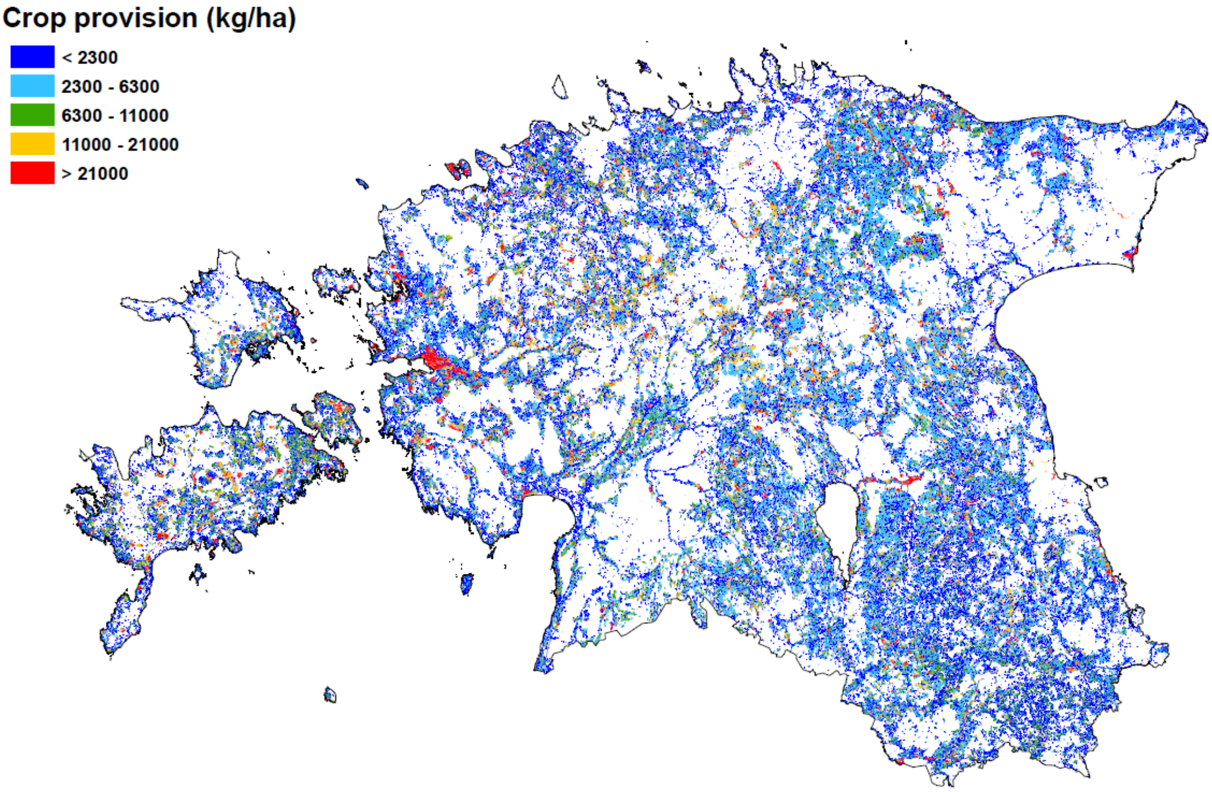


Figure 6. The ecosystem service provisioning areas (croplands and grasslands) and values of crop provision (excluding crop residues). The areas coloured from blue to red represent service provisioning areas according to the physical unit value kg/ha). Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

4.2.3 Monetary value of crop provision

It has been discussed which methods could be used to calculate the monetary value of crop provision ecosystem service and the results of the discussion are displayed in a subchapter "4.2.4. Analysis of alternatives for evaluation methods of crop provision" below. In general the rent price method was agreed to be used due to the fact that calculation results of other approaches tested (see below which comprise only residual value) would underestimate the contribution of ecosystem. However there was no full consensus and according to the opinion of some experts in Estonia and also project team still the simple market value of the agricultural production could reflect in a best manner the ecosystem service of crop production in monetary terms as in this case calculation would reflect the ecosystem contribution in a straightforward manner (data are easily accessible and results are comparable) in a situation where theoretical foundation for the service valuation is still not commonly agreed. Currently in this nevertheless the rent price method was picked as an option for valuation.

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

Necessary data for rent price method are rent payments and extent of area under cultivation. Rent price data were available from agricultural statistics but no distinction on land type or county is made. The average rent price of agricultural land in 2020 was 76 €/ha. In order to calculate the value of fodder production service average rent prices were multiplied with the extent of land in hectares. It was possible to calculate monetary value of grasslands as a total value and additional division between semi-natural and permanent grasslands were made using yield data (permanent grasslands have almost 2.5 times higher yield). Input data from agricultural statistics was detailed enough to calculate monetary value separately for temporary grasslands and agricultural land regarding fodder component. The results are given in Table 21. The use of the crop provision ecosystem service is attributed to intermediate consumption by industries (agriculture sector).

Table 21. Monetary value of crop provision by ecosystem type, 2020, mln EUR

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

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

Output
- Less intermediate consumption
- Less compensation of employees
- Less other taxes on production
- Plus other subsidies on production

Equals Gross operating surplus
- Less consumption of fixed capital (depreciation)
- Less return to produced assets
- less labour of self-employed persons

Equals Resource rent
- = Depletion + net return to environmental assets

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

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

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

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

The resource rent value of agricultural food in 2020 was 14.93 million EUR, detailed calculation can be seen in Table 22.

Table 22. Resource rent value of crop provision, mln EUR, 2020

Transaction	Value, mln EUR
Output	385.39
Less intermediate consumption	283.63
Less compensation of employees	65.35
Less other taxes on production	2.23
Plus other subsidies on production	-91.52
Less consumption of fixed capital	57.85
Less return to produced assets	17.28
Less labor of self-employed persons	35.65
Resource rent	14.93

4.2.4 Analysis of alternatives for evaluation methods of crop provision

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

The Guidance Note on Accounting for the Crop Provision Ecosystem Service[40] (version February 2023) (hereinafter Guidance Note) suggests defining crop provision as *„the ecosystem contributions to plant growth as approximated by the amount of harvested crops for different uses. This includes food and fibre production, fodder and energy, and grazed biomass“*, as set out under proposal for the amendment of Regulation (EU) 691/2011 on European environmental economic accounts Annex IX.[41] It must be admitted that agricultural statistics require some digging to get oriented (especially from the point of view of a non-specialist in the specific field), and the Guidance Note quoted above provides valuable guidance for orientation.

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

[41] Regulation (EU) 691/2011

According to the guidance document, ecosystem accounts define crop provision as the ecosystem contributions to plant growth including food and fiber production, fodder and grazed biomass, and energy products, according to the proposed classification. An indicator of this service is the weight of harvested crops in 1000 tons at "EU standard humidity" or in the case of fodder crops and grazed biomass at the air-dry weight. The definition of the crop production service provided by the ecosystem is clear and understandable.

The guidance document suggests that all data needed on the crop production is available in material flow accounts (MFA). There is also distribution of crop production by ecosystem types (cropland and grassland).

Data in MFA is sufficient to obtain a statistically representative overview of the crop production ecosystem service with an accuracy that is suitable for comparing service provision at the EU level. In case of national analysis, it is possible to allocate the generalized results by using national geo-spatial data on crop production areas or data from the national registry of agricultural parcels.

The main aim is to analyze alternative evaluation methods of ecosystem service of agricultural production; comparing the results obtained by the evaluation method of market value, marginal residual value, rental price and resource rent; and describing the need for the initial data necessary for the calculation. As a result an overview of which indirect evaluation methods can actually be applied to calculate the monetary value of the crop production service provided by the ecosystem is given.

If one of the obstacles in finding the value of ecosystem regulating and welfare services (in addition to conceptual problems from the point of view of classical economic accounting) is the lack of data on the practical expression of corresponding ecosystem services, detailed statistics are available for the crop provision service. Crop provisioning ES enters the economic system in the form of agricultural production. There is a market price for the production and a rental price for the agricultural land (agricultural ecosystem) necessary for the production of agricultural products. In the same way, various cash flows generated during production are also described and available.

The quantification of the crops provision service of the ecosystem should not create ambiguities(which is not the case for several other ecosystem services), because the materialized output of the service is agricultural production, which is accounted for in conventional physical units, which are either mass or volume of production. There is also data on the price of production and the rent of agricultural land, the availability of which enables the financial equivalent of the ecosystem contribution to be found on the basis of the price of production and the rent of land. The statistics on agricultural production and the production process are comprehensive and well reflect the economic data related to production and production process. This is also to be expected, because the prerequisite for receiving various subsidies related to agricultural production common in the European Union is the timely submission of economic data in a way that meets the requirements. In summary, it ensures the comparability of agricultural statistics within the EU.

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

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

These conceptual questions have been raised and discussed by Statistics Estonia and Estonian experts in the London Group article “Two Languages or Two Narratives: Comparison of the Selected

Market Price and Revealed Preferences Valuation Methods to the Stated Preferences Method" in 2020[42]. According to the recommendations of methodological instructions there is a possibility to use four methods: rent price, resource rent, market price and hybrid. Considering that the market price method can use two different input data (agriculture and material flow account, hereinafter MFA), there are as many as five approaches that give a different monetary equivalent to the value of the crop production ES.

Crops such as crops, crop residues, fodder crops, and grazed biomass are classified according to CICES as ecosystem provisioning services. To calculate their monetary value, environmental economists recommend using revealed preference methods. The revealed-preferences method is based on the real shopping behavior of people. The monetary value of an environmental good is considered to be equal with the consumer surplus that the demanders on the market are willing to pay for the environmental good.

As part of previous pilot projects, the rental price, resource rent, market price (two different databases), and hybrid approach methods have been used to calculate the monetary value of crop production services. Below the results of the calculations, advantages and disadvantages of these methods are presented based on the experience gained from their application. The advantages and disadvantages were presented with the aim to make the decision on which of these methods would be the most suitable for the calculation of the monetary value of crop provision according to the proposed definition.

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

[42] 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

production service value, two different databases were used: (1) agricultural statistics, and (2) material flow accounts.
Using the market price method and data from agricultural statistics the value of fodder production ecosystem service was calculated. The total value of fodder production was calculated by multiplying the quantity of fodder produced in grassland with the average market price of the forage. In order to derive the ecosystem service value the expenditures were subtracted from the value of the benefit. As agricultural statistics calculates routinely the value of produced fodder that is traded on market, these data are available. Unfortunately, agricultural statistics do not include data on fodder that is consumed on the field nor crop residues.

The problem of missing data is solved in the data from MFA. To calculate the value of fodder provisioning ecosystem service the amount of fodder is multiplied with the relevant price.

4. The hybrid approach that is a combination of resource rent and market price method was also used. The difference between hybrid method and resource rent is that crop output is calculated using the market price and the variables of resource rent is calculated using the structure of expenditures from the national accounts. In principle, this method of calculation could give the best results, but as long as there is no reliable data on expenditures, this method cannot be used.

The financial values of crop provision ES of Estonian agricultural ecosystems (on fodder's example) as assessed by the above methods are presented in "Development of the land account and valuation of ecosystem services regarding grassland ecosystem services (Eurostat Grant Agreement no NUMBER — 831254 — 2018-EE-ECOSYSTEMS)"[43] and "Development of the ecosystem accounts (Eurostat Grant Agreement NUMBER — 881542— 2019-EE-ECOSYSTEMS)" [44]. The data on fodder production service from the same source (Table 23) clearly show the magnitude of the monetary value of fodder production ES estimated by different methods. The methodology for obtaining the data in the table is described and explained in detail in "Development of the land account and valuation of ecosystem services regarding grassland ecosystem services (Eurostat Grant Agreement no NUMBER — 831254 — 2018-EE-ECOSYSTEMS)"[45] and "Development of the ecosystem accounts (Eurostat Grant Agreement NUMBER — 881542— 2019-EE-ECOSYSTEMS)".

[43] 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/2021-07/Methodological%20report_831254_2018_EE_ECOSYSTEMS_revised_version_31_03%20%281%29.pdf
[44] Statistics Estonia, 2021. Development of the ecosystem accounts (Eurostat Grant Agreement NUMBER — 881542— 2019-EE-ECOSYSTEMS) https://www.stat.ee/sites/default/files/2021-07/D1.1%20Final%20methodological%20report_July_2021.pdf
[45] 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/2021-07/Methodological%20report_831254_2018_EE_ECOSYSTEMS_revised_version_31_03%20%281%29.pdf

Table 23. Values of fodder supply ecosystem service and ecosystem contribution by estimation approaches, million €, 2018 and their relative volume.

Valuation method	Value of the fodder production service	Value of ecosystem contribution	% of the market price-agriculture	% of the rent price evaluation method
Rent price		26.0	37.2	100
Resource rent		4.7	6.7	18.1
Market price - agriculture	69.8	9.1	13.0	35
Market price - MFA	39.3	5.1	7.3	19.6
Hybrid	69.8	5.3	7.6	20.4

From the data in Table 23, it can be seen that the rent price method attributes the highest value to the provisioning ES (provision of fodder), assigning more than one third (37.2%) of the production price. Financial equivalents of fodder provisioning ES found by other methods remain in the same order of magnitude, ranging from 6.7 percent for the resource rent method to 13.0 percent for the market price of production. (A separate methodological question, which is exhaustively described in the report, is how to find the ecosystem's share in the market price of production.)

Looking at the data obtained with the methods based on the market price of agricultural production and rental price of land as a means of production, it is apparently impossible to objectively decide which of the given methods reflects the value of the service of the ecosystem "more correctly" or "the most according to reality", because we do not know what the objective reality is here. And, finally, is the actual ecosystem contribution reflected in the market price of production and the rental price of agricultural land at all.

Based on the experience gained and discussed above it seems currently most reasonable to use the rent price method, which gives approx. 37% of the market price of production. With certain reservations, it can be assumed that the rental price reflects the market value of the land (agricultural ecosystem) as a component of the ecosystem contributing agricultural production. The rental price method has also been used by the Netherlands.[46] The results obtained using other methods attribute only approximately 10% of the market price of production to the ecosystem, which seems unfair to the contribution of the ecosystem, especially if, for example, to assume that the share of both the economic system and the ecosystem in the agricultural production is equally divided between both.

A separate topic is the availability of the data necessary for the implementation of the methods. Currently aggregated (official) statistics that can be directly implemented without any previous assumptions are not available to any of the methods. Hybrid market price method requires sophisticated statistics. The rental price method does not require complicated statistics and is also the only method that can be easily linked with spatial data. And in addition, the rental price method is superior to others in one aspect: namely, the rental price method is abstracted from the specific cultivated agricultural crop, remaining relatively indifferent to the type of agricultural production and the market price depending on it. This allows the rental price method to be more independent of the contribution of the economic system and more faithfully reflect the contribution of the ecosystem.

The natures contribution for maintaining of the agricultural ecosystems quality is still undercovered in current concepts. From this perspective analyzing the available data and methods to calculate

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

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

4.3 Wood provision

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

It is noted that wood provision data in ecosystem accounts and forest accounts should be coherent, and the latter could be the input for the previous. In the work, wood provision was assessed separate from forest account but analysis on results for 2019 was done because an attempt was done to compile forest accounts for 2019 but ecosystem accounts are compiled for 2020. The guidance note for wood provision[47] proposes removals as a voluntary indicator in addition to net increment.

For monetary valuation, the service was valued with stumpage prices calculated over increment and removals (harvested wood). The first is combined better with the physical indicator but the latter shows the real flow that enters economy better.

The service is included in both physical and monetary supply and use tables. These tables are displayed in chapter 4.9 and in Annex "D1_6_ Dataset of the supply and use tables of ecosystem services_101022852_2020-EE-ENVACC" (MS EXCEL file) more detailed distribution by ecosystem types and users is given. Result obtained by stumpage price based on increment is included in SUT out of the other tested alternative monetary valuation methods for the service.

4.3.1 Wood provision supply – physical account

Data on increment and removals was obtained from Estonian Environment Agency. As is described in the wood provision guidance note, a distinction is made between forest available for wood supply (FAWS) and forest not available for wood supply (FNAWS) (Table 24). Data on increment or removals from other land available for wood supply (AWS) or other land not available for wood supply (NAWS) is not included in the NA as it only includes forest. All use of wood provision from FAWS is attributed to 'Intermediate consumption by industries'.

The results in the format of the draft reporting tables for supply and use from the guidance note Annex 1 show the supply and use of wood provision service respectively in Table 25 and Table 26.

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

Table 24. Wood increment and removals (harvested wood) in land available for wood supply (AWS, FAWS- forest available for wood supply) and land not available for wood supply (NAWS, FNAWS- forest not available for wood supply), 1000 m3 overbark, 2020

	Forest and woodland	Total supply
Wood provision - increment in FAWS	11 777.52	11 777.52
Wood provision - increment in FNAWS	2 189.96	2 189.96
Wood provision – increment in other land AWS	n.a	n.a
Removals from FAWS	10 547	10 547
Removals from FNAWS	n.a	n.a
Removals from other land NAWS	n.a	n.a

Table 25. Wood provision – supply table (1000 m3 overbark), 2020

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

Table 26. Wood provision – use table (1000 m3 overbark), 2020

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

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

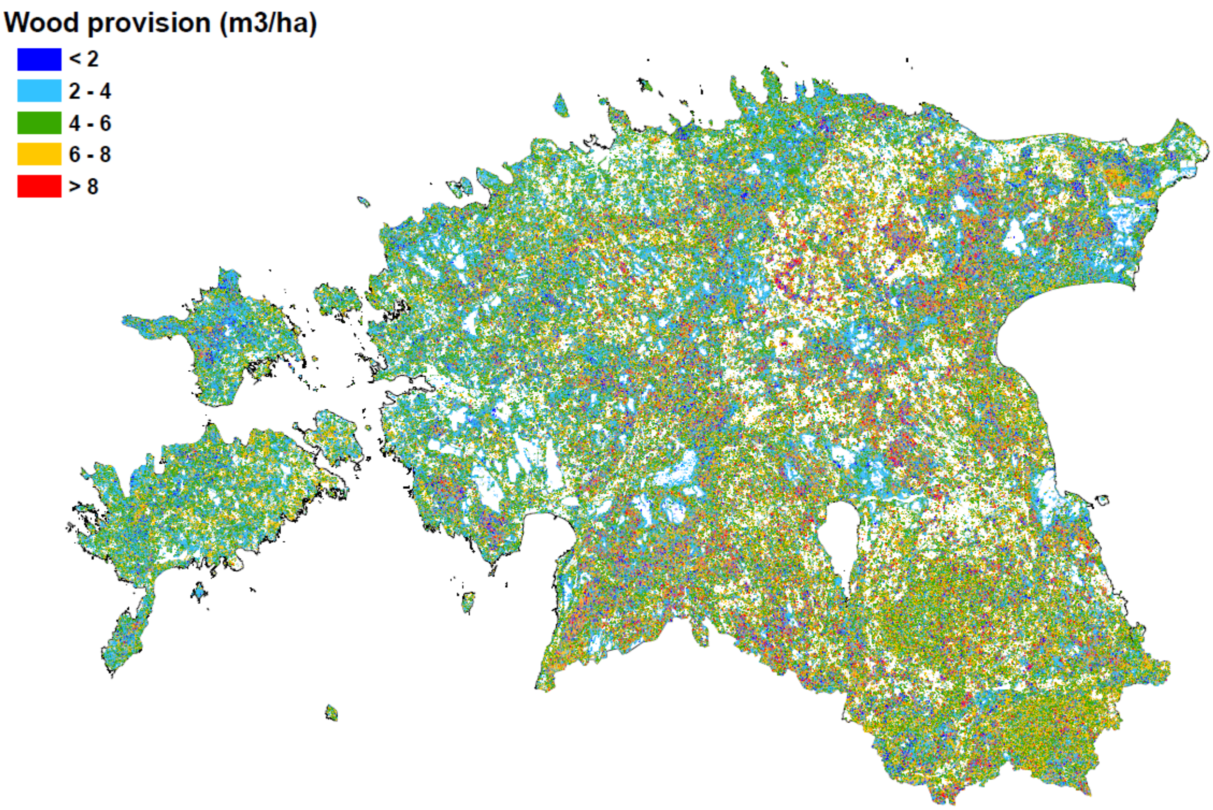

Figure 7. Wood provisioning (based on net increment) areas (forest available for wood supply) and values. The areas coloured from blue to red represent service provisioning areas according to the physical unit value m3/ha). Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

4.3.2 Monetary value of wood provision

Wood increment and harvested timber is also included in national accounts calculations and is a SNA value. Managed and economically restricted forest lands are taken into account, strictly protected forest is excluded.

Standing timber that is considered under inventories of work- in-progress in national accounts and is part of output value in SNA. According to the methodology used in national accounts to obtain the value of standing timber, first, the net increment has to be calculated from wood increment, 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 wood increment. Therefore, the increment of every tree species is reduced by the share of this approximation from the volume of increment.

In order to calculate monetary value of wood provision service, calculations were done separately for increment and harvested wood but using the same stumpage prices where the increment or harvested wood was divided by timber owner (State Forest Management Centre or other ownership), assortment and stumpage prices by timber species. 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.

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.

The value of the wood provision ecosystem service was calculated by multiplying the stumpage prices with the increment or removals (harvested wood). Differences between tree species and assortments were considered.

Table 27. Stumpage prices based on net increment and removals, mln EUR, 2020

	State Forest management Centre	Other ownership	Total
Stumpage price based on net increment	100.4	137.7	238.1
Stumpage price based on removals	88.21	130.04	215.3

Illustrative map of the monetary value was created using stumpage prices based on net increment (Figure 8).

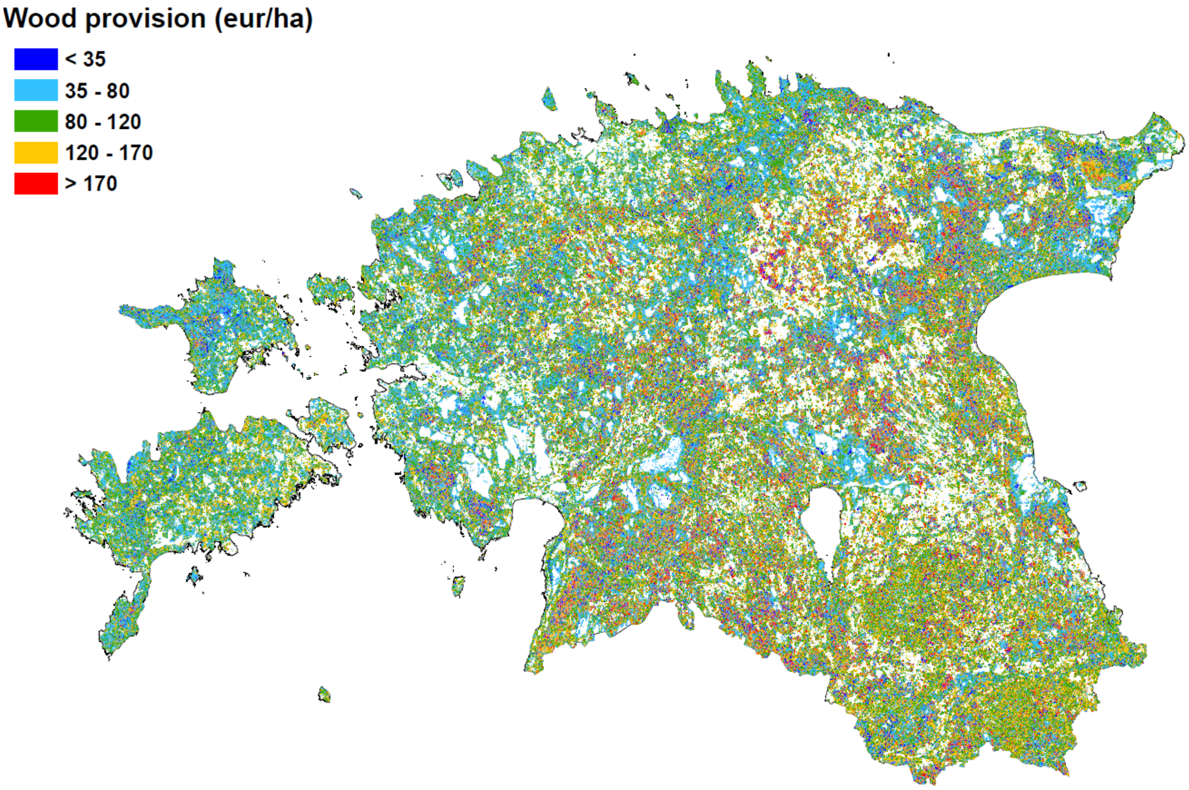

Figure 8. Wood provisioning areas (forest available for wood supply) and the monetary values of the service (stumpage prices based on net increment). The areas coloured from blue to red represent service provisioning areas according to the monetary unit value eur/ha). Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

4.3.3 Coherence between forest accounts and ecosystem accounts

In parallel with developing ecosystem accounts, developing forest accounts is also ongoing and it is foreseen that in the future that data from forest accounts can be used as an input for ecosystem accounts regarding wood provision ecosystem service. This could help to fill the current gaps regarding increment in other land available for wood supply and voluntary indicators regarding removals from land that is not forestland. Ecosystem account was compiled for year 2020 using National Accounts and physical amounts from Estonian Environment Agency as input, but European Forest Accounts are currently compiled only for 2019.

The wood increment calculated in NA for 2019 was slightly less than in forest accounts (*Table 28*). While looking at the calculations

Net increment= increment – dead wood,

it was found that the two approaches calculate dead wood differently. In NA, it is a fixed share from the total increment, whereas in forest accounts a distinction is made for tree species which results in a more precise estimate. This aspect needs to be considered when compiling the accounts.

Table 28. Wood increment in forest accounts and ecosystem accounts, 1000 m3 overbark, 2019

	Net increment in European Forest Accounts	Net increment in ecosystem accounts
Forest	14606	14246
Forest available for wood supply	12362	12052
Forest not available for wood supply	2244	2193

4.3.4 Review and feedback on the methodology and concepts for economic evaluation wood supply as an ecosystem service

The forest ecosystem is characterized by the multitude of ecosystem services it provides, the forest offers both provisioning, regulating and welfare services. At the same time, in the case of a forest, an important fact is that the forest ecosystem cannot provide all these services simultaneously in equal volumes. Thus, wood, the main supply service of the forest ecosystem, competes with regulatory and welfare services. For example, a forest that has undergone clear-cutting no longer has the biological characteristics of a forest ecosystem and cannot provide the regulatory and welfare services typical of a forest ecosystem. The fact that the wood supply service does not occur in isolation from other forest ecosystem services, and often reduces the ability to provide other services, makes accounting for forest ecosystem wood services particularly responsible.

The Guidance Note on Accounting for the Wood provision Ecosystem Service [48] (version February 2023) (hereinafter Guidance Note) suggests to define wood provision as "*the ecosystem contributions to the growth of trees and other woody biomass*". The proposed Forest accounts legal module defines net increment as follows: "*Net annual increment of timber is defined as the average annual volume growth of live trees, calculated from the stock of live trees (growing stock) available at the start of the year less the average annual mortality*".

According to the proposal of the Guidance Note, the annual growth of wood is recommended as a mandatory indicator for accounting for wood, the main supply service of the forest ecosystem. The

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

main drawback of the proposed headline indicator is that the growth of wood (in other words, the increase in biomass) is not directly related to the wood cut from the forest and entering the economy. An alternative and more real economy-based approach would be to account for the removals (second proposed indicator for ecosystem accounting in case of wood provision in relevant guidance note). According to this definition accounting of wood supply services would be based on the wood that actually enters the economy (i.e. felling volumes), functioning accounting exists and is even more easily available than data on annual growth. After all, the annual growth of wood (increment) is much more loosely related to the economy compared to harvested wood (removals).

To justify use of this alternative accounting indicator for the wood supply service of the forest ecosystem, we draw the parallel between the forest accounting service flow estimation and market based approach for crop provisioning services of agricultural ecosystems.

To compare the different accounting bases, an example can be given of accounting for crop provision as a supply service for agricultural ecosystems. The Guidance Note on Accounting for the Crop Provision Ecosystem Service [49] (version February 2023) (hereinafter Guidance Note) suggests to define crop provision as *„the ecosystem contributions to plant growth as approximated by the amount of harvested crops for different uses. This includes food and fibre production, fodder and energy, and grazed biomass"*.

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

For example, in 2019, the net increment of the forest was 12 362 x 10^3 m^3 and the removals were 11 779x$10^3$$m^3$. Thus, the difference was 583 x 10^3 m^3, what is about 5%. From the point of view of accounting and forest statistics, the difference is not quantitatively large, but qualitatively very important, if you look at the services of the forest ecosystem in a complex way, but not only the wood supply service in isolation.

Namely, the increment does not provide information about the quality of the forest, because the cutting (removals) takes place in old (i.e. ripe for cutting) forests, where both emission and especially cultural ecosystem services are high. However, the increment takes place in a significant part in young forests, which cultural services and biological value (especially habitats for biological species) are of considerably lower value compared to old forests. Thus, the age structure of forests can continuously deteriorate, while the annual increment of wood exceeds the removals.

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

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

services of a specific delimited land area. In addition, by using increment-based statistics, a false impression may arise that the use of supply services does not have a significant impact on the total value of ecosystem services of a particular forest.

Three different methods have been currently tested in Estonia for the compilation of forest accounts for the calculation of the stocks but also flows (annual increment and removals) of timber:
1) present value of future revenues, increment 319.80 million euros, removals 304.72 million euros;
2) average net income, increment 142.16 million euros; removals 135.46 million euros;
3) average stumpage price method, flows multiplied by stumpage: increment 369.06 million euros, 304.72 million euros.

Calculating the monetary value of timber provision as one supply service of the forest ecosystem is basically possible using all three proposed methods. All three methods are based on the market price of timber as a supply service output, which is typical for finding the monetary equivalent of ecosystem supply services. But which of the three methods described above would best align with accounting for ecosystem provisioning services? When accounting for ecosystem provisioning services, it must be kept in mind that it is important to adhere to methodological uniformity with provisioning services of other ecosystems.

Apart from the forest, the second major ecosystem that provides provisioning services is the agricultural ecosystem, the economic accounting of which supply service has been compared above with various alternatives of forest accounting.

The currently used methodology for calculating the financial equivalent of the supply service of agricultural ecosystems (agricultural production) is based on the market price of agricultural production (paragraph 4.2.3 and 4.3.4). With such an approach, the question inevitably arises of how to distinguish the component of the contribution of the ecosystem in the market price of the service (agricultural produce) from the contribution of the economy (discussed in London Group article “Two Languages or Two Narratives: Comparison of the Selected Market Price and Revealed Preferences Valuation Methods to the Stated Preferences Method”[50]). This question is complex and theoretically unresolved so far. Thus, (at least initially) the supply service of agricultural ecosystems is taken to be proportional to the market value (market price) of the production.

Of the methodologies proposed to find the monetary value of the supply service of the forest ecosystem, "Value of timber calculated solely with the stumpage prices" corresponds to this best. If the supply service cycle of agricultural ecosystems (from sowing to harvest) is typically 1-2 years, in the case of forests it is considerably longer, being proportional to the trees becoming ripe for cutting. Thus, the time factor is much more important in the assessment of forest supply services compared to agricultural ecosystems.

The time factor is taken into account by applying asset valuation methodology "Net present value of expected future revenues", which takes into account the much longer cycle of forest management compared to agriculture. The essence of the method consists in the present value of the cash flows predicted on the basis of the average stumpage, that is, as the name of the methodology suggests, the

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[50] 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

present value of future income. The fact that it does not distinguish the contribution of the ecosystem from the contribution of the economy to the market value of wood can be considered a drawback of the method. Thus, the deficiency is methodologically similar to the supply service of agricultural ecosystems.

The "Net present value of the future profit" method, which considers the net profit from the wood, would seemingly solve this problem. Unfortunately, this method raises also questions that need to be solved. If you look at the value of assets calculated using this method, it is striking that the differences in the value of during a 10-year period differ many times! Difference between the value of the assets at the beginning and end of the year could be rather high in case of the volatility of the prices. Such volatility would definitely not be recommended in official statistics. Second, one must take into account the nature of profit in the economy.

As we know, the profit (residual value) depends on both the economic situation in the market and the economic policy decisions of the (timber) companies. For example, in some cases the companies could reduce profit to optimize taxes. The influence on the value of the removals from forest is one issue but it should have essentially nothing to do with the value of the ecosystem service. And how does the financial value of the forest supply service show in practice when the company's profit is negative in some years, i.e. if the company is in loss is not clear as well.

Looking from the perspective of ecosystem accounting, this alternative suits best with residual value concept (SEEA EA, chapter 9.36)[51] which is also suggested as one approach in case where the prices (and associated values) are embodied in market transactions. As according to this concept profit can be seen as the residual value if all manmade costs are subtracted from revenue, residual value concept equals the contribution of the ecosystem with the gained profit. If in case of crop provision service the residual value approach was not justified due to the fact that it reduces ecosystem contribution, than in case of forest accounting the high volatility of the market and economic policy of forest companies are main reason why to question the suitability of residual value approach from the viewpoint of valuing ecosystem service timber.

Thus, it seems that from the ecosystem point of view the least controversial is to calculate the monetary value of the timber provisioning service and assets of the forest ecosystem by applying "**Net present value of expected future revenues"** or "average stumpage price method".

4.3.5 Conclusion

The guidance note for wood provision proposes removals as a voluntary indicator in addition to net increment. An attempt was made to find results for both of the indicators of net increment and removals. For forest land available for wood supply the net increment was 11 million m3 overbark and

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

removals was 10 million m3 overbark, but there is little information on the indicators for other land categories, which in another hand contribute only somewhat compared to forest land which is the main contributor to the service.

It is noted that wood provision data in ecosystem accounts and forest accounts are foreseen to be coherent, and the latter could be the input for the previous. In the work brief analysis was made between forest account and ecosystem account regarding wood provision service. The definitions regarding wood provision service should also be homogenized with those given in forest accounts.

For monetary valuation, the service was valued with stumpage prices calculated over increment or removals (harvested wood). Stumpage prices calculated over increment were 237.9 million euros and it is directly connected with the proposed mandatory physical indicator. Stumpage prices calculated over removals were 215.3 million euros and it shows better the real flow that enters the economy. Net present value of future revenue (increment 319.80 million euros, removals 304.72 million euros) and average net income (increment 142.16 million euros; removals 135.46 million euros) were additional methods which were applied in forest account that could give the economic value for wood provision.

4.4 Crop pollination

According to the definition of the proposal for the amendment of Regulation (EU) 691/2011, the ecosystem service pollination is defined as the ecosystem contribution by wild pollinators to the production of the crops above. The contributions shall be reported in tonnes of pollinator-dependent crops that can be attributed to wild pollinators, by type of crop for the main types of pollinator-dependent crops comprising fruit trees, berries, tomatoes, oilseeds and 'other'.

In the proposal for the amendment of Regulation (EU) 691/2011 and the respective guidance note for pollination[52], the service is named 'pollination' but it was found by national experts that is more correct to name the service as 'crop pollination' because it focuses on benefits received only from production of the crops and excludes other important functions related to pollination.

Pollination was one of the ecosystem services that was assessed in previous grant project (881542— 2019-EE-ECOSYSTEMS[53]) and the methodology was very similar to the methodology presented in the guidance note for pollination. The used version of the guidance note is still in early draft form therefore the methodology was not yet modified to accommodate the differences between the used and proposed methodology (pollinator species, foraging range, included crop types and their pollination demand). Because of the strong connection with crop provision ecosystem service, additional work required dividing pollination also between crop types.

For monetary valuation of the service the method and model used in physical accounting was complemented with basic prices by crop type.

The service is included in both physical and monetary supply and use tables. These tables are displayed in chapter 4.9 and in Annex "D1_6_ Dataset of the supply and use tables of ecosystem services_101022852_2020-EE-ENVACC" (MS EXCEL file) more detailed distribution by ecosystem types and users is given.

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[52] Eurostat – Unit E2. Guidance note for accounting for the pollination ecosystem service in the EU- second draft. Doc.ENV/EA/TF/2023_1/7. Task force on ecosystem accounting 22 - 23 February 2023
[53] Statistics Estonia, 2021. Development of the ecosystem accounts (Eurostat Grant Agreement NUMBER — 881542— 2019-EE-ECOSYSTEMS) https://www.stat.ee/sites/default/files/2021-07/D1.1%20Final%20methodological%20report_July_2021.pdf

4.4.1 Methodology and results

Biophysical and monetary service flow was modelled using spatial data of crops and pollinator habitats. Input data included yearly data for 2020 from agricultural statistics (PM0281: Agricultural land and crops by county[54]), spatial data of agricultural support and land parcels (Estonian Agricultural Registers and Information Board (ARIB)[55], ecosystem extent map), basic unit prices of agricultural crop products.

The methodology proposed by scientists of Wageningen University and Research [56] 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[57].

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[58], 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[59].

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[54] https://andmed.stat.ee/en/stat/majandus__pellumajandus__pellumajandussaaduste-tootmine__taimekasvatussaaduste-tootmine/PM0281/table/tableViewLayout2

[55] https://avaandmed.eesti.ee/information-holders/pollumajanduse-registrite-ja-informatsiooni-amet

[56] 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

[57] 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

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

[59] ibid

Using the obtained dataset the relative visitation rate (scale 0-100) in crop field unit c from surrounding habitat units h was calculated [60]

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

where

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

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:

[60] 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

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

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.

The result 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 75 thousand tons. In comparison, the total crop provision of the crops that depend on pollination was 387 thousand tons. The ecosystem service value by ecosystem types and crop types is shown in Table 29. The format for the reporting table is taken from the guidance note for crop pollination (chapter 3). According to guidance the reporting unit should be 1000 tonnes, but here unit of tons is used to illustrate the values better. In the draft table 'MF.1.1.1 Cereals' is not included as most common cereals don't require pollination, but buckwheat which is one of cereals has been included in the calculation of the service (pollination demand up to 90%), therefore cereals were included in the results table.

The use of the service is assigned, like the crop provision service, to the intermediate consumption by industries (Table 30).

Table 29. Supply of crop pollination ecosystem service (tons), 2020

	Artificial area	Cropland	Grassland	Forest	Wetland	Coast	Other	Total supply
Crop pollination (total)	15 915.6	1 358.3	25 577.0	32 142.4	254.9	3.4	37.2	75 288.8
MF.1.1.1 Cereals	509.6	42.7	989.7	981.7	8.9	0.3	1.4	2 534.4
MF.1.1.4 Pulses	1.8	0.1	2.0	1.5	0.0	n.a	0.0	5.5
MF.1.1.6 Oil-bearing crops	14 400.8	1 145.5	22 838.3	29 597.9	223.8	2.9	32.6	68 241.9
MF.1.1.7 Vegetables	720.5	86.7	1 215.9	944.3	15.0	0.1	2.3	2 984.8
MF.1.1.8 Fruits	282.9	83.2	531.1	617.0	7.1	0.1	0.9	1 522.3

Table 30. Use of crop pollination ecosystem service (tons), 2020

	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	Total use
Crop pollination (total)	75 288.8					75 288.8
MF.1.1.1 Cereals	2 534.4					2 534.4
MF.1.1.4 Pulses	5.5					5.5
MF.1.1.6 Oil-bearing crops	68 241.9					68 241.9
MF.1.1.7 Vegetables	2 984.8					2 984.8
MF.1.1.8 Fruits	1 522.3					1 522.3

Spatial distribution of the ecosystem service (Figure 9) 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.

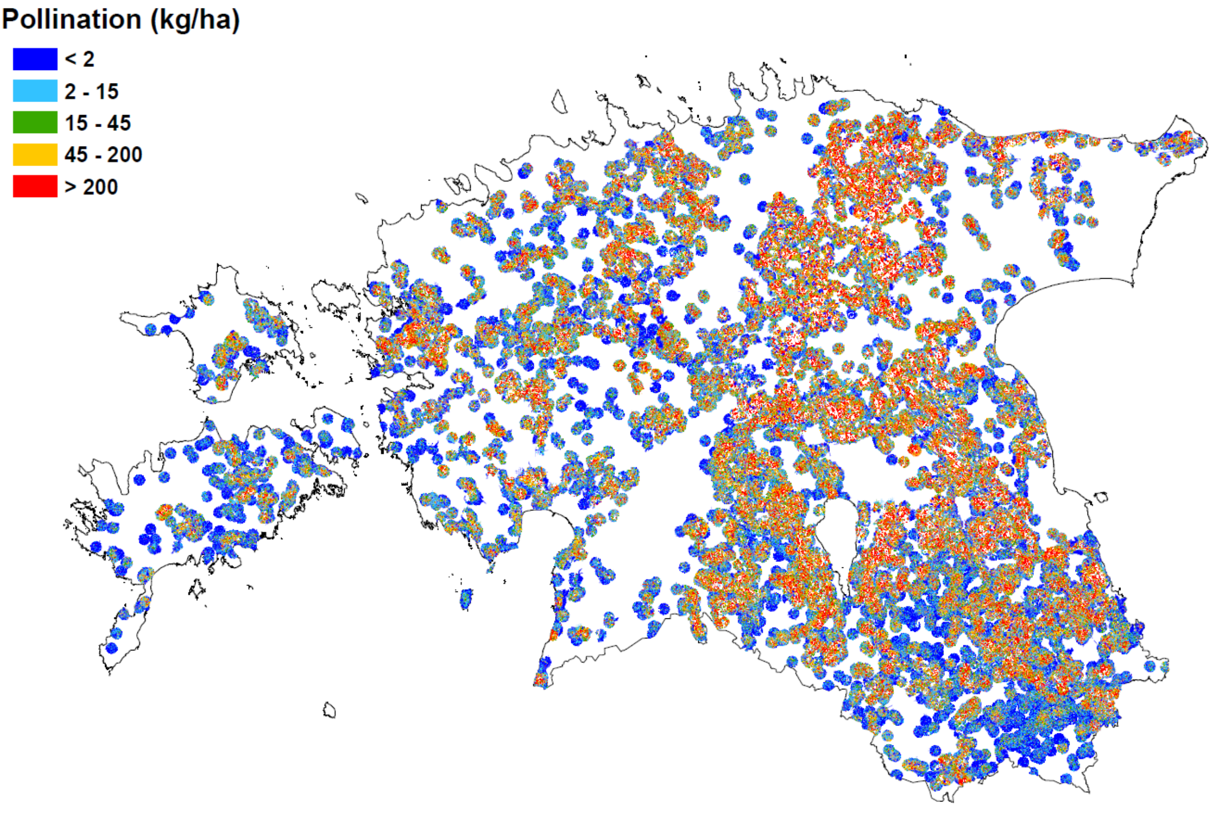

Figure 9. The ecosystem service provisioning areas and values of ecosystem service of crop pollination. The areas coloured from blue to red represent service provisioning areas according to the unit value (kg/ha) supplied by ecosystem assets. Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service in the current scope of the study.

As mentioned above by incorporating average crop basic price data in the step where potential crop production reduction is calculated, the result from the model for the ecosystem service is obtained in monetary units instead of biophysical. The total monetary value of the pollination service was 29. 5

million EUR. In 2019, the monetary value of the service was calculated for 31 million EUR. The ecosystem service value by ecosystem types and crop types is shown in Table 31. Similarly to physical flow, an illustrative map was created to display the monetary value of pollination service spatially (Figure 10)

Table 31. Supply of crop pollination in monetary values (thousand euros), 2020

	Artificial area	Cropland	Grassland	Forest	Wetland	Coast	Other	Total supply
Crop pollination (total)	6 180.52	605.99	9 992.62	12 573.85	102.15	1.37	14.64	29 471.14
MF.1.1.1 Cereals	70.05	5.88	136.04	134.93	1.22	0.04	0.20	348.35
MF.1.1.4 Pulses	0.36	0.03	0.39	0.30	0.0006	0	0.00002	1.08
MF.1.1.6 Oil-bearing crops	5 382.29	428.13	8 535.83	11 062.22	83.66	1.09	12.18	25 505.40
MF.1.1.7 Vegetables	242.34	29.16	408.97	317.64	5.06	0.02	0.76	1 003.96
MF.1.1.8 Fruits	485.48	142.80	911.40	1 058.76	12.21	0.21	1.50	2 612.36

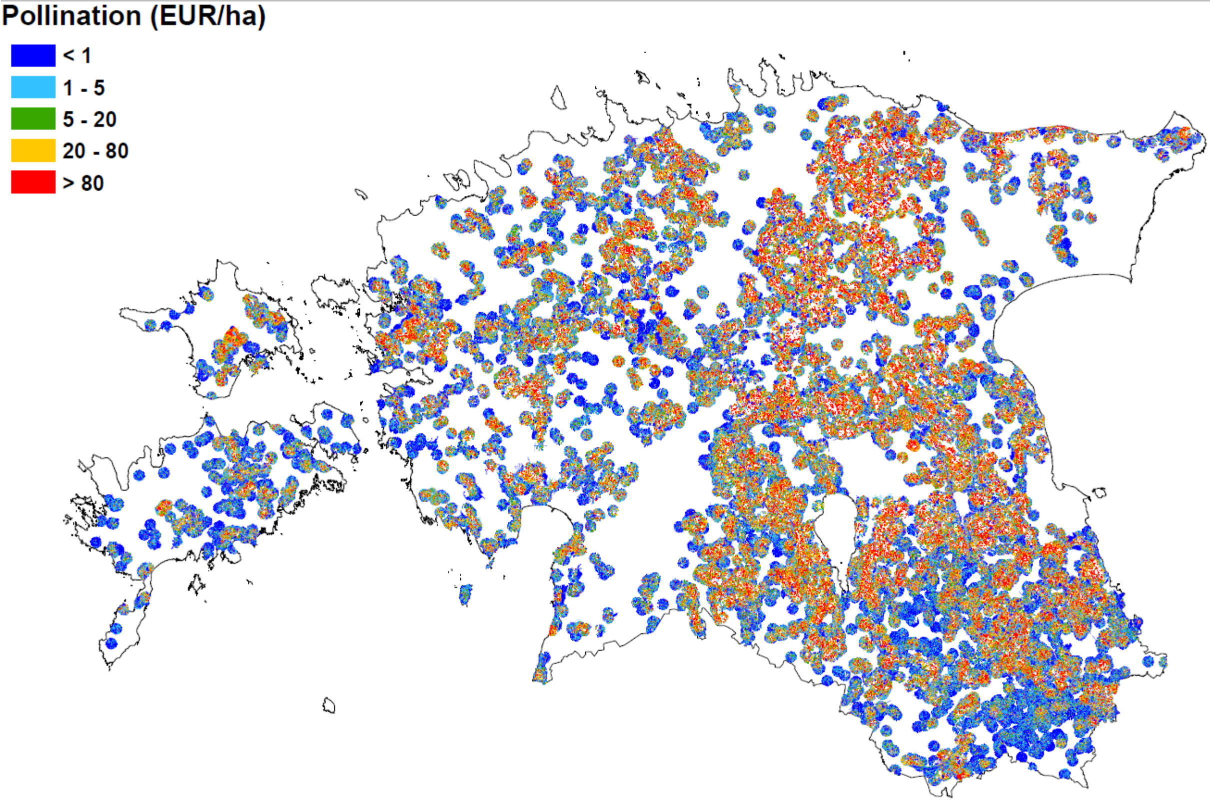

Figure 10. The ecosystem service provisioning areas and monetary values of ecosystem service of crop pollination. The areas coloured from blue to red represent service provisioning areas according to the unit value (eur/ha) supplied by ecosystem assets. Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service in the current scope of the study.

4.4.2 Conclusion

Crop pollination was accounted for by using a methodology and model developed in previous works which is similar to the method proposed in the guidance note for pollination. In addition to the division of the supply by ecosystem type, the data was linked with crop types solidifying the connection with accounting for crop provision. Pollination service was estimated to be 75 thousand tons. In comparison, the total crop provision of the crops that depend on pollination was 387 thousand tons.

In the proposal for the amendment of Regulation (EU) 691/2011 and the respective guidance note for pollination[61], the service is named 'pollination' but it was found by national experts that it is more correct to name the service as 'crop pollination' because it focuses on benefits received only from production of the crops and excludes other important functions related to pollination. Arguably it is difficult to account for and even qualify all the benefits received due to pollination and in this sense it performs more like a regulating than provisioning service. Considering the previous, it would be good to differentiate 'crop pollination' as it only covers one aspect of 'pollination' and use 'crop pollination' with the respective assumptions for estimating the service.

For monetary valuation of the service the method and model used in physical accounting was complemented with basic prices by crop type. The total monetary value of the pollination service was 29. 5 million EUR.

Pollination is assessed in ELME1 project[62] using InVEST model[63] which additionally considers the condition of the ecosystems and the synergy between ecosystem assets. When comparing the input datasets (habitat suitability) several differences were found. It may be that the assumptions by the experts were made on different bases but objective data cannot be obtained unless separate studies for this purpose are carried out but until then the data remains to be agreed upon. In both of the assessments one foraging flight range is used (1750 m used in Statistics Estonia, 400 m used in ELME1). Due to the different flight ranges these models essentially either focus on pollinators with short (bumblebees) or long (recluse bees) foraging range. The guidance note for pollination also proposes to distinguish between species or species groups, with at least two groups dividing pollinators based on short or long flight distances, to improve the calculations. Therefore, it was considered a reasonable addition to include different flight ranges to the calculation of visit rates in the model for pollination service in the future.

4.5 Air filtration

According to the definition of the proposal for the amendment of Regulation (EU) 691/2011, the ecosystem service air filtration is defined as the ecosystem contribution to filtering air-borne pollutants through the deposition, uptake, fixing and storage of pollutants by ecosystem components (particularly trees). This mitigates the harmful effects of the pollutants. The contributions shall be reported in tonnes of particulate matter adsorbed.

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[61] Eurostat – Unit E2. Guidance note for accounting for the pollination ecosystem service in the EU- second draft. Doc.ENV/EA/TF/2023_1/7. Task force on ecosystem accounting 22 - 23 February 2023

[62] Helm, A., Kull, A., Veromann, E., Remm, L., Villoslada, M., Kikas, T., Aosaar, J., Tullus, T., Prangel, E., Linder, M., Otsus, M., Külm, S., Sepp, K., 2021. Metsa-, soo-, niidu- ja põllumajanduslike ökosüsteemide seisundi ning ökosüsteemiteenuste baastasemete üleriigilise hindamise ja kaardistamise lõpparuanne. ELME projekt. Tellija: Keskkonnaagentuur (riigihange nr 198846). http://loodusveeb.ee/en/countrywide-MAES-EE-condition-and-services-terrestrial

[63] Sharp, R., Douglass, J., Wolny, S., Arkema, K., Bernhardt, J., Bierbower, W., Chaumont, N., Denu, D., Fisher, D., Glowinski, K., Griffin, R., Guannel, G., Guerry, A., Johnson, J., Hamel, P., Kennedy, C., Kim, C.K., Lacayo, M., Lonsdorf, E., Mandle, L., Rogers, L., Silver, J., Toft, J., Verutes, G., Vogl, A. L., Wood, S, and Wyatt, K. (2020). InVEST 3.8.6 User's Guide. The Natural Capital Project, Stanford University, University of Minnesota, The Nature Conservancy, and World Wildlife Fund.

The assessment of the service in physical units was done in co-operation with the Department of Air and Climate of Estonian Environmental Research Centre (EKUK). It was also discussed by experts that according to the definition and methodology described in the guidance note for air filtration, the service is best described as deposition of particulate matter rather than air filtration. Therefore in the chapter 'air filtration', 'deposition' and 'air quality' are used as synonyms denoting the ecosystem service of air filtration.

For monetary valuation of the service, an overview was done on research articles and possible methods that could be best implemented for benefit transfer of the monetary value regarding the physical indicator describing the service (amount of deposited PM2.5). Economic value of air filtration was also estimated based on CVM questionnaire.

The service is included in both physical and monetary supply and use tables. These tables are displayed in chapter 4.9 and in Annex "D1_6_ Dataset of the supply and use tables of ecosystem services_101022852_2020-EE-ENVACC" (MS EXCEL file) more detailed distribution by ecosystem types and users is given.

4.5.1 Methodology and results

The PM concentration ($PM_{2.5}$) C_{PM} was used to calculate the amount of deposition. Following emissions assessments and modeling were carried out for the year 2020:

- Fine particles ($PM_{2.5}$) from all anthropogenic sources, like:
    - Traffic,
    - Residential wood combustion,
    - Energy and industrial sector,
    - Agriculture

National emissions data (2020) was used as input for the emissions, which were validated with air quality monitoring results.

The emission dataset was imported into the Airviro modeling system and emission sources were identified as grid sources. The modeling utilized meteorological observation data from the year 2020. The Eulerian grid dispersion model was used. For the modeling of the entire Estonia, the size of the modeling grid cell of 1000x1000 m was used. Hourly results from the dispersion model were aggregated into annual average value, where each grid cell in the modeling grid corresponded to the arithmetic mean of the calculated hourly average values for that grid cell. The modeling results (Figure 11) were compared to monitoring data at monitoring points. The model was considered reliable if sufficient agreement was obtained at all monitoring points.

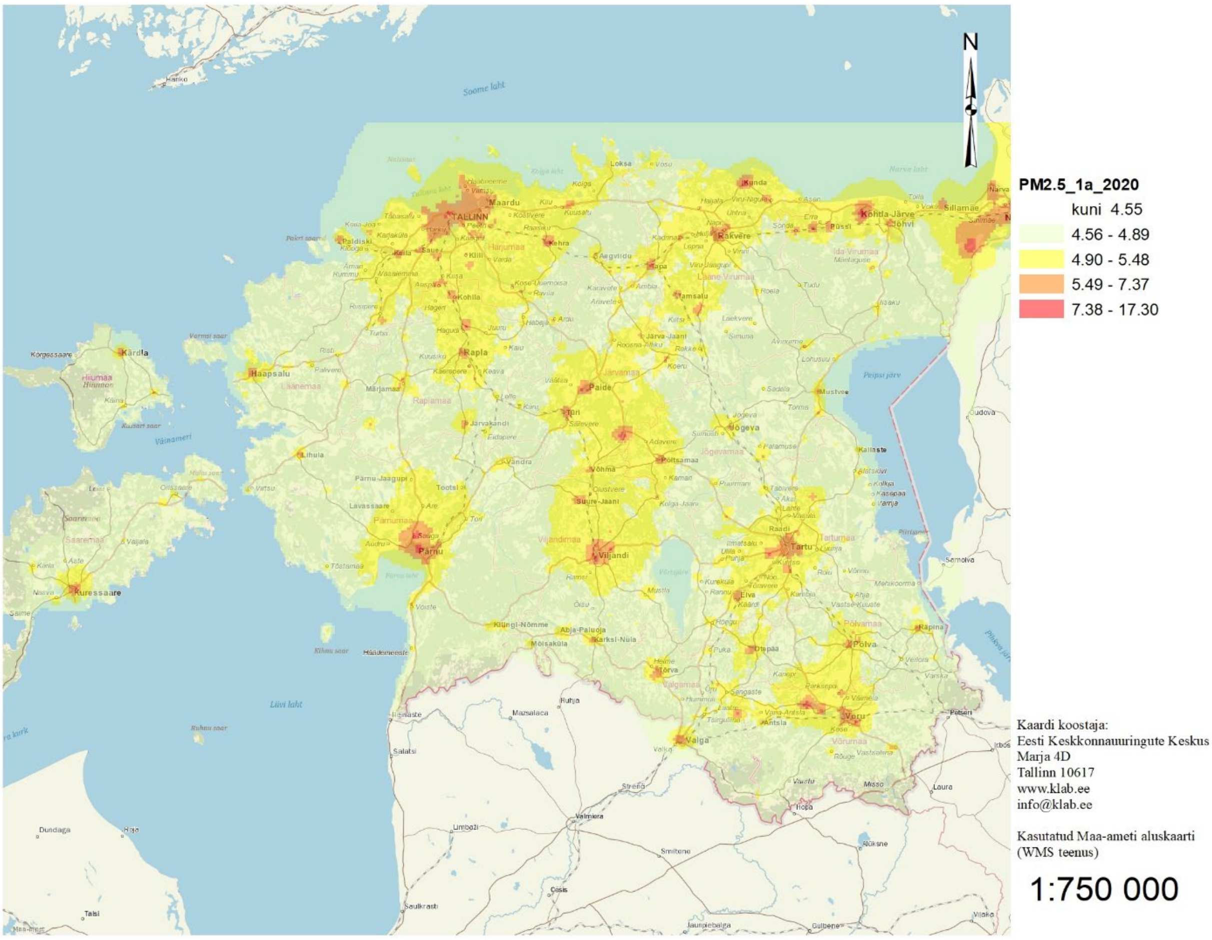

Figure 11. Modelled $PM_{2.5}$ yearly concentration, µg/m^3

For the deposition velocity Copernicus Land Monitoring service was used, where the open access LAI data with 1000 metre spatial resolution (Figure 13) and for the 2020 vegetation period (May to end of August), was used. In order to compute the deposition for a certain time period, the instantaneous deposition must be multiplied for the number of seconds of the selected period. The following equation yields the Vd in a certain pixel for a certain period:

$Vd = Vd_{(LAI)} \times LAI$ (Equation 1)

With:

Vd = Deposition velocity for PM per period in cm/s, adjusted by actual LAI. In the case of $PM_{2.5}$, but not PM_{10}, Vd is amongst others influenced by wind speed (see Annex 1).

$Vd_{(LAI)}$ = Deposition velocity values for PM per unit of LAI and period, in cm/s, see Table 1

LAI = Leaf Area Index per period.

Table 32. $Vd_{2.5LAI}$ as a function of wind speed

Wind speed (m/s)	$Vd_{(LAI)}$ (cm/s)
0	0.000
1	0.030
2	0.087
3	0.143
4	0.160
5	0.176
6	0.182
7	0.504
8	0.819
9	0.810
10	1.836
11	1.772
12	1.688
13	1.625

A basic method of annual average Vd(PM2.5) was used according to equation 1.

Yearly average wind speed data from Copernicus was used and are presented in Figure 12.

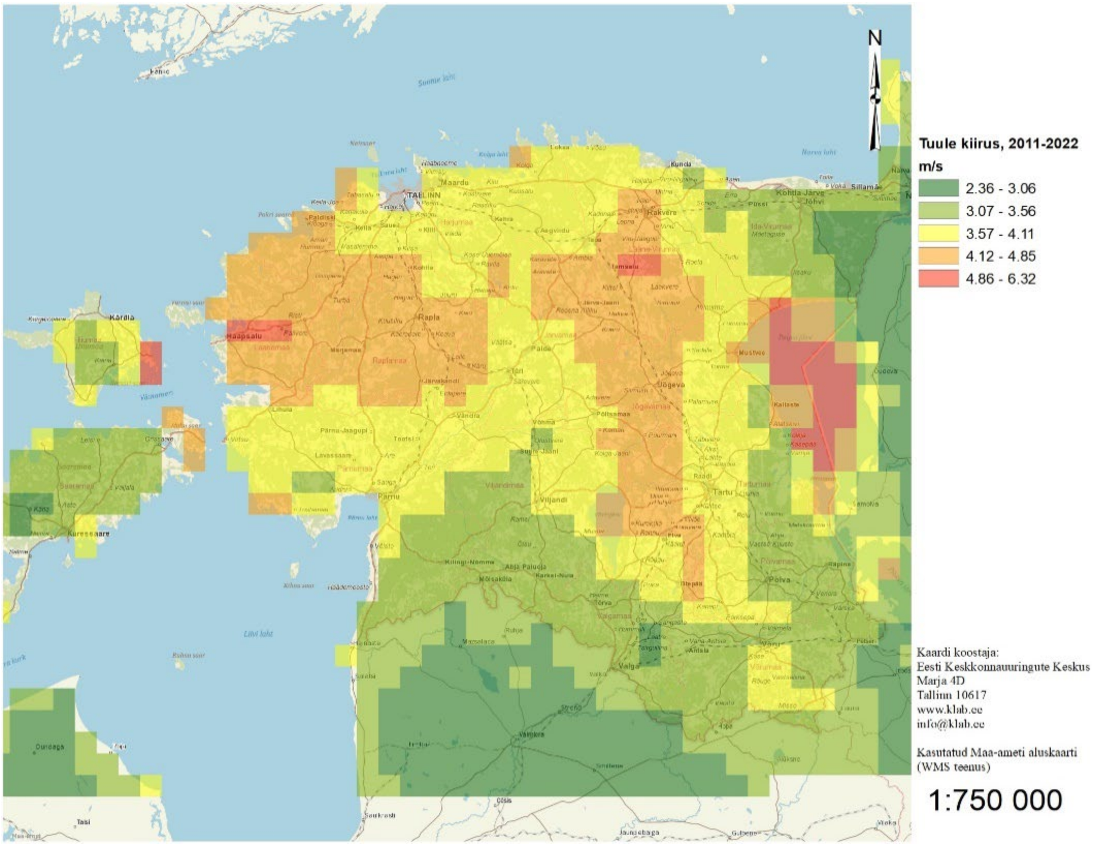

Figure 12. Copernicus wind speed data, m/s

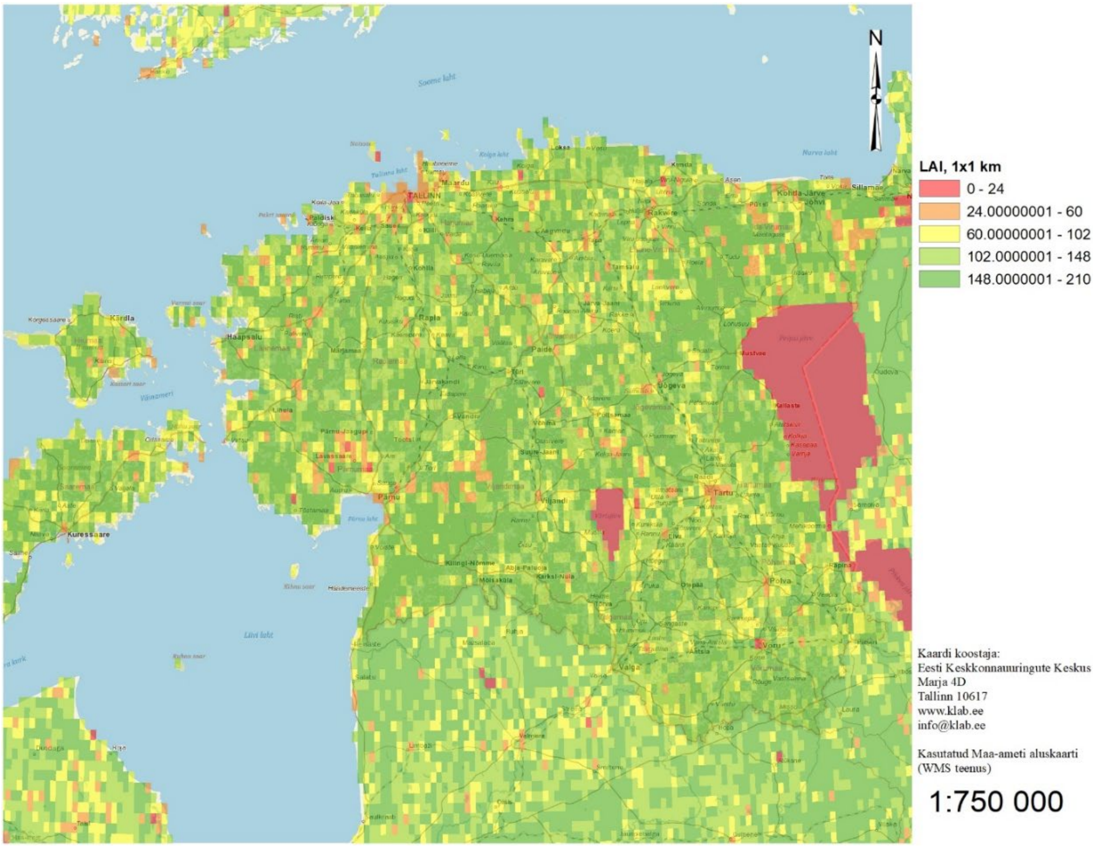

Figure 13 . Used LAI data

Based on $PM_{2.5}$ concentration and Vd data the PM2.5 deposition was calculated, using following formula:

$$PM_{2.5} \text{ deposition (tonnes/km}^2\text{/year)} = \text{Vd (cm/s)} \times C_{PM} \ (\mu g/m^3) \times 3.1536 \times 10^{-3} \quad \text{(Equation 2)}$$

$$\text{Total } PM_{2.5} \text{ deposition (tonnes/year)} = \sum \text{PM deposition (tonnes/km}^2\text{/year)} \quad \text{(Equation 3)}$$

$PM_{2.5}$ deposition (tonnes/km^2/year) are presented in Figure 14 and in total 554 tonnes of $PM_{2.5}$ are adsorbed yearly due to “air filtration”. The users of the service are households.

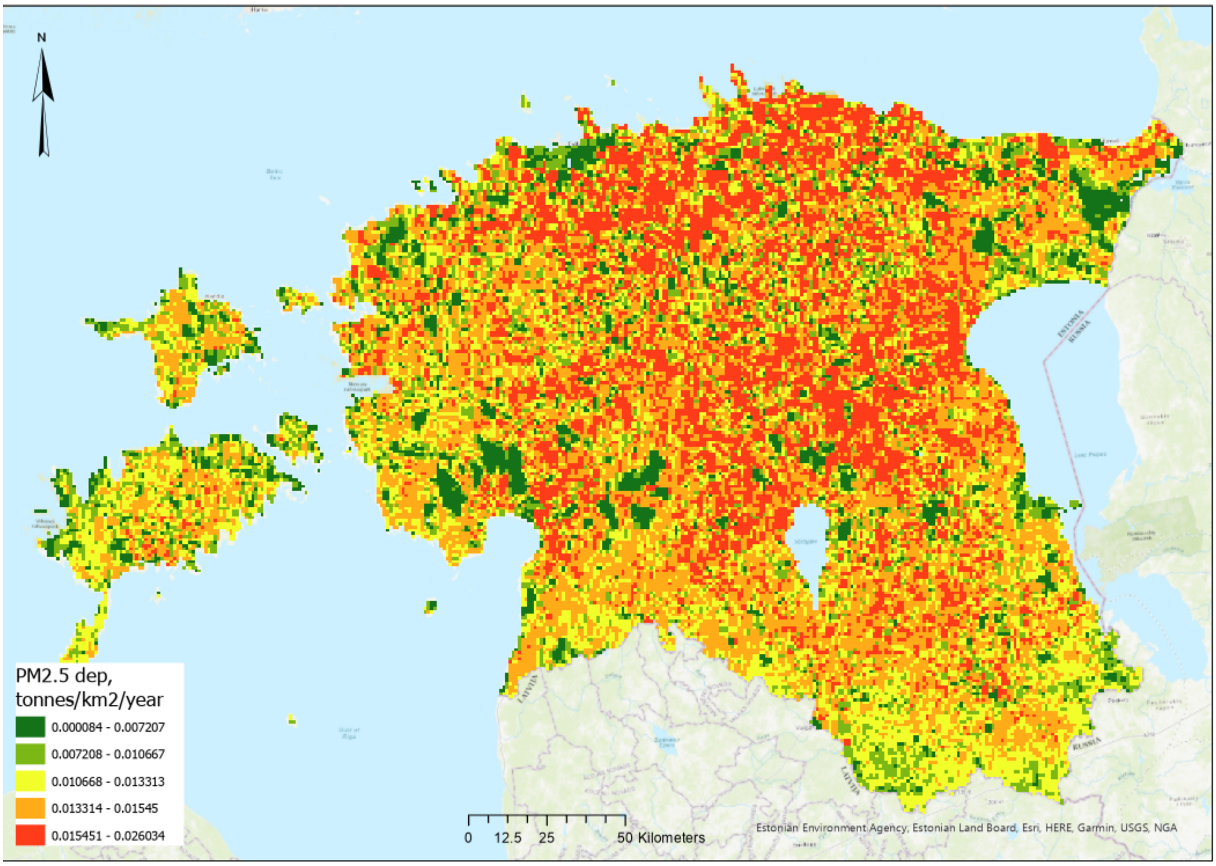

Figure 14 . PM2.5 deposition (tonnes/km^2/year) in 2020

In Table 33 the air filtration ecosystem service by the ecosystem type level 1 results can be found. For the ecosystem classification the Corine Land Cover (CLC) 2018, Version 2020_20u1 (https://land.copernicus.eu/pan-european/corine-land-cover/clc2018?tab=metadata) dataset was used (Figure 15) and combined with the PM2.5 deposition dataset in order to merge the spatial coverage of both datasets and fill the Table 33.

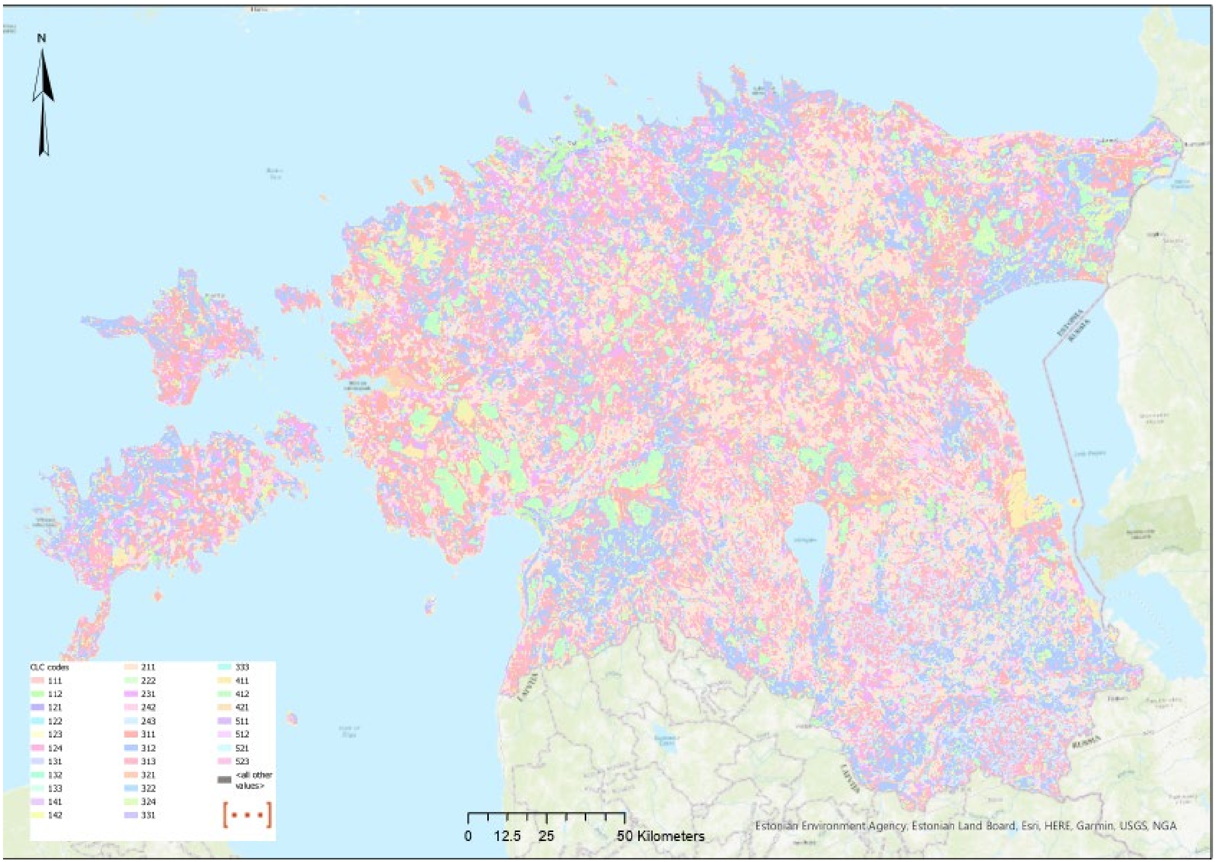

Figure 15. Corine Land Cover (CLC) 2018 dataset

Table 33. Reporting format for the supply of the air filtration ecosystem service

Reporting item	Ecosystem type level 1											
	1	2	3	4	5	6	7	8	9	10	11	12
	Settlements and other artificial areas	Cropland	Grassland	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystems	Inland wetlands	Rivers and canals	Lakes and reservoirs	Marine inlets and transitional waters	Coastal beaches, dunes and wetlands	Marine ecosystems
Air filtration (Tonnes of PM adsorbed) (mandatory)	15.98	186.45	4.02	225.27	98.72	0.05	18.52	1.23	3.05	0.01	0.58	0.08

Obtained map for deposited PM2.5 was merged with extent map and additionally division between ecosystem types (Classification of ecosystems for ecosystem accounting in Estonia) was found (Table 35)

4.5.2 An overview of studies and the calculation of economic value of the air filtration ecosystem service

The proposed legal module Ecosystem accounts defines the air filtration service as the ecosystem contribution to filtering air-borne pollutants through the deposition, uptake, fixing and storage of pollutants by ecosystem components (particularly trees). Air filtration ecosystem service shall be reported in tons of particulate matter ($PM_{2.5}$ or PM_{10}) adsorbed.[64]

The main aim of this paper is to give an overview of the studies where the economic value of the air filtration regulation has been calculated, and analyses which of these studies can be used for benefit transfer. Three limiting factors of the search was set:

1. The study calculates the economic value of air filtration ecosystem service (preferably value of tons of particulate matter deposited);
2. The publication period of the article is from 2010 to the present day;
3. The study was carried out in countries with similar or close socio-economic and climatic conditions to Estonia.

The following databases was used: Ecosystem Services Valuation Database (ESVD)[65], research database EBSCO *via* Tallinn University of Technology library[66], The ReseachGate[67]. Also simple Google search[68] was used. The following key words was used to search appropriate scientific articles and reports: “monetary value”, “economic value”, “value”, “air filtration”, “air purification”, “particulate matter” “PM2.5”, “PM10”, “external costs”, “damage costs”.

Below is presented study reports that may be considered to use for benefit transfer to calculate economic value of air filtration (PM2.5) in Estonia. No of these results are directly transferable as they have been carried out in countries with very different socio-economic conditions compare with Estonia. During the transfer process the economic difference of the study country and Estonia must be leveled.

1. Baro and others (2014)[69] conducted research within the administrative boundaries of the municipality of Barcelona, Spain. There is 1.62 million inhabitants in an area of 101.21 km^2. The total green space within the municipality of Barcelona amounts to 28.93 km^2 representing 28.59 % of the municipal area and a ratio of 17.91 m^2 per inhabitant. In the last decade, the city has repeatedly exceeded the EU limit values for average annual concentrations of nitrogen dioxide (NO2) and PM10 pollutants (40 lg m^3 for both pollutants).

   The i-Tree Eco model was used to quantify ecosystem services and disservices in Barcelona. The Public Health Agency of Barcelona provided PM10 concentration data from the 13 operational monitoring stations of the city during the year 2008. The i-Tree Eco model estimates dry deposition of air pollutants (i.e., pollution removal during non-precipitation periods), which takes place in urban trees and shrub masses. Externality value applied to the case study is transferred from U.S report where PM10 = 6614 USD per ton (year 2007) [70].

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[64] European Commission Eurostat (2023) Guidance note for accounting for the local climate regulation ecosystem service in the EU – third draft. Task force on ecosystem accounting. 21 – 22 February 2023. Virtual meeting
[65] https://www.esvd.net/
[66] https://taltech.ee/koik-andmebaasid
[67] https://www.researchgate.net/
[68] https://www.google.com/
[69] Baro, F., Chaparro, L., Gomez-Baggethun, E., Langemeyer, J., Nowak, D.J., Terradas, J. (2014) Contribution of Ecosystem Services to Air Quality and Climate Change Mitigation Policies: The Case of Urban Forests in Barcelona, Spain. AMBIO 2014, 43:466–479
[70] Murray, F.J., L. Marsh, and P.A. Bradford. 1994. New York state energy plan Vol. II: issue reports. Albany, NY: New York State Energy Research and Development Authority.

Air filtration in case of PM10 removal by Barcelon trees and shrubs is estimated at 166.0 tons per year with an economic value of 1,097,964 USD per year (USD 2008 year).

2. Yin and others (2017)[71] carried out the study with aim to assess health impacts and external costs related to PM2.5 pollution in Beijing. PM2.5 concentrations were retrieved for the entire 2012 period in 16 districts of Beijing. Exposure-response coefficients were obtained from literature. Both the value of statistical life (VSL) and the amended human capital (AHC) approach were applied for external costs estimation, which could provide the upper and lower bound of the external costs due to PM2.5. The results showed that the external costs were equivalent to around 0.3% (AHC, China's guideline: C_0 = 35 μg/m^3) to 0.9% (VSL, WHO guideline: C_0 = 10 μg/m^3) of regional GDP depending on the valuation method and on the assumed baseline PM2.5 concentration (C_0). Among all the health impacts, the economic loss due to premature deaths accounted for more than 80% of the overall external costs. Among the morbidity health impacts, chronic bronchitis was associated with the largest economic loss: from US$ 0.14 billion (AHC, C_0 = 35 μg/m^3) to US$ 0.42 billion (VSL, C_0 = 10 μg/m^3). The external cost calculated using the WHO guideline (10 μg/m3) were almost double than the external cost estimated with China guideline (35 μg/m^3). The external costs ranged from US$ 18 to US$ 147 per capita among all districts and were highest in Shijingshan and Daxing districts.

3. Gómez and Iturra (2021)[72] applied hedonic price method to study economic value of air filtration. The study's main dataset came from the Chilean National Socioeconomic Characterization Survey for 2017. PM2.5 concentration is a health threat especially affecting the population living in the central and southern communes of Chile. Using housing data for 312 spatial units, along with interpolation techniques to predict air pollution for communes with missing information, they found that, on average, 1 μg/m^3 increase in PM2.5 produces a decrease of 4.1 % in housing rental prices. An average Chilean household would be willing to pay US$12.31 per month for a one-unit reduction in PM2.5 concentration. Similar monetary values have been found in previous studies for both México and Chile. As with PM2.5 concentration, the average marginal willingness to pay exhibits marked differences across communes.

4. Li and Managi (2022)[73] studied whether the current concentrations of air pollution (SO2, NOX, and PM2.5) affect humans' attitudes toward air pollution and decrease human well-being. The study is based on a nationwide survey conducted from 2015 to 2017, which covers almost 300,000 people in Japan. Authors applied aggregated data of hourly measured concentrations of air pollutants collected by 1,906 measurement points distributed in the whole of Japan provided by the National Institute for Environmental Studies of Japan. They used questionnaire to get information on willingness to pay of air pollution reduction.

Based on the analyses of 300,796 observations, authors came to the conclusion that air pollutants (SO2, NOX, and PM2.5) are negatively related to life satisfaction. Study results

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[71] Yin, H., Pizzol, M., Xu, L. (2017) External costs of PM2.5 pollution in Beijing, China: Uncertainty analysis of multiple health impacts and costs. Environmental Pollution. Volume 226, pages 356-369

[72] Gómez, K., Iturra, V. (2021) How does air pollution affect housing rental prices in Chile? An economic assessment of $PM_{2.5}$ concentration across Chilean communes in Environment and Development Economics. Volume 26 (4) pp 364 – 380. https://doi.org/10.1017/S1355770X20000522

[73] Li, C., Managi, S. (2022) Spatial Variability of the Relationship between Air Pollution and Well-being. Sustainable Cities and Society. Volume 76, January 2022, 103447. https://www.sciencedirect.com/science/article/pii/S2210670721007204#sec0012

showed that on average, a 1-unit reduction of PM2.5 was worth 7,111 USD per capita. Researchers concluded also that humans perceive the air pollution severity to some degree, rather than accurately and absolutely.

UK Department for Environment, Food and Rural Affairs (2021) [74] published a dataset 'Enabling a Natural Capital Approach'. The database includes case studies where the financial value of removing PM2.5 from the air has been calculated (Table 34). Avoided health cost (mainly life years lost) method is used to calculate monetary value of the service.

Table 34. Indicative average values for air pollution removal in 2015 for different habitats calculated from aggregate UK values.

Source	Value	Notes
Jones et al (2017) for ONS	£ 771 / hectare (2012 prices)	Indicative average annual value for air pollution removal by **urban woodland** - calculated by dividing UK value for urban woodland by the modelled area of urban woodland (97,600 hectares).
	£245 / hectare (2012 prices)	Indicative average annual value for air pollution removal by **rural woodland** - calculated by netting off UK urban woodland value (£75 million) from UK woodland total (£759 million) and dividing by UK area of non-urban woodland (2.79 million hectares).
	£149 / hectare (2012 prices)	Indicative average annual value for air pollution removal by **urban grassland** - calculated by dividing value for urban grassland in (£61.3 million) by area of urban grassland (0.412 million hectares).
	£14 / hectare (2012 prices)	Indicative average annual value for air pollution removal by **enclosed farmland** - calculated by dividing UK enclosed farmland value (£172 million) by UK enclosed farmland area (12.55 million hectares).
	£26 / hectare (2012 prices)	Indicative average annual value for air pollution removal by **coastal margins** - calculated by dividing UK coastal margins value (£1.1 million) by UK coastal margins area (44,500 hectares) .
ONS (2019)	£1.3 billion (2018 prices)	Estimate of UK avoided health costs in 2017 from pollution removal by UK vegetation, based on Jones et al (2017) and using Defra's updated damage cost valuations in 2019 (see Air Pollution tab). No habitat breakdowns are given. Asset values are also provided based on pollution projections but also population and income growth.

[74] UK Department for Environment, Food and Rural Affairs (2021) Enabling a Natural Capital Approach.https://www.data.gov.uk/dataset/3930b9ca-26c3-489f-900f-6b9eec2602c6/enabling-a-natural-capital-approach

The following input data were used to calculate the monetary value of PM2.5 deposition by Estonian ecosystems in 2020:

1. According to Estonian Environmental Research Center Estonian ecosystems absorbed 554 tons of PM 2.5 in 2020[75];
2. The monetary value of PM10 absorption by trees and bushes was 6614 USD/ton (year 2007) [76];
3. According to the Estonian ambient air monitoring map[77] PM10 measured in Estonian air contains an average of 40% PM2.5 over the last 10 years;
4. The exchange rate of the euro and the US dollar in 2020 was 1.142[78].

Total monetary value of Estonian ecosystem ability to deposit PM2.5 is 1 284 237 EUR in 2020. The value of the PM 2.5 deposition by ecosystem is presented in Table 35.

Table 35.Physical and monetary value of deposited PM2.5 by ecosystem types, 2020

Ecosystem type	DEposited PM2.5, tonnes	Monetary value of PM2.5 deposition, eur
Grassland	60	138 585
Wetland	23	52 854
Cropland	109	253 143
Forest	325	753 301
Artificial area	27	62 308
Other	0	983
Coast	0	148
Inland waterbodies	10	22 815
Total	554	1 284 137

4.5.3 Economic value of air filtration regulation based on CVM questionnaire

The air surrounding an individual is (along with water) the basis of life on Earth. The continuous consumption of oxygen is essential for the existence of most higher living organisms (including humans). It is not possible not to breathe the surrounding air. Unlike water, clean air cannot be bottled or purified by boiling or filtering. The fact that an individual cannot avoid and must consume the air that surrounds him shows the exceptional objective importance of air quality in ensuring human health, as well as its importance as a guarantor of subjective well-being.

The Guidance Note for Accounting for the Air Filtration Ecosystem Service in the EU[79] (hereinafter Guidance Note) addresses the ecosystem service associated with air cleaning in compliance with SEEA EA 2021 and SEEA EEA TR 2017 *as the ecosystem contribution to filtering air-borne pollutants through the deposition, uptake, fixing and storage of pollutants by ecosystem components (particularly trees).*

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[75] Maasikmets, M., Garcia, J. (2023) Hindamismetoodika ökosüsteemiteenuse „õhufiltratsioon" kohta vastavalt määruse (EU) No 691/2011. Eesti Keskkonnauuringute Keskus OÜ, Tallinn.
[76] Murray, F.J., L. Marsh, and P.A. Bradford. 1994. New York state energy plan Vol. II: issue reports. Albany, NY: New York State Energy Research and Development Authority.
[77] https://xn--huseire-00a.ee/?zoomLevel=8&lat=58.88711&lng=25.569944
[78] https://data.oecd.org/conversion/purchasing-power-parities-ppp.htm
[79] The Guidance Note for Accounting for the Air Filtration Ecosystem Service in the EU – Fourth Draft. Doc. ENV/EA/TF/2023_1/3 Item 3 of the agenda.

This approach clearly places the air cleaning service among the regulatory ecosystem services that can be objectively evaluated through quantitative changes in the state of the environment. In The Guidance Note, it is recommended to take the change in the concentration of particulate matter (PM) particles (primarily PM2.5 and PM10) in the air because of the ecosystem's activity as a quantitative criterion for the air cleaning (filtering) service of the ecosystem. The chosen criterion is logical, because the concentration of PM particles in the air is widely measured and their impact on human health has been extensively studied.

The Guidance Note also describes practical problems that arise when attributing changes in the concentration of PM particles to ecosystems, such as the effect of atmospheric movement (wind) on the concentration of PM particles, the seasonality of the ecosystem service (outside the vegetation period, the service decreases considerably), the dependence of the volume of the ecosystem service on the concentration of PM particles in the surrounding air, etc. To overcome practical problems related to service seasonality and wind, the Guidance Note proposes two methods. A basic method, where default values of annual average Vd(PM10) or Vd(PM2.5) are used that are not adjusted for seasonal variation in LAI (Leaf Area Index) or wind speed, and advanced method, where Vd is modelled based LAI and, in the case of PM2.5, also wind speed. Thus, there are no methodological obstacles to the practical application of PM particle concentration change as a quantitative measure of ecosystem air filtration regulatory service. However, it appears that the final decision to adopt PM particle concentration as a measure of air filtration ecosystem service is based on the availability of data on PM particle concentration and an institutional system for data collection.

Also, people's subjective welfare related to air quality does not only depend on the concentration of PM particles (which, in general, cannot be directly felt by the senses in most cases), but also on several other air-related indicators. Therefore, it is a reasonable hypothesis that, in addition to the reduction of the concentration of PM particles, which measures the regulatory service of ecosystem air filtering, the services that influence the air quality by the ecosystem also have features of so-called welfare services, what can be quantified and monetarily valued using methods specific to ecosystem welfare services. The impact of ecosystem air cleaning and oxygen production services on the welfare of individuals as well as its monetary equivalent have been studied using the contingent valuation method both in Estonia and elsewhere in the world.
The work "Air quality improvement estimation using contingent valuation method in HoChiMinh City"[80] carried out in HoChiMinh City can be cited as an example of air quality studies using the contingent valuation method. The purpose of the study is to estimate the air quality improvement in the urban areas of HoChiMinh City through resident's willingness to pay (WTP) by using contingent valuation method. Although the aim of the research was not to evaluate ecosystem services in improving air quality, it does show that air quality affects the well-being of individuals and that people have a significant willingness to pay for it. It can be concluded that there is also a WTP for ecosystem services that clean the air.

4.5.3.1 Empirical CVM Studies in Estonia

The aim of the study 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

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[80] https://www.researchgate.net/publication/330551055_Air_quality_improvement_estimation_using_contingent_valuation_method_in_HoChiMinh_City/link/604bd88492851c2b23c56bfa/download

studies were performed, one for each ecosystem. The sample sizes used for the CVM studies, share of positive payment decisions and total willingness to pay are shown in the Table 36. The sample structure was representative of the Estonian adult population.

Table 36. Sample size, share of positive payments and total WTP for forest, wetland and urban ecosystem services.

Ecosystem	Number of responses to be considered	The share positive payment decisions, %	Total WTP for all services included in the CVM questionnaire, million EUR/year
Forest	660	90	23.9
Wetland	400	89	12.3
Urban	720	91	17.3

The results of the work have been published in two articles (Ehrlich, Ü., 2021[81]; Ehrlich, Ü., 2022[82])

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. The basic data on total willingness to pay for all three CVM studies were three surveys of the willingness to pay of a representative sample of the Estonian working-age population. Based on this, the total demand functions for the respective ecosystem services were determined and the demand curves was constructed.

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.

It should be noted that the services presented for ranking in the different ecosystems CVM studies did not completely overlap. While the service directly related to air purification was defined as "Air and water purification" in the study of forest and wetland ecosystems, the corresponding service was "City air purification" in the study of urban ecosystems. The question is how to fairly divide the willingness to pay attributed to the "Air and water purification" service between water purification and air purification and what part of the monetary equivalent of the "joint service" can be attributed for the air purification service. Without further research, there is no precise basis for the distribution, so it is most convenient to divide the willingness to pay for water and air purification equally between water and air, attributing 50% of the total value of the combined service to the value of the air purification service. In addition, the list of ecosystem services to be evaluated included such an ecosystem service related to air quality as "Photosynthesis (oxygen production)", which was ranked high in all three studies, but the willingness to pay for this service cannot be directly attributed to air cleaning in the sense of removing PM particles, as the service is defined in the Guidance Note.

The monetary equivalent of the air cleaning ecosystem service is presented in Table 37. For all three studied ecosystems, this service has been rated as very important, ranking second among forest (1.

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[81] Ehrlich, Ü. 2021. Contingent Valuation as a Tool for Environmental Economic Accounting: Case of Estonia. Estonian Discussions on Economic Policy, 29 (1-2), 56–70. DOI: 10.15157/tpep.v29i1-2.18342.
[82] Ehrlich, Ü. 2022. Willingness to pay for urban ecosystem services as input for statistics: a case of Estonia. Estonian Discussions on Economic Policy, 30 (1-2), 85–103. DOI: 10.15157/tpep.vi1-2.22088.

oxygen production) and wetland (1. maintaining clean water resources) ecosystem services, and first among urban ecosystems of services.

Table 37. The Monetary equivalent of an air cleaning ecosystem service of forest, wetland and urban ecosystems.

ECOSYSTEM/ Ecosystem Service	Relative importance among services	% of total value of the services of the respective ecosystem	Total WTP for respective ES (thous. EUR)	Adjusted WTP for shared service between water and air (thous. EUR)
FOREST/ Air and water purification	2.	13.71	3271	1635.5
WETLAND/ Air and water purification	2.	13.29	1631	815.5
URBAN/ City air purification	1.	14.9	2579	2579
TOTAL				5030

The annual (adjusted) total willingness to pay of the adult population of Estonia for the air purification services of the three studied ecosystems is approximately 5 million euros per year.

4.5.4 Conclusion

The assessment of the service in physical units was done in co-operation with the Department of Air and Climate of Estonian Environmental Research Centre (EKUK). Total PM2.5 deposition (tonnes/km2/year) was 554 tonnes of PM2.5 are deposited yearly due to “air filtration”. The users of the service are households.

For monetary valuation of the service, a benefit transfer method was applied for the physical indicator describing the service (amount of deposited PM2.5) and the value was found to be 1.3 million euros. Economic value of air filtration was also estimated based on CVM questionnaire and found to be 5 million euros. As expected, different methods gave different results and therefore the assumptions behind the results need to acknowledged when discussing and using the results.

4.6 Global climate regulation

According to the definition of the proposal for the amendment of Regulation (EU) 691/2011, the ecosystem service local climate regulation is defined as the ecosystem contribution to reducing concentrations of greenhouse gases in the atmosphere through the removal (net sequestration) of carbon from the atmosphere and the retention (storage) of carbon in ecosystems. The contributions shall be reported in terms of tonnes of net sequestration of carbon and tonnes of organic carbon stored in terrestrial ecosystems, including above ground and below ground stock.

The guidance note for global climate regulation ecosystem service[83] further defines mandatory indicators and introduces voluntary indicators that support the understanding of the dynamics of the service.

It is noted in the guidance note that LULUCF sector (land use and land use change) in national greenhouse gas (GHG) inventories provide much of the data required to account for net carbon sequestration and carbon storage. In this work data on sequestration and emissions from GHG was

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

used. In accounting for storage separate spatial datasets for carbon stock in soil and carbon stock in woody above- and below-ground biomass prepared in ELME1 project were used.

Average EU ETS price in 2020 was combined with physical indicators (net sequestration and carbon storage) to find the economic value of the service.

The service is included in both physical and monetary supply and use tables. These tables are displayed in chapter 4.9 and in Annex "D1_6_ Dataset of the supply and use tables of ecosystem services_101022852_2020-EE-ENVACC" (MS EXCEL file) more detailed distribution by ecosystem types and users is given.

4.6.1 Net sequestration and storage of carbon – physical account

The data from National Inventory Report of greenhouse gas emissions in Estonia 1990-2020[84] was used to find carbon-related greenhouse gas (CO2, CH4) removals and emissions.

Net CO2 and CH4 flows are given in kilotons and these were converted to tons of carbon by using conversion factors: 1 ton CO2 equals 0.27 ton C and 1 ton CH4 equals 0.75 ton C respectively (Table 38).

It can be seen that forest is the only land-use category where carbon is sequestered and not emitted. Harvested wood products (HWP) are included in Table 38 but are excluded from the service value, since HWPs are reported in a separate category in the GHG inventories. It is a voluntary reporting item separate from net sequestration that could be beneficial to keep for transparency reasons, consistency checks and the provision of additional information to the user.

LULUCF includes only managed land. All forest is managed in Estonia. Managed land for wetlands category includes only peatlands drained and managed for peat extraction and excludes natural unmanaged wetlands. Wetlands, peatlands in particular, in their natural state are known to be carbon sinks, therefore they can be potential service providers. This aspect is also mentioned in the guidance note for global climate regulation. The guidance note gives further recommendations how to find carbon sequestration for unmanaged wetlands that are not included in LULUCF. An easy approach would be to estimate average per hectare annual carbon sequestration in unmanaged wetlands based on literature and to then to multiply that with the area of these wetlands. The guidance note proposes that as a default value, in case no national data are available, the net C sequestration in European undrained temperate peatlands can be assumed to be 0.56 (+ 0.19) tons C per hectare per year in all ecosystem types. It is assumed that peatlands in their natural state remove approximately 2 tons of CO2 (0.54 tons of C) per hectare in Estonia[85]. However, it is also noted by experts that due to drainage, which affects the majority of peatlands in Estonia directly or indirectly, wetlands in total have turned from being CO2 sinks to CO2 sources[86]. In this case, more detailed data and especially spatial data are necessary. Assessment of greenhouse gases on spatial scale is ongoing in ELME2 project[87] and it is foreseen that these results can be used in ecosystem accounts in the future to get the best estimation. Currently net sequestration in unmanaged wetlands is not included in the global climate service indicator 'net sequestration'.

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[84] https://unfccc.int/process-and-meetings/transparency-and-reporting/reporting-and-review-under-the-convention/national-inventory-submissions-2022
[85] Estonian Ministry of Environment, Draft "Eesti turbaalade kaitse ja säästliku kasutamise alused" (05.10.2010)
[86] Ilomets, M., 2005. Turba juurdekasv Eesti soodes. Tallinna ülikool, ökoloogia instituut.
[87] https://loodusveeb.ee/en/countrywide-MAES-EE-socioeconomic-terrestrial

Table 38. Carbon-related greenhouse gas removals and emissions, 2020, kt (kt=thousand tons). The signs for removals are negative (–) and for emissions positive (+).

Land-use category	CO2, kt	CH4, kt	CO2-C, kt C (CO2 = 0.273C)	CH4-C, kt C (CH4 = 0.75C)	N2O, kt
A. Forest land	-193.378	2.641	-52.212	1.981	2.641
B. Cropland	413.736	NO,NE,NA	111.709		NO,NE,NA
C. Grassland	63.867	0.005	17.244	0.004	0.005
D. Wetlands	1128.399	0.004	304.668	0.003	0.004
E. Settlements	375.844	NO,NE	101.478		NO,NE
F. Other land	65.975	NO,NE	17.813		NO
G. Harvested wood products	-922.241				
H. Other (please specify)	NO				NO
Total LULUCF	932.203	2.650	251.695	1.988	1.003

*NO (not occurring, IE (included elsewhere), NE (not estimated), NA (not applicable)

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 of the service by different ecosystems (Table 39) was obtained by the spatial allocation of carbon sequestration in forests was based on forest increment (Figure 16). The dataset and calculation of increment is described in chapter 4.3.1. 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 39. Supply of global climate regulation: net carbon sequestration by ecosystem types (2020).

Ecosystem	Global climate regulation: net carbon sequestration (thousand tons C)
Forest	52.2
…drained peatland forests	6.1
…mesotrophic boreal forests	12.3
…eutrophic alvar forests	0.9
…oligotrophic boreal heath forests	0.2
…oligo-mesotrophic boreal forests	10.5
…oligotrophic paludifying forests	0.5
…minerotrophic swamp forests	0.9
…eutrophic boreo-nemoral forests	6.3
…mixotrophic and ombrotrophic bog forests	1.2
…eutrophic paludifying forests	13.2
…forest on reclaimed pits	0.1

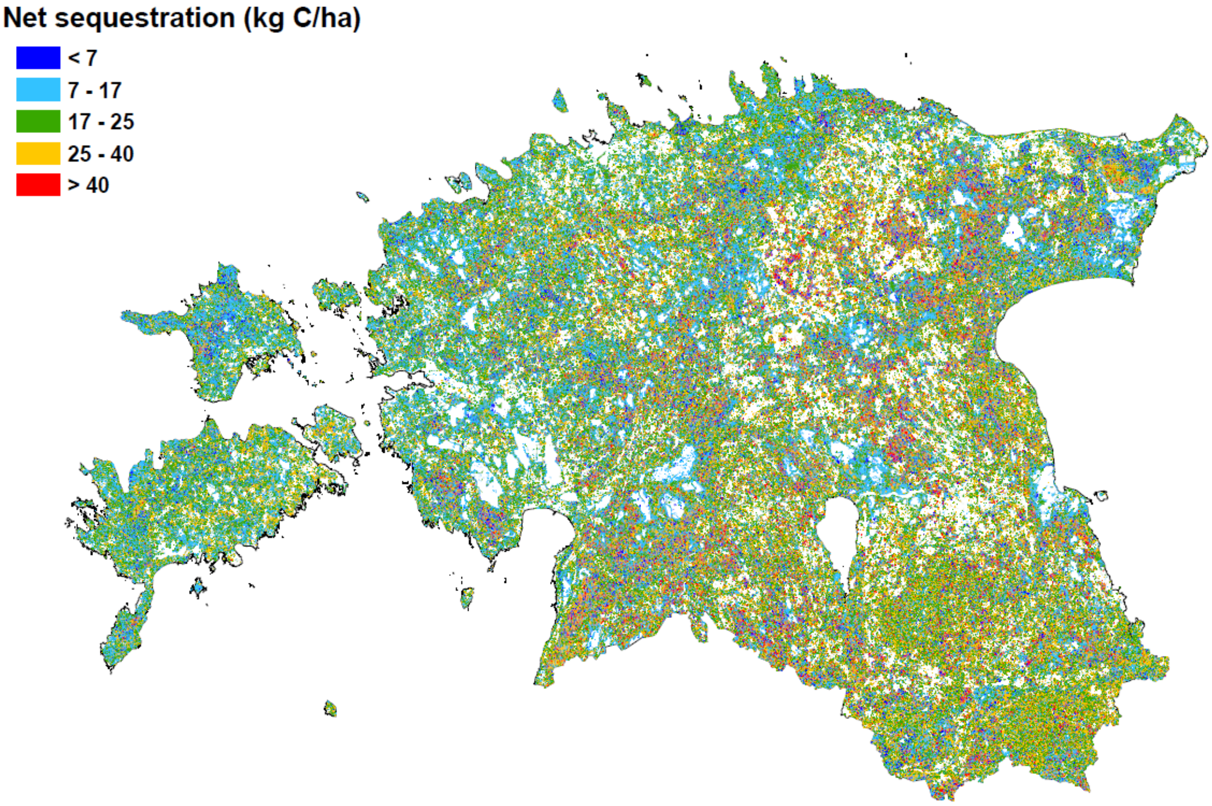

Figure 16. Net sequestration of global climate regulation ecosystem service (calculations are base don net increment in forests). The areas coloured from blue to red represent service provisioning areas according to the unit value kg C/ha). Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

Carbon storage was estimated based on separate spatial datasets for carbon stock in soil and carbon stock in woody above- and below-ground biomass prepared in ELME1 project[88]. Chapters 4.6.1.1and 4.6.1.2 give overview of the methodologies used in the compilation of the datasets.

To calculate carbon storage for ecosystem types, the datasets for carbon stock in soil and carbon stock in woody above- and below-ground biomass were combined with the extent map and for every ecosystem asset an average value of the stock in tons C/ha was found. Distribution between ecosystem types was then found by dividing it with the ecosystem area. The results can be seen in Table 40. Illustrative map on the spatial distribution of carbon stock is presented in Figure 17.

[88] Helm, A., Kull, A., Veromann, E., Remm, L., Villoslada, M., Kikas, T., Aosaar, J., Tullus, T., Prangel, E., Linder, M., Otsus, M., Külm, S., Sepp, K., 2021. Metsa-, soo-, niidu- ja põllumajanduslike ökosüsteemide seisundi ning ökosüsteemiteenuste baastasemete üleriigilise hindamise ja kaardistamise lõpparuanne. ELME projekt. Tellija: Keskkonnaagentuur (riigihange nr 198846). http://loodusveeb.ee/en/countrywide-MAES-EE-condition-and-services-terrestrial

Table 40.Carbon stock, 2020 (kt= thousand tons)

	Carbon stock, kt C, 2020
Artificial area	143 602
Coast	2 127
Cropland	556 564
Forest	2 355 080
Grassland	426 784
Inland waterbodies	53 934
Other	3 245
Wetland	492 983
Total	3 541 336

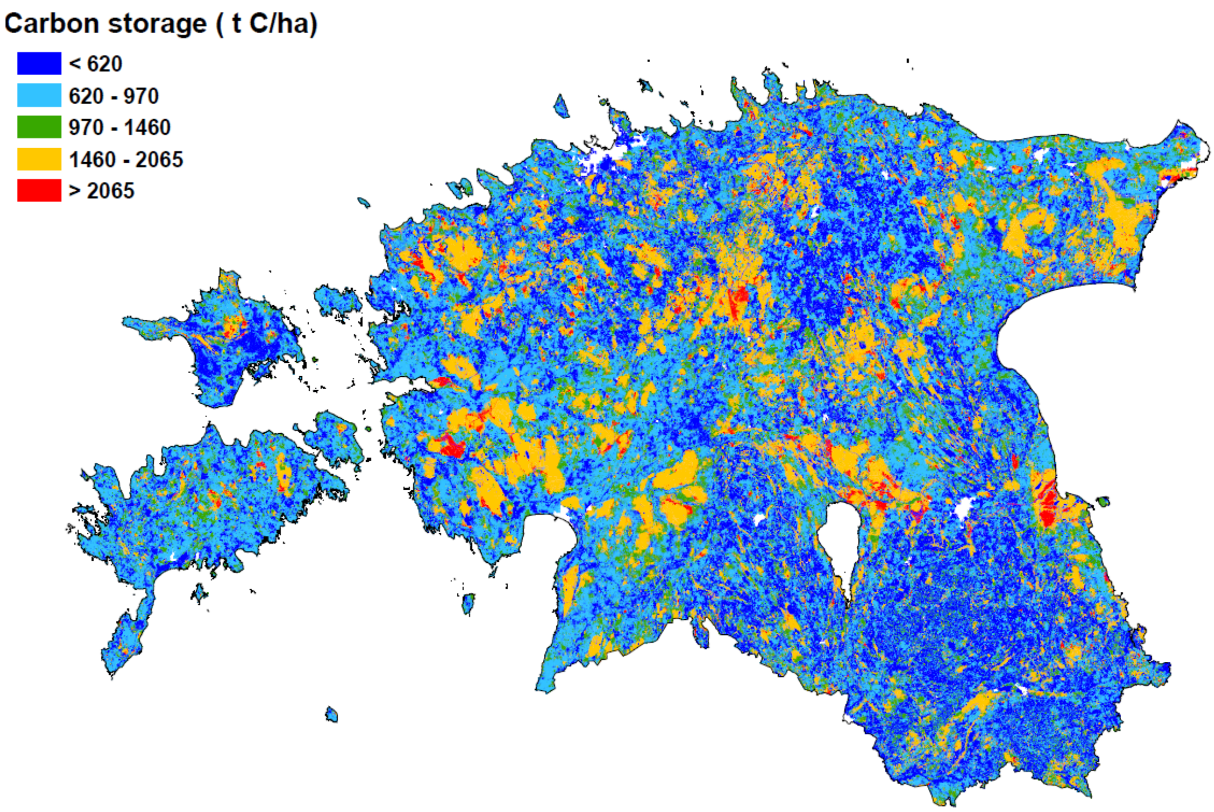

Figure 17. The ecosystem service provisioning areas and values of carbon storage. The areas coloured from blue to red represent service provisioning areas according to the physical unit value t C/ha). Areas coloured white represent areas (ecosystem assets) that do not supply the ecosystem service.

4.6.1.1 Carbon stock in woody above- and below-ground biomass

The methodology and the data layers originate from the ELME1 project (Helm et al. 2021).

To calculate the carbon stored in woody biomass (C t/ha) in forests, methodology described in ELME1 project (Helm et al. 2021) was used. For each fraction (stems, branches, coarse below-ground biomass (d>2mm)), a separate layer was calculated, which were summed up.

Only the forest land covered with Forest Register was comprised.

Based on the volumes (m^3/ha) of the first tree layer available in the Forest Register, stem weights (t/ha) were calculated based on tree species-specific stem wood densities (see Helm et al. 2021).

Based on the stem weights and the corresponding ratios (see Helm et al. 2021), the proportions of branches were found for each tree species, considering the change in the ratio with the age of stands.

To calculate the coarse below-ground biomass, the ratios with the sum of stem and branch weights were used (see Helm et al. 2021), without considering the age of stands, as it has been found that the stem and below-ground biomass of a tree develop proportionally.

Age data of the stands was obtained from the Forest Register (18.03.2019). Tree species data originates from the remote sensing-based data layers (Lang et al., 2018, and its modification created by Estonian Environment Agency).

Based on the obtained biomasses, the carbon stocks were calculated for all fractions.

In this work, the stocks of carbon in deadwood are not reflected due to the lack of relevant spatial data. The data on standing and lying deadwood given in the Forest Register is not spatially enough comprehensive and lacks information on decay rates which is substantial when assessing deadwood carbon content.

All used ratios and carbon contents in fractions are based on domestic research (Aosaar et al. 2011; Aosaar et al. 2013; Buht 2019; Külla 1997; Laas et al. 2011; Lutter et al. 2016; Lõhmus et al. 1996; Pikk & Kask 2014; Saarman & Veibri 2006; Tamm 2000; Uri 2018, 2020; Uri et al. 2007; Uri et al. 2009; Uri et al. 2011; Uri et al. 2012; Uri et al. 2014; Uri et al. 2017; Vares 1999; Varik et al. 2013; Varik et al. 2015).

To calculate the carbon stored in above-ground woody biomass (C t/ha) in bogs and mires, methodology described in ELME1 project (Helm et al. 2021) was used. Increment data gathered during different research projects (e.g., Kull 2016; Paal et al. 2016), and tree height and coverage data based on LiDAR[89]-based canopy height model were combined to calculate this layer.

References

Aosaar, J., Varik, M., Lõhmus, K. & Uri, V. (2011). Stemwood Density in Young Grey Alder (*Alnus in*cana (L.) Moench) and Hybrid Alder (*Alnus hy*brida A. Br.) Stands Growing on Abandoned Agricultural Land. *Baltic Forestry*, 17 (2), 256–261.

Aosaar, J., Varik, M., Lõhmus, K., Ostonen, I., Becker, H. & Uri, V. (2013). Long-term study of above- and below-ground biomass production in relation to nitrogen and carbon accumulation dynamics in a grey alder (*Alnus incana* (L.) Moench) plantation on former agricultural land. *European Journal of Forest Research*, 132 (5–6), 737–749.10.1007/s10342-013-0706-1

Buht, M. (2019). Kase maapealse biomassi fraktsionaalne jaotus, esialgsed biomassi mudelid ja tüvepuidu tihedus. Magistritöö, Eesti Maaülikool.

Helm, A., Kull, A., Veromann, E., Remm, L., Villoslada, M., Kikas, T., Aosaar, J., Tullus, T., Prangel, E., Linder, M., Otsus, M., Külm, S., Sepp, K., 2021. Metsa-, soo-, niidu- ja põllumajanduslike ökosüsteemide seisundi ning ökosüsteemiteenuste baastasemete üleriigilise hindamise ja kaardistamise lõpparuanne. ELME projekt. Tellija: Keskkonnaagentuur (riigihange nr 198846). http://loodusveeb.ee/en/countrywide-MAES-EE-condition-and-services-terrestrial

Kull, A. (2016). Soode ökoloogilise funktsionaalsuse tagamiseks vajalike puhvertsoonide määratlemine pikaajaliste häiringute leviku piiramiseks või leevendamiseks, II etapp. Sihtfinantseerimislepingu 8286. SFL nr 3-2_15/835-14/2014 aruanne. https://docs.wixstatic.com/ugd/6b6658_446958f4118b44a2a68812820c31119b.pdf

Külla, T. (1997). Keskealise männiku ja kuusiku maapealse ja maa-aluse osa struktuur. Teadusmagistritöö, Eesti Põllumajandusülikool.

Laas, E., Uri, V. & Valgepea, M. (2011). Metsamajanduse alused. Tartu Ülikooli Kirjastus. 863 lk.

Lutter, R., Tullus, A., Kanal, A., Tullus, T. & Tullus, H. (2016). The impact of former land-use type to aboveand below-ground C and N pools in short-rotation hybrid aspen (*Populus trem*ula L. × *P. tremuloides* Michx.) plantations in hemiboreal conditions. *Forest Ecology and Management*, 378, 79–90.10.1016/j.foreco.2016.07.021

[89] https://geoportaal.maaamet.ee/eng/Maps-and-Data/Topographic-Data/Elevation-data-p308.html

Lõhmus, K., Mander, Ü., Tullus, H. & Keedus, K. (1996). Productivity, buffering capacity and resources of grey alder forests in Estonia. In: Perttu, K., Koppel, A. (eds). Short rotation willow coppice for renewable energy and improved environment, 95–105.
Paal, J., Jürjendal, I., Suija, A., Kull, A. (2016). Impact of drainage on vegetation of transitional mires in Estonia. Mires and Peat, 18, 1–19. DOI: 10.19189/MaP.2015.OMB.183
Pikk, J. & Kask, R. (2014). Männipuidu ehitus ja omadused. Mänd Eestis. Koost. M. Kurm, Vali Press, lk. 154–188.
Saarman, E. & Veibri, U. (2006). Puiduteadus. Tartu: Eesti Metsaselts. Valli Press OÜ. 560 lk.
Tamm, Ü. (2000). Haab Eestis. Eesti Loodusfoto. 257 lk.
Uri, V. (2018). KIK metsanduse programmi 2016. a projekt nr. 11660, Süsinikubilanss palumännikute vanusereas, lõpparuanne.
Uri, V. (2020). KIK metsanduse programmi 2018. a. projekt nr. 14511 Süsinikubilanss viljakate kuusikute vanusereas, lõpparuanne.
Uri, V., Aosaar, J., Varik, M., Becker, H., Ligi, K., Padari, A., Kanal, A. & Lõhmus, K. (2014). The dynamics of biomass production, carbon and nitrogen accumulation in grey alder (*Alnus incana* (L.) Moench) chronosequence stands in Estonia. *Forest Ecology and Management*, 327, 106–117.10.1016/j.foreco.2014.04.040
Uri, V., Kukumägi, M., Aosaar, J., Varik, M., Becker, H., Morozov, G. & Karoles, K. (2017). Ecosystems carbon budgets of differently aged downy birch stands growing on well-drained peatlands. *Forest Ecology and Management*, 399, 82–93.10.1016/j.foreco.2017.05.023
Uri, V., Lõhmus, K., Kiviste, A. & Aosaar, J. (2009). The dynamics of biomass production in relation to foliar and root traits in a grey alder (*Alnus inca*na (L.) Moench) plantation on abandoned agricultural land. *Forestry*, 82 (1): 61–74.
Uri, V., Lõhmus, K., Mander, Ü., Ostonen, I., Aosaar, J., Maddison, M., Helmisaari, H.-S. & Augustin, J. (2011). Long-term effects on the nitrogen budget of a short-rotation grey alder (*Alnus incana* (L.) Moench) forest on abandoned agricultural land. *Ecological Engineering*, 37 (6), 920–930. DOI: 10.1016/j.ecoleng.2011.01.016
Uri, V., Lõhmus, K., Ostonen, I., Tullus, H., Lastik, R., & Vildo, M. (2007). Biomass production, foliar and root characteristics and nutrient accumulation in young silver birch (*Betula pendula* Roth.) stand growing on abandoned agricultural land. *European Journal of Forest Research*, 126 (4), 495–506.10.1007/s10342-007-0171-9
Uri, V., Varik, M., Aosaar, J., Kanal, A., Kukumägi, M. & Lõhmus, K. (2012). Biomass production and carbon sequestration in a fertile silver birch (*Betula pendula* Roth) forest chronosequence. *Forest Ecology and Management*, 267, 117–126.
Vares, A. (1999). The most important nutrients (NPK) and biomass in the experimental culture of black alder. *Metsanduslikud uuri*mused, 31, 90–97. ISSN 1406-9954.
Varik, M., Aosaar, J., Ostonen, I., Lõhmus, K. & Uri, V. (2013). Carbon and nitrogen accumulation in belowground tree biomass in a chronosequence of silver birch stands. *Forest Ecology and Management*, 302, 62–70.
Varik, M., Kukumägi, M., Aosaar, J., Becker, H., Ostonen, I., Lõhmus, K. & Uri, V. (2015). Carbon budgets in fertile silver birch (*Betula pendula* Roth) chronosequence stands. *Ecological Engineering*, 77, 284–296.

4.6.1.2 Global climate regulation: soil organic carbon stock

The methodology and the data layers originate from the ELME1 project (Helm et al. 2021) and have been elaborated in ELME2 project[90] (report in progress).

Soil organic carbon stock (t/ha) is calculated using the model EstSoil-EH created to assess the soil organic stock by scientists of Tartu University (Kmoch et al. 2021) also participating in the ELME project.

The model which is originally based on Estonian high-resolution digital soil map[91] has been kept up-to date when additional data has been collected. The layer of soil organic carbon has been calculated per each soil type polygon and for the whole soil profile. The layer covers all ecosystems and the whole country and when overlaying with ecosystem extent map, soil organic carbon contents in different ecosystem types can be calculated.

References

Helm, A., Kull, A., Veromann, E., Remm, L., Villoslada, M., Kikas, T., Aosaar, J., Tullus, T., Prangel, E., Linder, M., Otsus, M., Külm, S., Sepp, K., 2021. Metsa-, soo-, niidu- ja põllumajanduslike ökosüsteemide seisundi ning

[90] https://loodusveeb.ee/en/countrywide-MAES-EE-socioeconomic-terrestrial
[91] Estonian Soil Map | Geoportal | Estonian Land Board (maaamet.ee)

ökosüsteemiteenuste baastasemete üleriigilise hindamise ja kaardistamise lõpparuanne. ELME projekt. Tellija: Keskkonnaagentuur (riigihange nr 198846). http://loodusveeb.ee/en/countrywide-MAES-EE-condition-and-services-terrestrial

Kmoch, A., Kanal, A., Astover, A., Kull, A., Virro, H., Helm, A., Pärtel, M., Ostonen, I., & Uuemaa, E. (2021). EstSoil-EH: a high-resolution eco-hydrological modelling parameters dataset for Estonia. Earth System Science Data, 13(1), pp. 83–97. https://essd.copernicus.org/articles/13/83/2021/#section4

4.6.2 Supply and use of global climate regulation service – physical account

The guidance note for global climate regulation has proposed a table format for reporting the supply and use of mandatory indicators. The precise report unit is not yet clear based on the guidance note (tons or 1000 t, tons C or tons C). Here the results are given in tons C (which means net sequestration is converted from CO2 to C). Table 41 shows the supply of global climate regulation service. Table 42 shows the use of the global climate regulation service, the user of the service is government.

Table 41. Supply table: global climate regulation, 2020

	Ecosystem type (level 1)								
	Artificial area	Coast	Cropland	Forest	Grassland	Inland waterbodies	Other	Wetland	Total
Net carbon sequestration (tons C)				52212					52212
Carbon storage (closing stock) (tons C)	143 602 429	2 127 124	556 563 944	2 355 080 122	426 783 504	53 934 353	3 244 909	492 982 838	3 541 336 385

Table 42. Use table: global climate regulation, 2020

	Use type					
	Intermediate consumption by industries	Government final consumption	Households final consumption	Gross capital formation	Exports	TOTAL
Net carbon sequestration, (tons C)		52212				52212
Carbon storage (closing stock) (tons C)		3 541 336 385				3 541 336 385

Annex 1 in guidance note presents supply table that includes voluntary and memo items for accounting for the global climate regulation ecosystem service (Table 43). Reporting unit is here given to be 1000 tonnes of carbon. In addition the table references how the table can be filled in:

- **Indicators in bold**: mandatory reporting requirements.
- Blue cells: numbers can be retrieved from national GHG inventories.
- Grey cells: values can be assumed to be zero in respective ecosystem types.
- Italics: complementary variables.
- Underlined: recommended to report.

The table was not filled with data but in the light of previous estimation of the mandatory indicators and supporting data, some comments can be made.

1. Opening and closing stock is defined as stock up to 0.3 m soil depth in the guidance note but the proposed amendment to EU Regulation 691/2011 does not include this limit in service definition anymore. In this light currently the whole stock was considered as the supply of service.
2. An assumption is made that for some ecosystem types service indicator values can be zero. Whereas such an assumption is useful when there is no data available, previous work showed that organic carbon is stored in all ecosystem types in varying degrees.
3. Regarding other emissions (N2O, CH4), it is unclear what is the reporting unit and whether CO2 equivalents need to be calculated for them which then need to be converted to tons of carbon

Table 43. Table A1 in Annex 1 in guidance note for global climate regulating service. Supply table: global climate regulation – including voluntary and memo items

Service	Settlements and other artificial areas	cropland	grassland	Forest and woodland	Heathland and shrub	Sparsely vegetated ecosystem	Inland wetlands		Rivers and canals	Lakes and reservoirs	Coastal beaches, dunes and wetlands
							Managed	*Unmanaged*			
Carbon storage at the beginning of the reference year (opening stocks) (up to 0.3 m soil depth)											
Carbon sequestration (primary net carbon sequestration)											
Carbon emissions from ecosystems due to disturbances											
Of which: certainly due to human causes (excluding climate change)											
Net carbon sequestration											
Carbon removal from the stock due to wood harvest											
Carbon storage at the end of the reference year (up to 0.3m soil depth)											
Carbon storage up to 1 m soil depth at the end of the reference year											
Other emissions (N_2O, CH_4)											

4.6.3 Monetary value of global climate regulation service

Payment for ecosystem services (PES) schemes was considered 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 2020 was 24.8 €/t CO2[92].

CO2 net sequestration was multiplied with the EUA price. Carbon stock in tons C was first converted to carbon stock in tons CO2 (ton CO2=3.67 ton C) and then multiplied with the EUA price. The results and division by ecosystem types are presented in Table 44.

The use of the service is attributed to government as was the case in physical account of global climate regulation ecosystem service.

Table 44. Monetary value of global climate regulation

	Carbon stock, thousand tons C	Monetary value of carbon stock, million EUR	Net CO2 sequestration, thousand tons C	Monetary value of net CO2 sequestration, million EUR
Artificial area	143 602	13 070		
Coast	2 127	194		
Cropland	556 564	50 656		
Forest	2 355 080	214 350	193	4.8
Grassland	426 784	38 844		
Inland waterbodies	53 934	4 909		
Other	3 245	295		
Wetland	492 983	44 869		
Total	3 541 336	322 318	193	4.8

Other option is to use net present value (NPV) to estimate monetary carbon stock value. NPV 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. 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

$$K_0 = d/(r \times a)$$

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 were used:

- Stream of future flow of ecosystem service value is constant;
- Discount rate is 2% for regulating services. Discount rate is lower for those services which are more difficult or impossible to substitute or which are scarcer;

[92] https://icapcarbonaction.com/en/ets-prices

- Asset lifetime is 100 years or infinity – this assumption is used in this project but even shorter than 100 years is possible if this information would be available. Analyses of available information to determine more accurate asset lifetime would be possible subject for future.

When considering that the service value is 4.8 million euros the stock value using NPV formula would be 206.9 million euros if lifetime is 100 years and 240 million euros if lifetime is infinity. Difference of stock values calculated with straightforward approach and NPV formula is significant and further analyses is needed for monetary assessment methods be applied.

4.6.4 Conclusion

Physical and monetary account for the indicators net carbon sequestration and carbon stock for global climate regulating ecosystem service were compiled following the guidelines given in the guidance note in preparation by Eurostat and dedicated Task Force on ecosystem accounting.

By following the guidelines given in the guidance note the compilation of the physical account can be considered rather straightforward work. Existing international reporting data from Greenhouse gas inventories can be easily used as input data, however alignment between ecosystem types in LULUCF and ecosystem extent needs to be tackled separately considering also which data need to be included or are included in LULUCF (managed vs unmanaged land). The latter aspect is important when dealing with natural wetlands which can be potential carbon sinks and, in this case, additional data sources need to included. In current work natural wetlands were excluded but it is foreseen that detailed spatial data for carbon sequestration becomes available in the future and then estimations can be made. The results of this work show that net carbon sequestration was 52 million tons in forest ecosystems and carbon stock was 3 541 million tons encompassing all ecosystem types.

In addition to calculating mandatory indicators, brief analysis was done on voluntary indicators and proposed reporting table given in the guidance note for global climate regulation ecosystem service.

Monetary valuation of the service was based on the physical indicators and EU ETS (European Union Emissions Trading System) European Union Allowance (EUA) price (€/t CO2). Economic value for carbon stock was estimated to be 322 318 million euros based on current rather straightforward approach and 4.8 million euros for net carbon sequestration. Using net present value economic value for carbon stock was estimated to be 206.9 million euros when lifetime is set to be 100 years and 240 million euros when lifetime is infinity.

The use of the service of global climate regulation ecosystem service is attributed to government in physical and monetary accounts.

4.7 Local climate regulation

According to the definition of the proposal for the amendment of Regulation (EU) 691/2011, the ecosystem service local climate regulation is defined as the ecosystem contribution to regulating ambient atmospheric conditions in urban areas through vegetation that improves the living conditions of people and supports economic production. It shall be expressed and reported as the reduction of temperature in cities, due to the effect of urban vegetation, in degrees Celsius on days exceeding 25 degrees Celsius.

In 2020, which is the accounting year for this ecosystem services account, daily maximum temperature did not exceed 25°C in major cities and hence, it can be said that the service, by how it is currently defined, was not supplied. However, considering that temperatures are predicted to be rising in the future in the region, the importance of the service cannot be neglected. Urban vegetation influences human wellbeing regardless of the currently defined temperature limit and this was affirmed with CVM questionnaire of urban ecosystem services where willingness to pay was found for microclimate regulation.

Due to service not being supplied in 2020 and technical capability for modelling the service in necessary timeframe was not available, the primary focus of the work was on alternative methods.

For monetary valuation of the service, an overview on research articles and possible methods, that could be best implemented when the service were to be supplied, based on the physical indicator describing the service (deduction in urban temperatures due to the cooling effect of vegetation) was done. Economic value of local climate regulation was estimated using CVM.

4.7.1 Local climate regulation – physical supply

The guidance note for local climate regulation[93] introduces mandatory and voluntary indicators to be reported:

- Reduction in heat exposure, expressed as average temperature reduction on days with maximum temperature exceeding 25°C (mandatory)
- Number of days with maximum temperature exceeding 25°C (voluntary)
- Number of days with maximum temperature exceeding 30°C (voluntary)
- Number of days with maximum temperature exceeding 35°C (voluntary)

The service is foremost important in urban areas, and the guidance note further details that the indicator is to be reported for cities. ‘Cities’ are not defined in the proposal for the amendment of Regulation (EU) 691/2011 nor in the guidance note for the service but when we follow how ‘cities’ are defined for condition account (e.g. green areas in cities, chapter 3.1), then ‘cities’ mean local administrative units, categorized as cities according to the degree of urbanisation typology set out under Regulation (EU) 2017/2391[94]. Therefore, three major cities in Estonia: Tallinn, Tartu, Narva within their administrative borders, would be included in the calculation of the service. Another option would be to include all urban areas as defined in the condition account.

Second condition is that the service is provided on days with maximum temperature exceeding 25°C. Dataset of direct measurements of maximum air temperatures (°C) in an hour from 35 different weather stations[95] were used to calculate daily average maximum temperature. The weather stations are generally nearby settlements and describe the surrounding weather conditions. The guidance note for microclimate regulation mentions that direct measurements from weather stations should be preferred over modelled data because it is less prone to further uncertainty derived from models. However, when we consider the heat island effect, the measurements should be instead done where the heat island effect can occur, i.e. inside the settlement. The best option should be done considering both aspects.

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[93] Eurostat – Unit E2. Doc. Doc. ENV/EA/TF/2023_1/2. Guidance note for accounting for the local climate regulation ecosystem service in the EU – third draft. Task force on ecosystem accounting. 21 – 22 February 2023.
[94] https://ec.europa.eu/eurostat/web/degree-of-urbanisation/background
[95] Estonian Environment Agency, Historical weather data https://www.ilmateenistus.ee/kliima/ajaloolised-ilmaandmed/

Table 45 gives an overview on the number of days with daily maximum temperature over 25°C in a year and the number of stations where daily maximum temperature was over 25°C in a year (not all stations were included in a given day but the number of stations was summed over all days when daily maximum temperature was over 25°C). In addition, it is brought out whether any of the cities: Tallinn, Tartu, Narva, were affected. Number of days with daily maximum temperature over 20°C in a year is also given.

Table 45. Number of days with daily maximum temperature >25°C and corresponding stations. Number of days with daily maximum temperature >20°C.

Year	Number of days with daily maximum temperature >25°C	Number of stations where daily maximum temperature >25°C	LAU cities (Tallinn, Tartu, Narva) where daily maximum temperature >25°C	Number of days with daily maximum temperature >20°C
2006	8	13	Tartu	47
2007	2	3		41
2008	0	0		20
2009	0	0		22
2010	20	26	Tartu, Tallinn	58
2011	8	27	Tartu, Tallinn	50
2012	5	16	Tartu	28
2013	2	14	Tallinn	45
2014	12	23	Tallinn, Narva	49
2015	0	0		18
2016	2	4	Tartu	32
2017	0	0		12
2018	13	31	Tartu, Tallinn, Narva	54
2019	5	11	Tallinn, Narva	42
2020	4	6		35
2021	16	33	Tartu, Tallinn, Narva	51
2022	13	31	Tartu, Tallinn, Narva	44

In 2020, which is the accounting year for this ecosystem services account, daily maximum temperature did not exceed 25°C in major cities and hence, it can be said that the service, by how it is currently defined, was not supplied. However, when we look at the later years (2021, 2022), daily maximum temperature was over 25°C on many days and considering that temperatures are predicted to be rising in the future in the region, the importance of the service cannot be neglected.

The guidance note for local climate regulation denotes that the contribution of urban vegetation to local climate regulation can be measured by comparing the situation with vegetation (i.e. the current situation) with a situation in which the vegetation is removed. In general, to find the effect of vegetation to temperature, a statistical analysis can be done based on the spatial and temporal data of a variety of explanatory variables (e.g., distance to sea, elevation, presence of urban vegetation). In the constructed regression model, the effect of vegetation can be singled out, and the vegetation can be removed from the equation in order to find the cooling effect of vegetation. However, due to service not being supplied in 2020 and even with existing know-how on modelling, the technical capability was not available for the necessary timeframe and therefore the physical accounting for the service was not given primary focus in the work.

4.7.2 An overview of studies on the calculation of economic value of the local climate regulation ecosystem service

The proposed legal module Ecosystem accounts defines the local climate regulation service as evaporative cooling of ambient air provided by urban trees. (Hereafter: *microclimate regulation*.) This service is of particular relevance to urban areas where most people are concentrated as well as due to the urban heat island effect where urban areas heat up more than the rural areas. According to the European Commission Eurostat guidance note (2023) the microclimate regulation is expressed and reported as the reduction of temperature in cities, due to the effect of urban vegetation on days exceeding 25 degrees Celsius (measured during a 24h period). [96]

The main aim of this paper is to give an overview of the studies where the economic value of the urban microclimate regulation has been calculated, and analyses which of these studies can be used for benefit transfer. Three limiting factors of the search was set following:

1. The study calculates the economic value of microclimate regulation in urban areas;
2. The publication period of the article is from 2010 to the present day;
3. The study was carried out in countries with similar or close socio-economic and climatic conditions to Estonia.

The following databases was used: Ecosystem Services Valuation Database (ESVD)[97], research database EBSCO *via* Tallinn University of Technology library[98], The ReseachGate[99]. Also simple Google search[100] was used. The following key words was used to search appropriate scientific articles and reports: “monetary value”, “economic value”, “value”, “microclimate regulation” “local climate regulation” “cooling”, “heat reduction”, “urban park”, “urban forest”, “urban tree”, “heatwaves”.

Below is presented study reports that may be considered to use for benefit transfer. No of these results are directly transferable as they have been carried out in countries with very different socio-economic and climatic conditions compare with Estonia.

1. McDonald and others (2020)[101] have assembled GIS-based information on tree cover and developed land-cover information for 97 US cities, housing 59 million people, and have used regression analyze to discover how much current urban tree cover reduces summer air temperatures and associated heat-related mortality, morbidity, and electricity consumption. To estimate the value of avoided morbidity a cost-of-illness approach is applied, quantifying the costs of emergency department and outpatient visits, hospitalizations, and the lost work productivity associated with these events. For estimating the value of avoided electricity consumption, data on average household residential electricity consumption and average cost per KWh of electric have used.

   They found that 78% of urban dwellers are in neighborhoods with less than 20% tree cover. Some 15.0 million people (25% of total) experience a reduction of 0.5–1.0°C from tree cover, with another 7.9 million (13% of total) experiencing a reduction of greater than 1.0°C. Relationships between temperature and health outcomes imply that urban tree cover helps avoid 245–346 deaths annually. For the 97 cities studied, the total annual economic value of avoided mortality, morbidity, and electricity consumption is an estimated $1.3–2.9 billion, or

[96] Eurostat – Unit E2. Doc. Doc. ENV/EA/TF/2023_1/2. Guidance note for accounting for the local climate regulation ecosystem service in the EU – third draft. Task force on ecosystem accounting. 21 – 22 February 2023.
[97] https://www.esvd.net/
[98] https://taltech.ee/koik-andmebaasid
[99] https://www.researchgate.net/
[100] https://www.google.com/
[101] McDonald, R.I., Kroeger, T., Zhang P., Hamel, P (2020) The Value of US Urban Tree Cover for Reducing Heat-Related Health Impacts and Electricity Consumption. Ecosystems volume 23, pages137–150

$21–49 annually per capita. Analysis estimated the value of avoiding one unit of heat-related impact, expressed in 2015 US dollars (USD, $).

The results of this study can be used for benefit transfer to calculate economic value of microclimate regulation in Estonia. During the transfer process the economic difference of the study country and Estonia must be leveled.

In the following articles, the economic value of the microclimate regulation of a specific ecosystem has been calculated using the conditional valuation method (CVM), i.e. the welfare value of the ecosystem service has been found.

2. Chen and Nakam (2015)[102] studied residents' preference and willingness to conserve homestead woodlands in coastal villages in Okinawa Prefecture, Japan. Homestead woodlands have played a key role in protecting settlements from strong wind and storm. To evaluate residents' willingness to conserve homestead woodlands the contingent valuation method (CVM) was used. The survey was conducted in December 2011 - January 2012. The sample size was 535, of which 480 answers were analyzed.

The majority of respondents (91%) favoured the conservation of homestead woodlands. Estimated mean and median lump sum willingness to pay (WTP) were JPY 1451 (USD 18[103]) per household and JPY 1000 (USD 12) per household, respectively.

The results of this study are useable for benefit transfer to calculate economic value of microclimate regulation of urban green areas. At the same time must consider that the willingness to pay for conservation of homestead woodlands was studied that is broader concept than microclimate regulation.

3. Zhang, *et al* (2021)[104] investigated residents' WTP for permeable pavement construction to mitigate urban heat impacts (UHI). The CVM was used and the WTP question was presented as follows: "If the Guangdong provincial government plans to replace more than 80% of the urban built-up area with permeable pavement by 2030, considering your financial condition and personal experience, would you agree to pay extra on your monthly water bill for the next 10 years to promote the construction of permeable pavement for UHI mitigation?" In questionnaire three bidding options were proposed: 5CNY, 20CNY, and 50CNY. The water bill was chosen as a payment vehicle in this study because it is compulsory and thus reduces the possibility of free riding.

799 urban residents of Guangdong Province responded to an online questionnaire. WTP intention was explored by establishing structural equation modelling based on the extended theory of planned behavior.

The findings show that the mean WTP was CNY 17.98 (USD 2.58[105]) per resident per month for permeable pavement construction for its UHI mitigation benefit. According to the official statistics, there were 115.21 million residents in Guangdong in 2019, so the present value of the total annual public WTP amounts to CNY 24.86 billion (USD 3.82 billion) per year.

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102 Chen, B., Nakama, Y. (2015) Residents' preference and willingness to conserve homestead woodlands: Coastal villages in Okinawa Prefecture, Japan. Urban Forestry & Urban Greening. Volume 14 (4), pg 919-931. https://www.sciencedirect.com/science/article/pii/S1618866715001181

103 USD 1 = 81.45 JPY (2011)

104 Zhang, L., Yang, X., Fan, Y., Zhang, J. (2021) Utilizing the theory of planned behavior to predict willingness to pay for urban heat island effect mitigation. Building and Environment. Volume 204, 108136. https://www.sciencedirect.com/science/article/pii/S0360132321005370#bib66

105 USD 1 = CNY 6.96 (2019)

Since the study does not specify how large area will be covered with permeable pavement, and how many degrees the UHI will decrease, the result obtained from benefit transfer is suitable to illustrate the situation in general.

Ecosystems that provide a microclimate regulation service are the subject of the following two studies.

4. Zhang, *et al* (2017)[106] conducted the study to estimate the economic values of and the dominant contributors to five key ecosystem services of wetlands in Beijing (total area 51 434 ha), by using the wetland inventory data in 2014 and economic valuation methods.

From June to August in Beijing, evaporation from water surfaces reaches is 363.8 mm; hence, the amount of evaporated water reaches approximately 134 million tons based on water surface ratio and wetland areas. The heat of water evaporation is 2260 kJ/kg in circumstances such as 1 standard atmospheric pressure and 100 °C; therefore, wetlands in Beijing can absorb approximately 3.03 PJ of heat through water evaporation during hot summer days, with an average value of 58.96 GJ/ha. River wetland can absorb 1.34 PJ of heat, reservoir wetland absorbs 1.15 PJ of heat as ponds, marshes and park wetlands are minor contributors to summertime heat absorption. However, reservoir wetland exhibits the highest absorption heat capacity with a value of 73.48 GJ/ha. On 2014, the price of electricity in Beijing was 0.5 RMB/kwh.

On 2014, total monetary value of the cooling effect of Beijing wetlands was calculated RMB 421 million[107] (USD 69 million) or RMB 8185 (USD 1333) per hectare.

5. Qianjiangyuan National Park in Kaihua County area is mainly (81.7%) covered by forest, remaining area is wetland and water. Zhao, *et al* (2019)[108] mapped ecosystem services of the park and calculated their economic value by using market value method and shadow engineering method. Studies were carried out in years 2005, 2010, 2015, and 2018.

According to the study methodology only wetland contributes to climate regulation. The value of regulating humidity have calculated by multiplying the average surface evaporation, steam power consumption converted from per unit volume of water and electricity price. The value of regulating temperature have calculated by multiplying the average surface evaporation, heat of vaporization of water and electricity price. Climate regulation service benefits people from May until September and therefor the value has calculated only for this period.

The total value of regulating humidity and temperature was RMB 0.51 billion (USD 63 million[109]), RMB 0.41 billion (USD 62 million[110]), RMB 0.27 billion (USD 42 million[111]), RMB 0.18 billion (USD 26 million[112]) in 2005, 2010, 2015 and 2018 respectively or USD 14.000, USD 13.800, USD 9.333 and USD 5.800 per one hectare of wetland in 2005, 2010, 2015 and 2018 respectively.

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[106] Zhang, B., Shi, Y., Liu, J., Xu, J., Xie, G. (2017) Economic values and dominant providers of key ecosystem services of wetlands in Beijing, China. Ecological Indicators. Volume 77, pg 48-58. https://www.sciencedirect.com/science/article/pii/S1470160X17300535
[107] USD 1 = RMB 6.14 (2014)
[108] Zhao, X., He, Y., Yu, C., Xu, D., & Zou, W. (2019). Assessment of Ecosystem Services Value in a National Park Pilot. Sustainability, 11(23), 6609. https://www.researchgate.net/publication/337451727_Assessment_of_Ecosystem_Services_Value_in_a_National_Park_Pilot#fullTextFileContent
[109] USD 1 = RMB 8.07 (2005)
[110] USD 1 = RMB 6.59 (2010)
[111] USD 1 = RMB 6.50 (2015)
[112] USD 1 = RMB 6.88 (2018)

According to the comment of reviewer of the Ecosystem Services Valuation Database, the results seem to be too high.

In conclusion, the methods considered for benefit analysis for local climate regulation gave different results. However, as the methods are also different, the results are not easily comparable. Also, the methods mainly rely on contingent valuation (willingness to pay) and not using the quantity of the physical indicator that is currently defined as the reduction of temperature due to the effect of vegetation in cities. Therefore, no basis was found for the application of benefit transfer method for this service.

4.7.3 Economic value of local climate regulation based on CVM questionnaire

In Guidance Note for accounting for the Local Climate Regulation Ecosystem Service in the EU[113] (hereinafter Guidance Note) it is stated that the use of the service is, entirely, allocated to households final consumption. According to the Guidance Note, the service is of particular relevance to urban areas, since this is where most people are concentrated and because urban areas heat up more than the surrounding rural areas due to the urban heat island effect. This additional heating occurs due to a number of reasons, including the higher absorption of sunlight by darker materials such as asphalt and concrete, the release of this heat by these materials, reduced wind circulation between buildings and lower evapotranspiration because of soil sealing and a lower amount of vegetation.

Local climate regulation is defined in the proposed legal module as '*the ecosystem contribution to regulating ambient atmospheric conditions in urban areas through vegetation that improves the living conditions of people and supports economic production.' 'It shall be expressed and reported as the reduction of temperature in cities, due to the effect of urban vegetation, in degrees Celsius on days exceeding 25 degrees Celsius.'*

Regulation of microclimate by vegetation (i.e. ecosystem) in the way described in the Guidance Note undoubtedly classifies this service among ecosystem regulative services. Regulating the microclimate (or lowering the temperature) in an urban environment is a service that is becoming more and more actual due to the warming of the climate, the increase in the number of consumers can also be predicted geographically, including in the northernmost countries of Europe, where it was not so relevant before. Unlike several other ecosystem regulatory services, such as carbon sequestration, microclimate has an immediate, directly felt effect on the welfare of individuals. Therefore, microclimate regulation service of the ecosystem has, in addition to the regulatory one, a strong welfare service component, and its value can be studied not only by the biophysical methods referred to in the Guidance Note, but also by methods characteristic of the welfare services of the ecosystem.

The ecosystem microclimate regulation service has been studied as a welfare service mostly in Asia. For example, the contingent valuation (hereafter CVM) method has been used to study the ecosystem service value of urban forests in South Korea (Jo Jang-Hwan et. al., 2020)[114] and to study the ecosystem service value of forests in Japan (Bixia Chen, Yuei Nakama, 2015)[115]. Neither of the studies

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[113] Eurostat – Unit E2. Doc. Doc. ENV/EA/TF/2023_1/5. Guidance note for accounting for the local climate regulation ecosystem service in the EU – third draft. Task force on ecosystem accounting. 21 – 22 February 2023.
[114] Jo Jang-Hwana, Park So-Heeb, Koo JaChoonc, Roh Taewood, Emily Marie Lime and Youn Yeo-Changb, 2020. Preferences for ecosystem services provided by urban forests in South Korea. Forest Science and Technology E-ISSN 2158-0715, 2020, VOL. 16, NO. 2, 86–103. https://doi.org/10.1080/21580103.2020.1762761
[115] Bixia Chen, Yuei Nakama, 2015. Residents' preference and willingness to conserve homestead woodlands: Coastal villages in Okinawa Prefecture, Japan. Urban Forestry & Urban Greening, Vol 14 (4), pg 919-931. https://www.sciencedirect.com/science/article/pii/S1618866715001181

cited above specifically focuses on the microclimate regulation service of the ecosystem but examines this service together with other services. The same approach is used in the study of well-being services of urban ecosystems in Estonia (Ehrlich, 2022)[116] where microclimate-regulating services of urban ecosystems are studied in one CVM study together with other services of urban ecosystems.

A contingent valuation study on ecosystem services of urban green spaces in Estonia was conducted in 2019. The survey is based on 720 respondents and the sample structure was representative of the Estonian adult population. Whereas one of the aims of the CVM study was to find the financial equivalent of nonmarket services in the urban ecosystem, the structure of the questionnaire was more complicated than typical CVM survey. In addition to the typical parts of the CVM questionnaire, such as the simulated market scenario, the willingness to pay question (discrete choice format) and the sociometric part of the respondents, the questionnaire also included additional questions on the use and sufficiency of urban green areas. To link WTP to individual services of urban ecosystems, respondents were asked to rank urban ecosystems and ecosystem services according to their subjective preferences.

The estimation of the aggregated demand curve for the preservation and maintenance of urban green spaces of Estonian`s adult population is based on the actual distribution of WTP amounts obtained from the survey. The results are generalized to the proportion of the population with positive WTP, which is 90,5 per cent i.e. about 969000 persons 18 years of age or older in Estonia as of January 1st, 2019. In calculations, one respondent corresponds to 1486 inhabitants. The annual demand for urban green spaces by the Estonian adult population expressed through WTP is approx. 17,29 million euros.

In addition to identify willingness to pay for urban ecosystem services, an additional goal of the study was to divide willingness to pay between different services according to individuals' subjective preferences for services. The corresponding data are presented in Table 46.

Table 46. The willingness to pay of the Estonian population for urban ecosystem services.

Urban area ecosystem service	Importance	% (of inverse value)	WTP (thous. 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 shortcoming of the study in relation to the identification of the microclimate regulation service of the urban ecosystem is the formulation of the service "Urban microclimate regulation and carbon sequestration" used in the questionnaire, which handles microclimate regulation and carbon sequestration together in one service. It can be assumed that the microclimate regulation service separately (without carbon sequestration) would have received a lower place in the ranking and thus a lower willingness to pay. However, according to the formulation in the questionnaire, individuals placed

[116] Ehrlich, Ü., 2022. Willingness to pay for urban ecosystem services as input for statistics: a case of Estonia. Estonian Discussions on Economic Policy, 30 (1-2), 85–103. DOI: 10.15157/tpep.vi1-2.22088.

this service in seventh place (among 10 services), according to which approximately 1.7 million euros per year were attributed to this service from the total willingness to pay.

In addition to individuals' preferences for ecosystem services, the subjective importance of different urban ecosystems for people was also investigated, on the basis of which WTP was distributed among different ecosystems. The corresponding results are presented in Table 47.

Table 47. Distribution of WTP for the service "Urban microclimate regulation and carbon sequestration" between urban ecosystems.

Urban Ecosystem	WTP, thous. EUR
Big Parks	390.18
Small parks in the city centre	289.22
Tall landscaping (by the roads)	266.13
Forests within the city borders	210.82
Privately owned gardens	175.83
Lawn strips and flower pots by the sidewalks	175.35
Lawn strips by the road and between lanes	166.98
TOTAL, thous. EUR	1674.52
% of total value	9.69

People considered "Big parks" to be the most important ecosystem, whose "Urban microclimate regulation and carbon sequestration" service can be attributed 390 thousand euros per year from the total willingness to pay. "Small parks in the city center" (298 thousand euros) and "Tall landscaping" (266 thousand euros) follow. As expected, "Lawn strips and flower pots by the sidewalks" and "Lawn strips by the road and between lanes" are among the last ecosystem elements, as urban ecosystems with smaller biomass, which participate more modestly in climate regulation compared to parks.

4.7.4 Conclusion

In general, it can be assumed that although the microclimate regulation service is not as relevant (according to the definition given in the proposal of the legal text) in Estonia with a moderate climate, where there are few days exceeding +25 degrees per year as in countries located to the south. The importance of the service is on the rise due to the warming of the climate. However, the annual willingness to pay of around 1.7 million euros attributed to this service is by no means small. The climate regulation ecosystem service deserves an independent treatment as a welfare service and a CVM study dedicated specifically to this service.

4.8 Nature-related tourism and recreation services

According to the definition of the proposal for the amendment of Regulation (EU) 691/2011, the ecosystem service nature-based tourism-related services are defined as the ecosystem contribution, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use and enjoy the environment through direct, in-situ, physical and experiential interactions with the environment. These contributions shall be reported in number of overnight stays in hotels, hostels, camping grounds, etc. that can be attributed to visits to ecosystems.

The scope of recreation-related ecosystem services in the proposed legal module Ecosystem Accounts is limited to nature-based tourism-related services. Visits by locals and same-day visitors are considered for voluntary reporting and are discussed in paragraph 4.8.4.

For monetary valuation, the service was valued with time use and expenditures made during the trip.

The service is included in both physical and monetary supply and use tables. These tables are displayed in chapter 4.9 and in Annex "D1_6_ Dataset of the supply and use tables of ecosystem services_101022852_2020-EE-ENVACC" (MS EXCEL file) more detailed distribution by ecosystem types and users is given. Result found using time-use value is included in SUT out of the other tested alternative monetary valuation methods for the service.

4.8.1 Nature-based tourism-related services (number of overnight stays of tourists in hotels, hostels, camping grounds, etc., that can be attributed to visits to ecosystems)

The number of overnight stays of tourists in hotels, hostels, camping grounds, etc., that can be attributed to visits to ecosystems is considered the mandatory indicator for the nature-based tourism-related ecosystem service and it is foreseen that the reporting is to be done by attributing the indicator to specific ecosystem types at level 1. The precise definition according to the proposed legal text is the following

> '*Nature-based tourism-related services are defined as the ecosystem contribution, in particular through the biophysical characteristics and qualities of ecosystems, that enable people to use and enjoy the environment through direct, in-situ, physical and experiential interactions with the environment. These contributions shall be reported in number of overnight stays in hotels, hostels, camping grounds, etc. that can be attributed to visits to ecosystems."*

Guidance note prepared by Eurostat[117] requires using a three step-approach for the measurement of the indicator:

1) Collecting tourism statistics on overnight stays
2) Isolating the ecosystem contribution in general
3) Apportioning overnight stays between ecosystem types.

We used statistics on nights spent in hotels, holiday and other short-stay accommodation; camping grounds, recreational vehicle parks and trailer parks published at NUTS level 2 published by Eurostat (Online data code: TOUR_OCC_NIN2D, (https://ec.europa.eu/eurostat/databrowser/view/tour_occ_nin2d/default/table?lang=en), which is also available in Statistics Estonia Database (TU111: Accommodation by type of settlement, https://andmed.stat.ee/et/stat/majandus__turism-ja-majutus__majutus/TU111). The input data on overnight stays is given in Table 48.

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

Table 48. Nights spent at tourist accommodation establishments by degree of urbanisation, 2020

	Domestic	Foreign	Total
Cities	555 772	982 855	1 538 627
Towns and suburbs	644 099	250 897	894 996
Rural areas	1 070 339	170 050	1 240 389
Total	2 270 210	1 403 802	3 674 012

At NUTS level 2 Estonia is considered as one region, including the bigger cities. There are more detailed tourism statistics available in Statistics Estonia, such as overnight stays by municipality level (TU112: Accommodated tourists and nights spent by county and country of residence, https://andmed.stat.ee/en/stat/majandus__turism-ja-majutus__majutus/TU112), which could be used to improve the accuracy of isolating the ecosystem contribution and the apportionment to ecosystem types in the next steps.

It is recommended that calculating the ratio of ecosystem contribution is done by applying Recreation Potential Map (RP, developed by JRC), which is based on the presence of reachable opportunities for nature based activities (quantified using inland and water related elements). The ratio of ecosystem contribution could be then scaled based on additional data like input data on higher spatial accuracy, the degree of urbanization or trip purpose. However, as the Recreation Potential Map is not yet available for the member states to be used additional data sources could not be applied in this step and it was decided it is better to use degree of urbanization and corresponding ecosystem contribution ratios by expert judgement to reflect better the share of overnight stays that could be attributed to visits to ecosystems. Rough estimations based on available national statistics on overnight stays and trip purpose (percentage of trips for professional versus personal reasons in cities, rural areas and in between) were 20% for cities, 60% for towns and suburbs and 90% for rural areas (Table 49).

Table 49. Nights spent at tourist accommodation establishments attributed to visits to ecosystems, 2020

	Ecosystem Contribution Ratio	Domestic country	Foreign country	Total
Cities	20	111 154	196 571	3077 25
Towns and suburbs	60	386 459	150 538	536 998
Rural areas	90	963 305	153 045	1 116 350
Total		1 460 919	500 154	1 961 073

The total number of overnight stays attributed to visits to ecosystems were further attributed to specific ecosystem types at level 1 on EU Ecosystem typology according to the shares found by Recreation Potential Map for Estonia presented in the guidance note in an example. In Recreation Potential Map the spatial allocation is based on a weighted distribution inside NUTS2 regions, whereby the percentage of overnights stays attributed to an ecosystem is equal to the attractiveness metric of the ecosystem divided by the sum of all attractiveness metrics within the NUTS2 region.

Table 50. Supply of Nature-based tourism-related services by ecosystem types, 2020.

	% of Total overnight stays	Domestic country	Foreign country	Total
Settlements and other artificial areas	0	0	0	0
Cropland	0	0	0	0
Grassland (pastures, semi-natural and natural grassland)	9.36%	136 697	46 799	183 497
Forest and woodland	70.46%	1 029 297	352 386	1 381 683
Heathland and shrub	0.45%	6 609	2 263	8 871
Sparsely vegetated ecosystems	0.02%	290	99	390
Inland wetlands	8.12%	118 556	40 588	159 144
Rivers and canals	0.25%	3 633	1 244	4 877
Lakes and reservoirs	11.15%	162 953	55 788	218 741
Marine inlets and transitional waters	0	0	0	0
Coastal beaches, dunes and wetlands	0.20%	2 884	987	38 71
Marine ecosystems (offshore coastal shelf and open ocean)	0	0	0	0
Total	100%	1 460 919	500 154	1 961 073

The use of the service is divided between household and export. Domestic tourism by residents is to be reported as 'Households' final consumption'. Overnight stays performed by visitors who are not resident of the reporting country (also called inbound tourism) are to be reported as 'Exports'.

Table 51. Use of nature-based tourism-related services by ecosystem types and institutional sectors, 2020.

	Households	Export	Total use
Settlements and other artificial areas	0	0	0
Cropland	0	0	0
Grassland (pastures, semi-natural and natural grassland)	136 697	46 799	183 497
Forest and woodland	1 029 297	352 386	1 381 683
Heathland and shrub	6 609	2 263	8 871
Sparsely vegetated ecosystems	290	99	390
Inland wetlands	118 556	40 588	159 144
Rivers and canals	3 633	1 244	4 877
Lakes and reservoirs	162 953	55 788	218 741
Marine inlets and transitional waters	0	0	0
Coastal beaches, dunes and wetlands	2 884	987	3 871
Marine ecosystems (offshore coastal shelf and open ocean)	0	0	0
Total	1 460 919	500 154	1 961 073

4.8.1.1 Analysis on the valuation of nature-based tourism-related services

1. In step 3 there are two options for attributing the service to specific ecosystem types: 1) weighted distribution based on attractiveness metrics and 2) uniform distribution. We applied the first one. By applying uniform distribution the spatial allocation would be uniform among the selected ecosystems within the NUTS2 regions meaning ecosystem types are treated equal and the distribution depends on the area of ecosystems. When we compare the shares these two options give, we see that the results give significantly different results for some ecosystem types (7% difference is equal to approximately 270 000 visits) (Table 52).

   In addition, there was a willingness to pay questionnaire carried out during the project where the contact time with different ecosystems during overnight nature trips in Estonia was asked. The data only represents domestic trips with the purpose of nature-related activities and includes a narrower scope of ecosystem types (forest, swamp and marsh, grassland, seacoast, rivers and

lakes, other) where the ecosystem type is subjective to respondent's views. The results are rather different from the results received by Recreation potential model. Remarkable difference is seen for coastal beaches. The class should be included in the RP model but it has no recreation potential in the example calculated for Estonia regardless that Estonia has a long coastline. It may be due to the coarseness of CLC map used for RP map but more detailed analysis should be done
The share is also different for forest where RP gives it twice as high share as is received from the WTP questionnaire. In addition to the proportion lost to coastal ecosystems, it may be that forests have received higher proportion of shares due to its bigger area.

Table 52.Results of the shares attributed to different ecosystem types by weighted distribution, uniform distribution and distribution based on CVM questionnaire.

	Weighted distribution, %	Uniform distribution, %	CVM questionnaire (Proportion of time in contact with different ecosystems during overnight trips, %)
Settlements and other artificial areas	0%	0%	
Cropland	0%	0%	
Grassland (pastures, semi-natural and natural grassland)	9%	10%	6.6%
Forest and woodland	70%	77%	37.6%
Heathland and shrub	0%	0%	
Sparsely vegetated ecosystems	0%	0%	
Inland wetlands	8%	6%	12%
Rivers and canals	0%	0%	14.9%
Lakes and reservoirs	11%	6%	
Marine inlets and transitional waters	0%	0%	25.8%
Coastal beaches, dunes and wetlands	0%	0%	
Marine ecosystems (offshore coastal shelf and open ocean)	0%	0%	
Other			2.7%

2. There is the question how well the shares applied to account for visits to ecosystems according to urbanisation represent the reality. As Estonia has a small area and low population it is easy to travel from a city to natural locations. Therefore using data on the trip destination (TOUR_DEM_TNHD, https://ec.europa.eu/eurostat/databrowser/view/tour_dem_tnhd/default/table?lang=en) could be more meaningful than urbanisation data. Unfortunately in current statistics there is a overwhelming share of not specified data as other (59% of total in 2019).

Table 53. Overnight stays by type of destination of the trip (personal trips only), 2019

	Nights spent by type of destination of the trip (personal trips only), 2019	Share, %
Total	6 016 932	
City	1 830 749	30%
Countryside	953 804	16%
Seaside	714 301	12%
Cruise ship		
Mountains		
Other	3 567 576	59%

4.8.2 Monetary valuation of overnight stays that can be attributed to visits to ecosystems

We applied the previously used method of valuation of time use to find the monetary value of the service. The data is derived from the

There is also data available from tourism statistics on the average expenditure on an overnight domestic trip for holidays, leisure and recreation purpose (TU56: Expenditure on an overnight domestic trip of Estonian residents by main purpose of trip, https://andmed.stat.ee/en/stat/majandus__turism-ja-majutus__eesti-elanike-reisimine/TU56). In 2020 it was 180.06 euros. The expenditure includes expenses for travel, accommodation, catering, entertainment, shopping and other money spent.

Table 54. Monetary value of the supply of nights spent at tourist accommodation establishments by ecosystem types using expenses made during the trip, thousand euros, 2020

	Domestic country	Foreign country	Total
Settlements and other artificial areas	0	0	0
Cropland	0	0	0
Grassland (pastures, semi-natural and natural grassland)	24 614	8 427	33 040
Forest and woodland	185 335	63 451	248 786
Heathland and shrub	1 190	407	1 597
Sparsely vegetated ecosystems	52	18	70
Inland wetlands	21 347	7 308	28 655
Rivers and canals	654	224	878
Lakes and reservoirs	29 341	10 045	39 386
Marine inlets and transitional waters	0	0	0
Coastal beaches, dunes and wetlands	519	178	697
Marine ecosystems (offshore coastal shelf and open ocean)	0	0	0
Total	263 053	90 058	353 111

The use in monetary terms is divided similarly as was done for use in physical terms.

Another option is to apply the valuation by time use and use the monetary equivalent of contact time with ecosystems 56 EUR/overnight trip which was based on that 1 hour=7 EUR and that the average contact time of one person with nature (ecosystems) during one overnight trip is 8 hours. The concept can be read further in chapter 4.8.4. The results are seen in Table 55.

Table 55. Monetary value of the supply of nights spent at tourist accommodation establishments by ecosystem types using time use valuation, thousand euros, 2020

	Domestic country	Foreign country	Total
Settlements and other artificial areas	0	0	0
Cropland	0	0	0
Grassland (pastures, semi-natural and natural grassland)	7 655	2 621	10 276
Forest and woodland	57 641	19 734	77 374
Heathland and shrub	370	127	497
Sparsely vegetated ecosystems	16	6	22
Inland wetlands	6 639	2 273	8 912
Rivers and canals	203	70	273
Lakes and reservoirs	9 125	3 124	12 249
Marine inlets and transitional waters	0	0	0
Coastal beaches, dunes and wetlands	162	55	217
Marine ecosystems (offshore coastal shelf and open ocean)	0	0	0
Total	81 811	28 009	109 820

Expenditure made and time use approach was used together with number of overnight stays attributed to visits to ecosystems to find the monetary value of the service. The total value is 353 mln euros found by expenditures and 110 mln euros found by time use.

4.8.3 An overview of the use of the contingent valuation method (CVM) in the evaluation of ecosystem services

4.8.3.1 Contingent valuation method in the SEEA EA framework

Many ecosystem services they contribute to the increase in the well-being of individuals without their use being associated with an actual (described according to the rules of economic accounting) monetary turnover for the service. In economics, such good and services, that do not have a price on the market are called non-market benefits. Thus, many public goods are non-market. Among ecosystem services, regulating services and cultural services correspond to the characteristics of public goods.

If in assessing the monetary value of an ecosystem provisioning service, the main question is what part of the market price of an ecosystem service (for example, agricultural production) should be attributed to the ecosystem and what should be its methodological basis, then in the case of non-market services, the problem is how to quantify and evaluate the value of the service at all and on the basis of which data.

In the methodological handbook "System of Environmental-Economic Accounting— Ecosystem Accounting"[118] (hereinafter SEEA EA), two groups of methods are referred to in accounting for non-market services: revealed preferences and stated preferences. According to SEEA EA (p 200) "*Stated*

[118] United Nations et al. (2021). System of Environmental-Economic Accounting— Ecosystem Accounting (SEEA EA). White cover publication, pre-edited text subject to official editing. Available at: https://seea.un.org/ecosystem-accounting

preference methods do not utilize information on the behaviour of people in existing markets but rather use information from questionnaires to elicit likely responses of people by asking them to state their preferences in hypothetical situations". At the same time, it is recognized that „*Stated preference methods do not directly reveal exchange values and hence require adjustment for use in accounting* ".

SEEA EA (p. 200) places two broad types under stated preference methods: contingent valuation and choice experiment. The SEEA EA defines the contingent valuation method (hereinafter CV) as "*a survey-based stated preference technique that elicits people's behaviour in constructed markets. In a contingent valuation questionnaire, a hypothetical market is described where the good in question can be traded. This contingent market defines the good itself, the institutional context in which it would be provided, and the way it would be financed. Respondents are asked about their willingness to pay for, or willingness to accept, a hypothetical change in the level of provision of the good, usually by asking them if they would accept a particular scenario. Respondents are assumed to behave as though they were in a real market"*.

Although the methodological material of the SEEA EA referred to above states that „*the information obtained from contingent valuation methods and choice experiments is the willingness to pay (WTP) for an ecosystem service or willingness to accept (WTA) payment for its loss. This information is then used to assess changes in consumer and producer surplus and, as such, does not provide an estimate of the value required for accounting purposes*". However, SEEA EA argues that "*by combining information on WTP or WTA of a range of recipients of the service, it is possible to derive a demand function for the ecosystem service and such a demand function may subsequently be used to derive an exchange value using an SEV approach"*. Therefore, the use of the contingent valuation method to find the monetary equivalent of non-market ecosystem service values is also according to the SEEA EA guidance report fully acceptable if the methodology is followed and the limitations related to the method are taken into account.

4.8.3.2 Applications of the contingent valuation method

Both internationally and in Estonia, the use of the contingent valuation method has long-term traditions. The first application of the technique was in 1963 when Davis (Davis 1963) tried to estimate the value hunters and tourists placed on a wilderness area. In the mid-1970s, the contingent valuation method started to spread rapidly. Since then the method has grown increasingly more popular and is widely used in all advanced democracies, being a good instrument for adopting democratic decisions and allowing to decide on the application of different scenarios of natural resource use, making non-market values one-dimensional with market values. Comprehensive accounts of the method may be found in Mitchell and Carson (Mitchell et al., 1989), Hanley and Spash (Hanley, et al., 1993) and Bateman and Willis (Bateman, et al., eds., 1999).

When applied methodologically correctly, the result obtained by the CV method (for example, the financial value of ES), unlike the methods based on market prices and revealed preferences methods, is directly related to the object under study and shows the increase in welfare associated with it, which is a measure of value. The CV also takes into account the consumer's price reserve, which is a problem for indirect methods based on belonging to the revealed preferences methodological group (e.g. travel costs).

In the assessment of the value of ecosystem services carried out in Estonia, the contingent valuation method was applied to find the monetary equivalent of different services of different ecosystems. The monetary equivalent of non-market services of grassland[119], wetland, forest and urban ecosystem services[120] was determined as a result of several CV studies (Ehrlich, 2021; Ehrlich, 2022). Although original research was not provided for in the grant of Statistics Estonia, cooperation with environmental economics researchers of Tallinn University of Technology made it possible to carry out original research and use the results in reports. It provided valuable new information about the use of CV in the financial evaluation of ecosystem services, highlighted the strengths and weaknesses of the method, and made it possible to make practical recommendations for the future use of CV. Confidence in using CV gave us also the SEEA EA guidance material cited above, where CV was recommended as one of the ES evaluation methods.

A characteristic methodological feature of these studies was that within the framework of one survey, the authors wanted to find out the value of several services of the ecosystem under study. For this purpose, in addition to declaring willingness to pay, the respondents were asked to rank the services of the studied ecosystem according to their subjective preference. According to the subjective importance of the services, the total willingness to pay for the services of the ecosystem under study was divided between individual services.

The studies conducted in Estonia allow us to conclude that it is not methodologically practical to try to cover all welfare services of one ecosystem with one CV study. It is difficult for many respondents to imagine many ecosystem services using a simulated market scenario, which ultimately leads to an easy underestimation of individual ecosystem services. Methodologically, it would be better to focus on one service in one CV study, as was done for the ecosystem recreational service value evaluated in Eurostat Grant-101022852-2020-EE-ENVACC[121].

4.8.3.3 Disadvantages and advantages of contingent valuation method

The strength of the method is the fact that it directly measures the increase in individual welfare due to the ecosystem service, making it possible to measure the values of such services, the use of which does not require direct physical contact with the ecosystem. Also, CV's strong point is the consideration of the number of consumers of the service when measuring the value of ecosystem welfare services. The method is based on the individual`s welfare changes (increase) and the value of the ecosystem service depends on the number of consumers of the service. Also, the use of the CV allows taking into account the subordination of the value of ecosystem services to the principle of marginal value which is often a disadvantage when using benefit transfer.

The disadvantage of CV is that the monetary equivalent of the ES value obtained by the contingent valuation method has no connection with the actual (i.e. „accounted“) turnover. Therefore, it is difficult to place the monetary equivalent of the service obtained using CVM in the existing system of accounting and statistics, which is why the corresponding values are also called non-SNA values. The result obtained with the contingent valuation method is sensitive to the details of the applied methodology. Therefore, in order to use the CV to find the values of ES services and use it in statistics, a standard must be developed that the CV studies on which the data are based must meet. also, a serious disadvantage of the method is the need for large-scale special studies from the point of view of statistics. Given that a methodologically serious study requires a sample of 1,000 individuals and the fact that an independent study should be done for each service, the use of CV as a basis for ES value statistics is a real challenge.

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[119] Eurostat Grants “Development of the land account and valuation of ecosystem services regarding grassland ecosystem” (831254-2018-EE-ECOSYSTEMS)
[120] Eurostat Grant “Development of the ecosystem accounts“ (881542-2019-ENVECO).
[121]Eurostat Grant-101022852-2020-EE-ENVACC

4.8.3.4 Conclusion

The suitability of the CV method for assessing the value of ecosystem services depends on what we actually want to evaluate. If the object of evaluation is the increase in welfare of individuals due to the consumption of ecosystem services, CV is a very suitable method for identifying the value of ecosystem welfare services. However, if the purpose of evaluation is to identify the share of the ecosystem in actual (described according to the rules of financial accounting) turnover, then this CV is not measured and identified. But regardless of the definition of the value of ecosystem services, CV remains indispensable for quantifying the values of welfare services that do not require physical contact with the ecosystem and therefore can not be measured using time value approach (for example, existence value and future value).

4.8.3.5 References

R. K. Davis, 1963. The Value of Outdoor Recreation: An Economic Study of the Maine Woods. Ph. D. Dissertation,.

R. C. Mitchell and R. T. Carson , 1989. Using Surveys to Value Public Goods: The Contingent Valuation Method. Washington, D. C.: Resources for the future.

N. D. Hanley and C. L. Spash, 1993. Cost-Benefit Analysis and the Environment, Edgar Elgar Publishing Limited, Aldershot, England.

D. W. Bateman and K. G. Willis (eds.) 1999. Valuing Environmental Preferences. Theory and Practice of the Contingent Valuation Method in the US, EU and Developing Countries, Oxford University Press Inc., New York.

Ehrlich, Ü. 2022. Contingent Valuation as a Tool for Environmental Economic Accounting: Case of Estonia. Estonian Discussions on Economic Policy, 29 (1-2), 56–70. DOI: 10.15157/tpep.v29i1-2.18342.

Ehrlich, Ü., 2022. Willingness to pay for urban ecosystem services as input for statistics: a case of Estonia. Estonian Discussions on Economic Policy, 30 (1-2), 85–103. DOI: 10.15157/tpep.vi1-2.22088.

4.8.4 About the value of the recreational service of Estonian ecosystems based on a questionnaire

The study to find out the recreational behaviour of the Estonian population and monetary value of recreational service of ecosystems was conducted in 2022. The questionnaire was longer and more comprehensive than the usual CVM questionnaire. The purpose of the questionnaire was to obtain information about the time people spend in nature, the proportion of contact with different ecosystems and the annual willingness to pay for the maintenance of recreational infrastructure. The survey was representative of basic sociometric indicators, and the results were extrapolated to the adult population of Estonia. A total of 992 properly completed questionnaires were received. All questionnaires were conducted in the form of personal contact and completed on paper. The basic data revealed by the research are presented in Table 56.

An adult resident of Estonia makes an average of 17 nature trips with recreational purposes per year. The duration of one trip is 6 hours on average. Thus, a person spends an average of 102 hours in nature (in contact with ecosystems) annually. A separate question was asked about overnight trips. On average, a person makes 4.3 overnight trips a year, spending an average of 2 nights on the trip.

Table 56. Results of the indicators from the questionnaire of recreational behavior in Estonia (CVM questionnaire, 2022)

Indicator	Result
The number of recreational nature trips made by one person per year	17
Average duration of one trip	6.0 hours
Time per year spent in nature trip for recreational purposes by one person	102 hours
Average number of overnight recreational trips per person per year	4.3
Average number of nights spent on overnight trips	2
Annual total willingness to pay of Estonian adult population for maintaining the infrastructure necessary for recreation in nature, EUR million/year	24.7

The CVM component of the survey, the willingness-to-pay question, was about the maintenance of recreational infrastructure. Annual willingness to pay for infrastructure maintenance was asked. The aggregated total willingness to pay of the adult population of Estonia for this was 24.7 million euros.

In the questionnaire, the respondents were asked to estimate the proportion of contact with different ecosystems during the time spent in nature for recreational purposes. The individual's average share of contacts with different ecosystems and the hours of contact with different ecosystems per year are shown in Table 57.

Table 57. Recreational contact of one individual with different ecosystems per year

Indicator	Forest	Swamp and marsh	Grass-land	Sea coast	Rivers and lakes	Other	Total
How many % of the time spent in nature does a person come into contact with which ecosystems, %	37.6	12.0	6.6	25.8	14.9	2.7	100 %
How many hours in nature do an individual come into contact with different ecosystems, hours/year	38.9	12.2	6.7	26.3	15.2	2.7	102 Hour/year
Monetary value of contact time with ecosystems, 1 hour=7EUR	272.3	85.4	46.9	184.1	106.4	19.9	714 EUR/year

As expected, people were in contact with the forest most of the time, 37.8% of the total. Sea coast followed with 25.8 percent and inland water bodies with 14.9 percent. People were in contact with grassland the least (6.6%). Considering the popularity of hiking trails through swamps and marshes, the small proportion of contacts with swamps and marshes in the total contact with ecosystems is somewhat surprising.

Finding a monetary value for ecosystem recreational service based on time in contact with ecosystems requires first assigning a monetary value to time. In this study, the value assigned to time is **1 hour=7 euros**. With such a monetary value of time, it can be said that **ecosystems provide the average Estonian adult resident with a recreational service for 714 euros per year.**

In Table 58, the recreational service of ecosystems provided to one individual is extrapolated to the adult population of Estonia. Extrapolating the recreational service provided to the average individual to the working-age population of Estonia, we get the result that **Estonian ecosystems provide a recreational service for a total of 762 million euros per year.** The service is divided between different ecosystems in proportion to the time vacationers (recreational service consumers) were in contact with the respective ecosystem.

Table 58. Recreational contact of Estonian adult population (1072458 individuals) with different ecosystems per year.

Indicator	Forest	Swamp and marsh	Grass-land	Sea coast	Rivers and lakes	Other	Total
How many % of the time spent in nature does an Estonian adult population contact with different ecosystems, %	37.6	12.0	6.6	25.8	14.9	2.7	100 %
How many hours in nature do Estonian adult population come into contact with different ecosystems, Million hours/year	41.1	13.1	7.2	28.2	16.3	2.9	108.9 Million hour/year
Monetary value of contact time with ecosystems, 1 hour=7EUR, Million EUR	287.6	91.6	50.4	197.7	114.2	20.6	762.1 Million EUR
Willingness to pay for maintaining the infrastructure necessary for recreation in nature, EUR million/year	9.3	3.0	1.6	6.4	3.7	0.7	24.7 Million EUR/year

Compared to the monetary value of the recreational service of ecosystems found through the value of time, the willingness to pay for the maintenance of the infrastructure necessary for recreation is modest - only 24.7 million euros per year. In part, this can be explained by the wording of the question of willingness to pay. After all, the willingness to pay for the preservation of ecosystems was not asked, but only for the maintenance of the infrastructure necessary for recreation. Considering this, 24 million euros per year is not at all small. This provides valuable information about the ability of recreation infrastructure to enhance the welfare of individuals and demonstrates the importance of infrastructure for consumers of ecosystem recreation services. It may even be argued that infrastructure participates in providing an ecosystem recreational service.

4.8.5 Overnight recreation based on questionnaire

The study of recreational behaviour and recreational preferences of the Estonian population was conducted in 2022. The sample size was 992 Estonian residents and the sociometric structure of the sample was representative of the Estonian adult population in terms of basic indicators (gender, age, education, income range), which allows extrapolation of the results. The study was based on the contingent valuation (hereinafter CVM) methodology and met the requirements set for such studies both in terms of the structure of the questionnaire and the representativeness of the interviewed sample. However, the aim of the study was broader than typical CVM studies. In addition to the question of willingness to pay typical of CVM studies, the goal was to obtain information from the surveyed sample on quantitative indicators of recreational behaviour, such as the number of annual recreational nature trips made by one person, time per year spent in nature trip for recreational purposes by one person, number of overnight recreational trips per person per year, number of nights spent on overnight trips and recreational contact with different ecosystems.

The data and analyses concerning the entire surveyed sample are presented in paragraph 4.8.4. Current chapter focuses on data related to overnight nature tourism trips. (Overnight here means staying in for at least two days where accommodation was used during the trip.) The main data related to overnight trips are given in Table 59. In order to separately treat individuals who made overnight trips, an extract was made from the database containing all the information of the survey, which only contained the data of individuals who made overnight trips. As a second step, trips with overnight stays had to be separated from all trips of the respective individuals.

Table 59. The main data of nature tourism trips with overnight stays

Indicator	
The proportion of persons who made nature trips with an overnight stay compared to all persons who made nature trips.	66%
The number of such trips per year by persons who made trips with an overnight stay, during which no overnight stay was taken.	13 trips
The number of overnight trips per year by persons who made overnight trips	6 trips
Average contact time of one person with nature (ecosystems) during one overnight trip.	8.0 hours
Time per year in contact with nature (ecosystems) during overnight trips by one person.	48 hours

As can be seen from the data (table 1), individuals who made overnight trips make 19 trips per year (13 without overnight stays and 6 with overnight stays), which is two trips more than the average of the entire sample. Of these, only 6 trips (32%) are where overnight stays were made during the trip. This clearly shows that the total volume of nature tourism cannot be understood only based on the statistics of overnight stays during the trip. In total, an individual is in contact with nature for an average of 48 hours a year during overnight trips. Compared to the average individual who spends a total of 102 hours a year in contact with nature, this is only 47%. If we take into account that only about 66% of those surveyed have made trips with an overnight stay, the difference between the time spent in contact with nature compared to the total time spent in nature is amplified even more.

Table 60 shows the time spent in contact with nature (ecosystems) by one individual during overnight trips and its financial equivalent, where the monetary value of one hour of contact is 7 euros. The share of contacts with different ecosystems during nature tourism trips with overnight stays does not differ much from the share of contacts made during all nature trips (see chapter 4.8.4).

Table 60. Recreational contact of one individual with different ecosystems during overnight trips per year.

Indicator/Ecosystem	Forest	Swamp and marsh (wetland)	Grass-land	Sea coast	Rivers and lakes	Other	Total
Proportion of time in contact with different ecosystems during overnight trips, %	36.7	12.0	7.2	25.4	15.9	2.8	100 %
Time per year the individual was in contact with different ecosystems during overnight trips, hour/year	17.6	5.8	3.5	12.2	7.6	1.3	48 Hour/year
Monetary equivalent of contact time with ecosystems, EUR/year. 1 hour=7EUR	123.2	40.6	24.5	85.4	53.2	9.1	336 EUR/year

In relative terms, nature tourists have been in contact with the forest the most (36.7% of the total time in contact with the ecosystem), followed by the sea coast (25.4%) and rivers and lakes (15.9%). The average individual spent 48 hours per year in contact with ecosystems on overnight nature trips. Taking the value of the time spent in contact with nature as 7 euros per hour, the monetary equivalent of the time spent in contact with nature during one individual's overnight trips is 336 euros. This value can be based on extrapolating the value of time spent in contact with ecosystems during overnight nature trips to the adult population of Estonia.

In order to find the monetary equivalent of the value of the time spent in contact with nature (ecosystems) during overnight trips, the results of the sample of this study who made overnight trips must be extrapolated to the adult population of Estonia (1072458 individuals). Overnight trips were made by 66.6% of the population, that is 714257 individuals. Considering that one individual's time in contact with nature during overnight trips is 48 hours a year, we can get the time spent in contact with nature during overnight trips of all individuals who made overnight, which is approximately 34,2 millions hours (34284336 hours).

In total, people spent more than 34 million hours per year in contact with ecosystems during overnight trips annually, the monetary equivalent of which is approximately 240 million euros. According to the time value method, this amount can be transferred to the ecosystems in proportion to the time in contact (which is done in Table 61), thereby deriving the monetary equivalent of the value of individual ecosystems.

Table 61. Contact with different ecosystems during overnight nature trips of the Estonian adult population, time spent in contact with ecosystems and its financial equivalent.

Indicator	Forest	Swamp and marsh	Grass-land	Sea coast	Rivers and lakes	Other	Total
How many % of the time spent in nature does an Estonian adult population contact with different ecosystems, %	36.7	12.0	7.2	25.4	15.9	2.8	100 %
How many hours in nature do Estonian adult population come into contact with different ecosystems, Million hours/year	12.582	4.114	2.468	8.708	5.451	0.960	34.283 Million hour/year
Monetary equivalent of contact time with ecosystems, Million EUR; 1 hour=7EUR	88.074	28.798	17.276	60.956	38.157	6.720	239.981 Million EUR

Comparing the volume of contacts with ecosystems during overnight nature trips (34,3 Million hours/year) to the total time spent in contact with ecosystems during nature trips by Estonian adults (108,9 Million hours/year), it must be recognized that the time spent in contact with ecosystems during overnight trips only accounts for about 31,5% of the total time people are in contact with ecosystems. This clearly demonstrates that nature tourism statistics based only on overnight trips greatly underestimates the total amount of time spent in contact with nature (ecosystems) during nature tourism and leads to an underestimation of the monetary equivalent of the value of ecosystems using the time value method.

Discussion document on Recreation ecosystem service, calculation of the contributions from different ecosystems was written and presented on 28th London Group meeting.[122]

[122] Recreation ecosystem service, calculation of the contributions from different ecosystems. oras.pdf (un.org)

4.8.6 Conclusions and discussion on nature-related tourism and recreation services

4.8.6.1 Physical valuation

According to the proposed legal module Ecosystem Accounts is limited to nature-based tourism-related services and these services are clearly defined. Indicator of these services is the number of overnight stays in different accommodations. At first glance, this approach seems too general, but the additional information obtained from the Recreation Potential Map specifies the potential (incl. attractiveness) of the service in such a way that the accuracy of the obtained result and the expenses incurred for obtaining this information are proportional. As a final step, the number of overnight stays is distributed between ecosystem types.

In addition to tourism statistics on the overnight stays of domestic and foreign tourists in cities, towns and suburbs, and rural areas in 2020, more detailed tourism statistics available in Statistics Estonia could be used to improve the accuracy of the next calculations. For example, there is data on overnight stays at the county level, which, when used together with the Recreational Potential Map, would provide very good input for both the implementation of the proposed methodology and the calculation of the monetary value of ecosystem recreation service.

According to the methodology, it is recommended that calculating the ratio of ecosystem contribution is done by applying the Recreation Potential Map, which presents the presence of reachable opportunities for nature-based activities (quantified using inland and water-related elements). The ratio of ecosystem contribution could be then scaled based on additional data like input data on higher spatial accuracy, the degree of urbanization, or trip purpose. Currently the Recreation Potential Map is not yet available, but with the help of experts and instead the relationship between the location of the overnight stays and the nature recreation potential of the destination has been estimated. The approach proposed by the experts is logical and helps to reach statistically reliable results. Experts suggested that about 20% of overnight stays in cities, 60% in urban and suburban areas, and 90% in rural areas are related to nature tourism.

Table 50 of the report presents the supply of nature-based recreation services division by ecosystem types in 2020. According to this information the most attractive ecosystem is forest and woodland (share 70.46%), followed by lakes and reservoirs (share 11.15%) and inland wetlands (share 8.12%). From the point of view of Estonian nature-based recreation, the share of forest and woodland is too high and inland wetlands is too low. A comparison can be made with the questionnaire of recreational behaviour in Estonia (CVM questionnaire, 2022), where respondents were asked to divide their time spent on nature recreation between the most common ecosystems in Estonia. The survey revealed that the most popular is forest (share 37.6%), followed by coastal beaches, dunes and wetlands (share 25.8%) and inland wetlands (share 12%). This division of shares seems more common for Estonian culture but even here the share of inland wetlands seems too low as it is a well-known fact that popularity of marshes and bogs as nature-based recreation sites is on the rise. The nature-based recreation services division by ecosystem types needs to be clarified in collaboration with specialists from different fields. The most accurate distribution can be obtained if each country develops its own distribution.

4.8.6.2 Monetary valuation

According to data available from tourism statistics Estonian residents' average expenditure on overnight domestic trips was 180.06 euros in 2020. This sum includes expenses for travel, accommodation, catering, and entertainment, shopping and other. Based on this information, the monetary value of nature-based ecosystem recreation services is 353 million euros per year. In calculation of monetary value domestic trip expenditure (180.06 EUR) is used also for foreign travelers.

Most likely, the expenditures of foreign tourists are different from those of domestic tourists and the appropriate expenditures should be found to improve the calculations.

Other options used to calculate monetary value of nature-based recreation service is based on the value of time (7 EUR per hour, total value110 million euros per year) and contingent valuation method (willingness to pay for recreational services of the Estonian adult population is 24.7 million euros per year).

In the frame of the questionnaire of recreational behavior in Estonia (CVM questionnaire, 2022) some physical indicators that are important for calculating the monetary value of the nature-based ecosystem recreation service were specified as:

- Estonian adult resident makes 17 recreational trips to nature and spends an average 102 hour in contact with nature annually. If the time value is 7 €/h then the monetary value of contact time with ecosystems of Estonian adult population (1 072 458 persons) is totally 762.1 million euros per year.
- Average Estonian makes 6 nature tourism trips with overnight stay annually which means that only 32% of total trips are overnight trips. Value of recreational contact with ecosystems during overnight nature trips of Estonian adult population is 239.981 million euros per year.

It can be concluded that nature tourism statistics based only on overnight trips (762.1 million euros per year) greatly underestimates the total amount of time spent in contact with nature and leads to underestimation of the value of ecosystem recreation services (239.981 million euros per year).

Since the results of the monetary value of nature-based ecosystem recreation services calculated using different methods are very different, the results should be used only with the underlying assumptions. To get better representation of the results, the questionnaire on the recreational behaviour should be carried out regularly in addition to top-down modelling methods that are proposed in the guidance note.

For better understanding of the results of nature-based ecosystem recreation service value obtained by using the contingent valuation method, the report could include an analysis of the socioeconomic indicators of the sample, which would allow to decide to what extent the sample correlates with the general population. For a better understanding of the analysis of willingness to pay, the report could include a graph of the aggregated willingness to pay curve and the demand curve prepared by regression analysis, as well as the calculated correlation coefficient.

4.9 Supply and use tables

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 the project physical and monetary supply and use tables of ecosystem services for 2020 for Estonia were compiled.

Supply and use tables give complete and structured way to present and analyse calculated values of ecosystem services. The structure of the supply and use tables are similar to tables used in National Accounts 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 it 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.

Table 62 and Table 63 show the supply and use of ecosystem services in physical account. Indicators describing the service have been added to the table to clarify which aspect of the service was accounted for. The services included in the table have different units, therefore summarizing over ecosystem types is not possible. Units recommended in the proposal for the amendment of regulation EU 691/2011 or respective guidance notes prepared by Eurostat were used.

Table 64 and Table 65 show the supply and use of ecosystem services in monetary account. The services have the same unit and are potentially additive. Therefore it was possible to calculate the total supply by ecosystem types and also bring out values for subcategories of services: provisioning (includes crop provision, crop pollination, wood provision), regulating (air filtration, global climate regulation: net carbon sequestration, global climate regulation: carbon storage, local climate regulation), cultural (nature-based tourism-related services: overnight stays). However, the gross values and also single monetary values should be treated cautiously considering the underlying assumptions of the definitions and methodologies.

Supply and use of the ecosystem services on a more detailed level 2 ecosystem types (using Classification of ecosystems for ecosystem accounting in Estonia) is presented in Annex “D1_6_ Dataset of the supply and use tables of ecosystem services_101022852_2020-EE-ENVACC” as MS EXCEL file.

Table 62. Supply of ecosystem services - physical account (2020)

		Ecosystem type								
Ecosystem service	**Indicator and unit**	Forest	Grassland	Cropland	Wetland	Artificial area	Coast (SHORES)	Inland waterbodies	Other	**Total supply**
Crop provision	crop production in thousand tonnes		804	3 749						**4 554**
Crop pollination	production of pollinator-dependent crops in thousand tonnes	32	26	1	0.3	16	0.003		0.04	**75**
Wood provision	net increment in thousand m3	11 778								**11 778**
Air filtration	tonnes of PM2.5 adsorbed	325	60	109	23	27	0	10	0.4	**554**
Global climate regulation: net carbon sequestration	tonnes of net sequestration of carbon	52 212								**52 212**
Global climate regulation: carbon storage	tonnes of stored organic carbon	2 355 080 122	426 783 504	556 563 944	492 982 838	143 602 429	2 127 124	53 934 353	3 244 909	**4 034 319 223**
Local climate regulation	reduced temperature in degrees Celsius									**n/a**
Nature-based tourism-related services: overnight stays	number of overnight stays	1 381 683	192 368		159 144		3 871	223 618	390	**1 961 074**

Table 63. Use of ecosystem services - physical account (2020)

		Economic activity and institutional sector						
Ecosystem service	**Indicator and unit**	..A Agriculture, forestry and fishing	...A.01 Crop and animal production, hunting and related service activities	...A.02 Forestry and logging	General government	Households	Rest of the world	**Total use**
Crop provision	crop production in thousand tonnes	4 554	4 554					**4 554**
Crop pollination	production of pollinator-dependent crops in thousand tonnes	75	75					**75**
Wood provision	net increment in thousand m3	11 778		11 778				**11 778**
Air filtration	tonnes of PM2.5 adsorbed						554	**554**
Global climate regulation: net carbon sequestration	tonnes of net sequestration of carbon				52 212			**52 212**
Global climate regulation: carbon storage	tonnes of stored organic carbon				4 034 319 223			**4 034 319 223**
Local climate regulation	reduced temperature in degrees Celsius							**n/a**
Nature-based tourism-related services: overnight stays	number of overnight stays					1 460 919	500 154	**1 961 074**

Table 64. Supply of ecosystem services – monetary account (2020), thousand EUR

	Ecosystem type								
Ecosystem service	Forest	Grassland	Cropland	Wetland	Artificial area	Coast (SHORES)	Inland waterbodies	Other	**Total supply**
Crop provision		0.02	0.05						0
Crop pollination	12 574	9 993	606	101	6 181	1		15	29 470
Wood provision	238 103								238 103
Air filtration	753	139	253	53	62	0.1	23	1	1 284
Global climate regulation: net carbon sequestration	4 796								4 796
Global climate regulation: carbon storage	188 156 989	34 097 481	44 466 171	39 386 416	11 472 986	169 945	4 309 036	259 249	322 318 272
Local climate regulation									n/a
Nature-based tourism-related services: overnight stays	77 374	10 773		8 912		217	12 523	22	109 820
Provisioning services	250 677	9 993	606	101	6 181	1		15	267 573
Regulating services	188 162 538	34 097 619	44 466 424	39 386 469	11 473 048	169 945	4 309 059	259 250	322 324 352
Cultural services	77 374	10 773		8 912		217	12 523	22	109 820
Total	188 490 589	34 118 384	44 467 030	39 395 482	11 479 229	170 163	4 321 582	259 287	322 701 746

Table 65. Use of ecosystem services – monetary account (2020), thousand EUR

	Economic activity and institutional sector						
Ecosystem service	..A Agriculture, forestry and fishing	...A.01 Crop and animal production, hunting and related service activities	...A.02 Forestry and logging	General government	Households	Rest of the world	**Total use**
Crop provision	0.07	0.07					0
Crop pollination	29 470	29 470					29 470
Wood provision	238 103		238 103				238 103
Air filtration					1 284		1 284
Global climate regulation: net carbon sequestration				4 796			4 796
Global climate regulation: carbon storage				322 318 272			322 318 272
Local climate regulation							n/a
Nature-based tourism-related services: overnight stays					81 811	28 009	109 820
Provisioning services	267 573	29 470	238 103				267 573
Regulating services				322 323 068	1 284		322 324 352
Cultural services					81 811	28 009	109 820
Total	267 573	29 470	238 103	322 323 068	1 284	28 009	322 701 746

5 Output indicators

Analyses of the output indicators was considered important and the workflow on this subject was foreseen in Activity 2. In general, it was discussed that each of the ecosystem services flow value dynamics per area or population could be regarded as an indicator dependent on its relevance by users. In order to find the links between possible outputs of ecosystem accounting with global reporting we analyzed possible indicators that could be derived from ecosystem accounting in Estonia, for example in connection with CBD (Convention on Biological Diversity, https://www.cbd.int/) reporting. In addition the monitoring framework related to the EU Biodiversity Policy was analysed.

In the first year of the project the concept of the aggregated ecosystem services index was analysed and contributing paper „Aggregation of the ecosystem service values in urban ecosystem account, application of the principles of gross ecosystem product (GEP) " was discussed in London Group on Environmental Accounting Meeting in 2021. Aggregated value estimates could have several restrictions but the state at the beginning of the project was that CBD (Convention on Biological Diversity) had selected gross ecosystem product (GEP) as a candidate for one of the lead indicators and it has been listed in "Proposed headline indicators of the monitoring framework for the post-2020 global biodiversity framework"(goal B, page 5). The methodological issues of compiling aggregate index were analysed and discussed using urban ecosystem account as example.

Many changes took place on the political landscape during the current grant project: in Europe the proposal for the nature restoration law (1) in line with the development of EU biodiversity policy and agreeing on The Kunming-Montreal Global Biodiversity Conservation Framework (2) and respective monitoring framework on global level were main processes of relevance. These new processes require a response from statistical institute and respective statistical activities were started in Estonia as well.

In a seminar organized by Statistics Estonia in 2023 (see ANNEX 2), the representatives of Environmental Ministry gave an overview on the Kunming-Montreal Global Biodiversity Conservation Framework (GBF) and the outline of the foreseen monitoring of its implementation was given. As GBF monitoring framework consists of measurable indicators which will be used to assess the meeting of the targets of the goals of GBF and several of these indicators (mandatory main indicators and voluntary additional indicators) will overlap with ecosystem accounting, the capacity of the statistical system to produce indicators was discussed. Also, the aspect of involving all relevant contributors was highlighted from the viewpoint of the partner inclusive system.

For many of these indicators the methodology for monitoring is still being developed and not yet agreed upon and the actual production of these indicators will depend on the methodological development in respective task teams. The reporting is already foreseen for years 2026 and 2029 and it coincides approximately with the first foreseen reporting on the ecosystem accounts module of the 691/2011. Statistical system is foremost involved in regards with SEEA EA and SEEA CF related outputs which are mainly related to the areas indicated on Figure 18. It was discussed (in final seminar, May 2023) that SEEA CF and SEEA EA provide basic statistics for calculating indicators, basis for the analyses and scenario modelling for monitoring of the goals of the biodiversity goals.

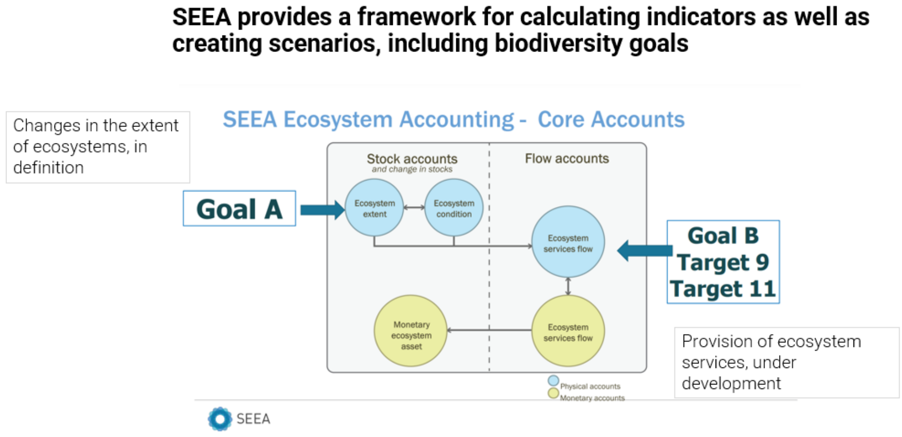

Figure 18. SEEA EA provides basic statistics for calculating indicators, bases for the analyses and scenario modelling for monitoring of the goals of the biodiversity[123]

Main indicators of GBF are related to:

- Extent of natural ecosystems
- Services provided by ecosystems (in development)
- Proportion of agricultural area under productive and sustainable agriculture
- Average share of the built-up area of cities that is green/blue space for public use for all.

GBF outline long-term goals (until 2050)such as protection of ecosystems, species, genetic diversity, valuing, maintaining, restoration of natural resources and contributions; equal distribution of revenues from the use of genetic resources, adequate resources for nature conservation; and short term-goals (until 2030) which can be summarized as reduction of impacts on biodiversity, sustainable use of natural resources and fair allocation of its revenue; developing means and solutions for meeting the goals and mainstreaming biodiversity were discussed on a seminar as well.

It was also emphasized that the links to other environmental accounts are important: statistical data are relevant regarding the monitoring of the measures on biodiversity conservation regarding global biodiversity framework, its targets and accounts as is indicated below on Figure 19.

[123] - Slide from the Statistics Estonia seminar on ecosystem accounting, 23.05.2023, adapted from the UNSD presentation; Monitoring the Kunming-Montreal Global Biodiversity Framework: The Role of Official Statistics; https://seea.un.org/sites/seea.un.org/files/biodiversity_side_event_unsc_0.pdf

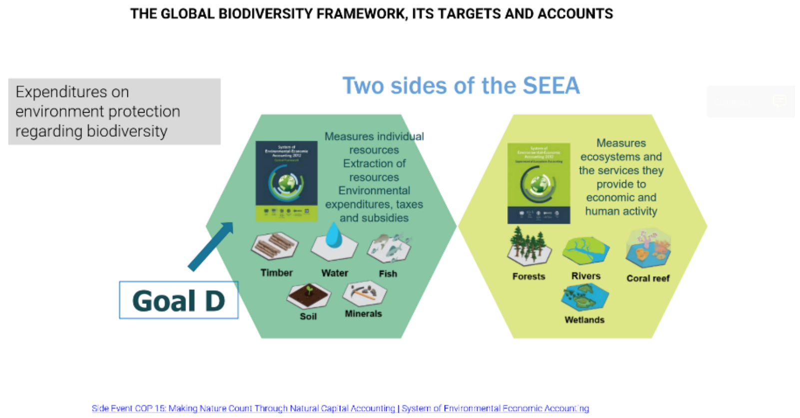

Figure 19. SEEA CF together with SEEA EA provide basic statistics for calculating indicators and scenario modelling for monitoring of the goals of the biodiversity[124]

During the second year of the project in addition to the indicators included in the proposal of the ecosystem accounts module of regulation EU 691/2011, additional potentially relevant indicators were analysed together with main partners who are experts in the field in Estonia. Additional indicators relevant concerning Nature Restoration Raw viewpoint were acknowledged.

Proposed Nature Restoration Law (22.06.2022, currently in negotiating phase in the EU) provides another monitoring framework for ecosystem condition. Indicators and reporting have been analyzed. The missing components outside of the scope of the proposal for the amendment of regulation on environmental economic accounts EU 691/2011 were analyzed and the topic was also discussed among experts and stakeholders in a seminar organized by Statistics Estonia. In principal, several of the proposed indicators for monitoring of the extent and condition of habitats could be associated with ecosystem accounts, such as the area of urban green space and the coverage of tree canopies in cities, abundance and diversity of pollinator species, grassland butterfly index, organic carbon stock of mineral soils of agricultural lands, share of agricultural land with diverse landscape elements, farmland bird index, dead wood, age structure of forests, coherence of forests, forest bird index. The reporting has to be harmonized and developed in coming years as currently reporting has been scheduled on 2031. These indicators and methods will be handled in more detail during the following years in the work on ecosystem accounts

Statistics Estonia has by now produced the first feasible round of statistics and indicators for the last available year for the condition account that is proposed by the amendment of the regulation on environmental economic accounts 691/2011.

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[124] - Slide from the Statistics Estonia seminar on ecosystem accounting, 23.05.2023, adapted from the UNSD presentation. Monitoring the Kunming-Montreal Global Biodiversity Framework: The Role of Official Statistics; https://seea.un.org/sites/seea.un.org/files/biodiversity_side_event_unsc_0.pdf

6 Development of partner-inclusive system for national ecosystem accounting

In Statistics Estonia work on ecosystem accounts is centered around the environmental economic accounting regulation. As the area of ecosystem accounting involves wide range of data providers and users the need for development of partner-inclusive system for national ecosystem accounting has been considered.

In the frame of the current project partners met already in kick off meeting in 2021 in order to discuss and plan, among other issues, which activities need to be carried out in the direction of creating activities in a system that includes partners in terms of methodology, experts, existing datasets and studies.

Regular compilation of accounts requires building institutional capacity at national level. Creating time series of data layers takes time and patience. There are several perspectives to consider, Figure 20 presents important perspectives: institutional, technical and stakeholder perspectives. All three are equally important. We also discussed earlier with our international consultants (Statistics Netherlands) on how the partner inclusive systems should be designed and how to design the efficient workflow for ecosystem accounts. We acknowledged that practices vary among countries.

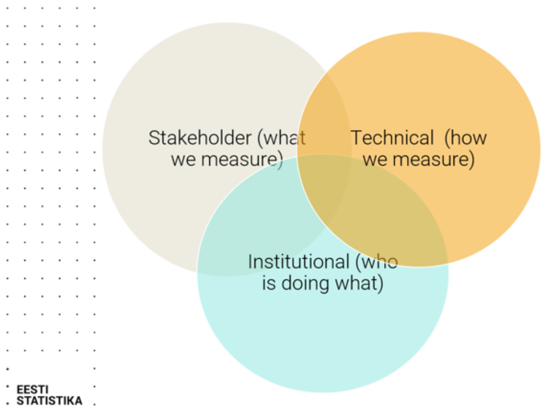

Figure 20. Developing ecosystem accounts, which perspectives needs to be considered

While the regulation sets quite soon the framework for harmonized measurement, the issue how ecosystem services, condition and extent will be assessed and also who is doing what during the regular production of accounts is still under debate. This debate has been initiated and also practical co-operation has started.

Figure 21 “Areas of cooperation and knowledge” reflects how the cooperation was finally discussed in the seminar involving wide range of partners. Various areas which require different knowledge are important for the compilation of ecosystem accounts. The cooperation between institutions which are the holders of respective knowledge is important for the efficient future production of ecosystem accounts. Cooperation among those who hold administrative databases which are the bases of the accounts is crucial and is focused more on technical issues. While the cooperation with those who hold the economic and ecological expertise and carry out studies and assessment in related areas is important from the viewpoint of integrating existing and created knowledge.

In addition, it was discussed that ecological knowledge is more and more used in local planning and assessment purpose. The integration of the knowledge on ecosystem services and condition is currently limited to few studies and assessments, the topic is becoming more actual. The coherence of the ecosystem accounting databases (Statistics Estonia) and administrative databases is important to be considered already from the beginning.

The cooperation in sense of the knowledge and the data are focused on the aspect of integration: which areas and how could be integrated in order to produce ecosystem accounts in future in most efficient way. It has been explored what could be the challenges for the compilation of ecosystem accounts in most efficient way.

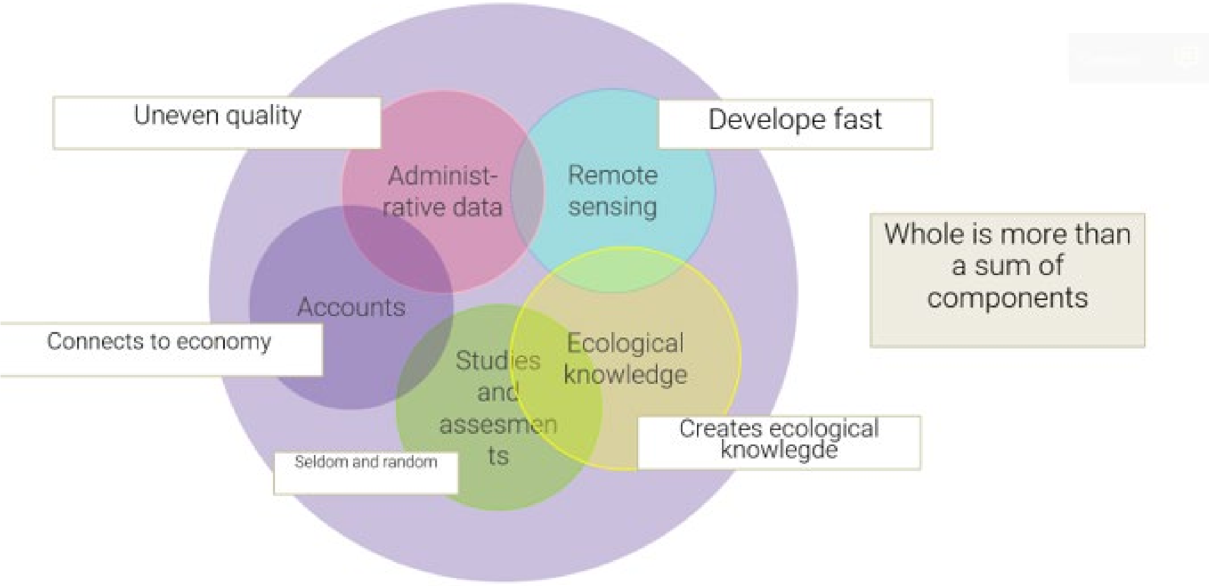

Figure 21. Areas of cooperation and knowledge, as handled on seminar on ecosystem accounting[125]

The cooperation with various players on the field varies depending on their specific roles. Work with the stakeholders focused on the produced output and relevance from the political perspective but also on the work with the definitions and methodology.

For the production of the condition accounts and ecosystem services accounts contracts were agreed in order to incorporate respective data, area knowledge, technical knowledge and work efforts already during this project. Contributions were received in a form of methodological consultations for the assessment of ecosystem services and condition indicators, regarding technical work, consultations and research and studies already carried out.

Statistics Estonia has validated the suitability of results of other ongoing projects and initiatives that also comprise ecosystems, condition and ecosystem services valuation in Estonia by assessing how suitable and in accordance with SEEA EA recommendations and with statistical framework given by proposed regulation on ecosystem accounts these are. Analyses of the work carried out under the nationwide assessment and mapping of ecosystem services ELME1 project[126] ("Establishment of tools for integrating socioeconomic and climate change data into assessing and forecasting

[125] - May 23, 2023

[126] Helm, A., Kull, A., Veromann, E., Remm, L., Villoslada, M., Kikas, T., Aosaar, J., Tullus, T., Prangel, E., Linder, M., Otsus, M., Külm, S., Sepp, K., 2021. Metsa-, soo-, niidu- ja põllumajanduslike ökosüsteemide seisundi ning ökosüsteemiteenuste baastasemete üleriigilise hindamise ja kaardistamise lõpparuanne. ELME projekt. Tellija: Keskkonnaagentuur (riigihange nr 198846). http://loodusveeb.ee/en/countrywide-MAES-EE-condition-and-services-terrestrial

biodiversity status, and ensuring data availability", Estonian acronym – ELME) project was done and available inputs were integrated where feasible and are highlighted under respective chapters in this report.

Partners themselves highlighted the need for harmonization of the methods for selected benefits and services and in sense of being usable also from national nature conservation and economic policy. Partners from Estonian Environment Agency and Tallinn University of Technology also contributed to the work of the Eurostat Task force on ecosystem accounting.

The work toward single national ecosystem extent map and on a certain feasible level uniform list of ecosystem services was considered. Eurostat reporting format for ecosystem extent was tested both by Statistics Estonia and also separately and voluntarily by ELME data holders. The testing results of the Eurostat ecosystem extent by the partners was currently considered partial. Statistics Estonia however tested the typology and also compiled the extent account fully in accordance with the guidance note (as this is the responsibility of Statistics Estonia).

Based on the results of the works of the nationwide assessment and mapping of ecosystem services ELME, it was planned to analyse the feasibility to develop and compile opening stock of ecosystem condition account for a given year based on ELME ecosystem condition data. The cooperation on condition indicators and ecosystem services of ecosystem accounts was rather successful. Condition account which was developed in Statistics Estonia in 2023 was largely based on ELME condition data, but also other basic condition data in Estonian Environmental Research Centre regarding spatial data for the concentration of PM2,5 condition indicator and State Forest Management Centre regarding the tree cover density.

For ecosystem services experts of national institutions provided both knowledge and, in some cases, also data for the compilation and modelling of the services as described in corresponding chapters.

Statistics Estonia also took part on the user seminars were the scientific insight to the valuation of the ecosystem services was discussed both on national and international level.

Statistics Netherlands has been an important partner in developing ecosystem accounts in Estonia in various ways: this co-operation concerned variety of methods and data sources and also further analyses of the whole area.

Regarding the development of the partner inclusive system, it was agreed that for the EU statistical regulation 691/2011 Statistics Estonia is responsible for the production of the statistics. However other institutions in Estonia have their role in providing input data depending on the specific role and the needs of the proposed amendment of the regulation on environmental economic accounting ecosystem accounts module. The level of detail varies depending on a task, but currently basic data are always needed from the partners as the values for services and condition need to be provided by ecosystem types. This is in one hand due to the compilation of the breakdowns by ecosystem types that can be done via using basic integrated ecosystem map which is also compiled in Statistics Estonia. It has been considered essential that the most detailed data and statistics need to be assembled and stored in order to allow further analyses to be carried out.

It was also discussed that while planning future tasks (and also the co-operation in the area of ecosystem extent account compilation) the focus will be on creating a sustainable IT solution to automate the compilation procedures for ecosystem extent account. The cooperation hence will be continued but on higher level. In future after crystallization of the full content of the reporting, the target would be that a uniform system for regular compilation of ecosystem accounts would be established, and agreements made concerning input data from partners. It was agreed that in general Statistics

Estonia's role in coming years would be to mainly focus on implementation of Eurostat's proposal regarding the legal basis but in addition Statistics Estonia is also testing additional services and condition indicators which are relevant for local stakeholders if feasible and funded. The following activities for the future workplan were discussed: crop provision, distinguishing ecosystem contributions, regarding the pollination service, including the characteristics of the habitats of the pollinators, for the global climate regulating service: to improve the scope of the account for the service and stock as is scientifically relevant. It is also important to create metadata for ecosystem services and validate financial assessment methods for all relevant indicators.

The partnership with scientific community is also important as the whole area is advancing quickly. Statistics Estonia had several co-operation activities with the experts of universities: Tallinn University of Technology, Tartu University on a contractual bases but also as a voluntary engagement and cooperation activities.

ANNEX 1. Summary of the first seminar on ecosystems grant work on October 5, 2021

Kick off meeting: Introduction of the Ecosystems grant work 2021-2023 and plans for the future

Zoom virtual meeting, October 5, 2021

Participants: Statistics Estonia: Kaia Oras, Argo Ronk, Kätlin Aun, Grete Luukas, Egert Indres; TUT: Üllas Ehrlich; Ministry of the Environment: Kadri Möller; Environmental Agency: Madli Linder, Marko Vainu, Laura Kütt, Peep Jürman; Ministry of Finance: Eleri Kautlenbach; Ministry of Rural Affairs: Kadri birch; University of Tartu: Aveliina Helm, Raul Rosenvald, Asko Lõhmus, Evelyn Uuemaa, Aleksander Kmoch, Maie Kiisel, Helen Poltimäe, Elisabeth Prangel, Kristiina Vain; Environmental Board: Kaja Lotman

Topics covered:

1. Ecosystem Extent Account 2
2. Classification and crosswalks, IUCN GET
3. Accounting of services and assets, supply and use tables
4. On-line user application prototype introduction
5. Activities and cooperation within the frame of development of ecosystem accounting in Statistics Estonia for 2021-2023
6. Current status of the proposal for the amendment of regulation EU 691/2011 regarding ecosystem accounting.

Questions and answers

1. Asko Lõhmus, UT : What are the "map units" of forests? In forests, habitat types are not a sufficient lowest classification unit from the point of view of services, because clearcuts and old stands are extremely different in terms of services.
   Statistics Estonia's answer: We use ecosystem types in the accounting of ecosystems, we consider that the data on the felling area and the old stand are data on the condition. Analyzing the condition of ecosystems is an upcoming job that requires cooperation.

2. Kaja Lotman: Could you give an example of which functional groups were not suitable for our types?
   Statistics Estonia's response: Keith et al. 2020 The EFG descriptions given in The IUCN Global Ecosystem Typology v1.01 did not match, for example, our semi-natural grasslands. To date, the IUCN GET classification has been updated and this group has been added (T7.5 Derived semi-natural pastures and old fields).

3. Aveliina Helm: Are the IUCN categories also used in the accounting of other countries?
   Statistics Estonia's answer: For example, the Netherlands and Australia have used the IUCN Global Ecosystem Typology in their ecosystem accounting.

4. Asko Lõhmus: 1) What is the reason that the difference between the willingness to pay and the results obtained with the methodology of specific services is so great? For example, a forest costs 24 million for people, which is almost only made up of mushrooms and berries, while the price of wood is 400 million (in addition, harvesting gives income to the harvesters, that's taken away from here).

Statistics Estonia's answer: The value of berries and mushrooms and wood services in the forest ecosystem obtained with the market-based services evaluation methodology expresses the equivalent of the service flow entering the economy.
The result obtained with the conditional valuation method (CVM) shows how much the evaluated value (in this case, the ecosystem service) affects the subjective well-being of service consumers (per year) and the financial equivalent of the increase in well-being. The total demand for the service depends on the number of consumers. The division of total demand into surface units (e.g. hectares) depends on the number of surface units (ie the size of the area). Therefore, the more consumers of the service whose well-being is positively affected by the service, the greater the financial value of the service. The larger the area that offers this service, the lower the monetary value per unit of area.

5. Asko Lõhmus: 2) in addition to willingness to pay, is the willingness to accept method also used in Estonia?
Statistics Estonia's answer: This method was not used in the project work. Compared to willingness to pay, it is practically not used much. The reason is the fact that the compensation willingness method abstracts from the actual financial possibilities of the individual and is not suitable (unlike willingness to pay) for systems containing real turnover, for example as an input to a social cost-effectiveness analysis.

   Aveliina Helm: In the willingness-to-pay questionnaire were regulatory services and provisioning services considered together (i.e. did people have to put both regulatory, cultural and supply benefits in the same order?)
Statistics Estonia's answer: In one questionnaire, both supply services, regulatory services and cultural services were combined for one ecosystem class (forest, meadow, marsh, urban ecosystems). You can find out more about the questionnaires in the report of the project work, which can be found at
https://www.stat.ee/et/avasta-statistikat/valdkonnad/keskkond/elurikkuse-kaitse-ja-maakasutus

6. Maie Kiisel : What kind of data usage and users is the willingness-to-pay methodology intended for? Services are perceived place-, time- and condition-specific. What conclusions can be drawn from, for example, when meadow ecosystems start to be rated higher in questionnaires?
Statistics Estonia's answer: We agree that in the case of indicators and methods, it would be necessary to specify how they are used and what they can be used for, e.g. what information is provided by the comparison of service values over time. We look forward to your feedback and continued discussion regarding both the willingness-to-pay methodology and the methodologies based on exchange values.
While the financial assessment of ecosystem service flows entering the economy of ecosystem accounting was presented at this meeting, the tables of supply and use of physical flows of services are also an important part of accounting, which certainly help to make better sense of the values found and changes in them.

7. Helen Poltimäe : In the grand scheme of things, does it stand out that recreational values are greater than the value of regulatory services?
Statistics Estonia's answer: We are here. In this work, according to exchange values, regulatory services are estimated at €120.5 million, cultural services at €180.7 million, of which recreation accounts for €135.5 million. In the case of well-being values, however, the picture is the

opposite (except in the urban ecosystem), regulatory services are valued at €32.1 million, cultural services at €6.9 million, of which recreation is €3.3 million.

8. Asko Lõhmus UT: In the example of pollinators vs soil, the treatment of necessary and sufficient reasons stood out. That is, pollinators are necessary, but not sufficient, to produce pollinated crop yields. Soil fertility is also necessary (even more necessary) for this, but it was evaluated as a "welfare value" and of a completely different (smaller) order.
   Statistics Estonia's answer: A legitimate observation. In the case of pollination, both exchange value-based and conditional evaluation methods were used, and only the conditional evaluation method was used to evaluate the soil fertility preservation service precisely for the aforementioned reason that there were no basic data for evaluating the service and there were no resources to start creating them ourselves. Service evaluation methodologies were chosen based on existing knowledge and data. Ecosystem accounting is experimental and still under development.
   When providing financial evaluations of services, the context of how they are used must be observed, and this is what we have tried to do. For example, it should be noted that the two general assessment methodologies given are not comparable; exchange values and welfare values are also kept separate in the service supply and use tables.
   We have discussed that the sum of all (intermediate/input) services cannot be greater than the value of the output.

9. Kaja Lotman, Environmental Board: Could you share the link of the draft regulation?
   Statistics Estonia's answer: The draft Regulation 691/2011 is not publicly available. If you are interested, you can request the document in the form of a file from Kaia Oras, and it was also forwarded to Merit Otsus at the Ministry of Environment.

Summary of the presentation of the work of Statistics Estonia

Statistics Estonia: We are waiting for feedback on the results of work 202-2021 by November 1 (on terms used in ecosystem accounting, assessment methods, definitions, data, outputs, including user application, etc.).

We will organize a methodological seminar at the beginning of 2022, to be specified.

We will inform you about the developments regarding changes to the environmental accounting regulation.

We are ready to contribute to the creation of a nationwide system for the creation of ecosystem accounting.

Consultations:

- In terms of methodology, experts, existing data sets and studies;
- Regarding the detail and distribution of the entities of the accounts' outputs (indicators, database tables, reporting, etc.);
- Avoidance of possible duplication;
- Work with definitions and definitions (including the terms of the Estonian version of the text of the ecosystem accounting module of the regulation on environmental economic accounting);
- Defining the scope of services.

Introduction of the works of the ELME 2.0 project - summary (Aveliina Helm)

The project consists of two stages:

- Phase I (15.07.2021 – 01.04.2022, ends with the presentation of the interim report and the interim seminar 11.03- 01.04.2022), during which the evaluated services and indicators are selected together with the dataset.
- Phase II (11.03.2022 – 31.01.2023, final report 25.11.2022 and public seminar January 2023), where the financial value of ecosystem services is assessed and mapped in protected areas, pilot areas and on a national-wide scale with the development of scenarios.

Basic principles

- Assessing the overall economic and social value of the benefits provided by ecosystems
- Metrics must take into account which services and benefits are irreplaceable, which changes are particularly difficult to reverse, and in which space and time scale they must be expressed;
- What are the risk levels of the selected benefits (including condition, our ability to replace them) and performance and minimum reserve thresholds;
- Define how the approach can be used.

Summary compiled: 06.10.2021

ANNEX 2. Summary of the final seminar on the development of ecosystem accounts (May 23, 2023, Statistics Estonia)

Seminar on the development of ecosystem accounts

May 23, 2023, Statistics Estonia

Summary

Teams meeting, recording is available here (in Estonian).

Participants:

Statistics Estonia, Tallinn University of Technology, Ministry of Environment, Ministry of Rural Affairs, Estonian Environment Agency, Tartu University, State Forest Management Centre, Estonian Environmental Research Centre

Kaia Oras, Aija Kosk, Allar Luik, Argo Ronk, Aveliina Helm, Elisabeth Prangel, Elsa Putku, Eve Veromann, Grete Luukas, Helen Saarmets, Iiri Raa, Kadri Kask, Kadri Möller, Karel Lember, Kaur Kõue, Krisela Uussaar, Laura Kütt, Lembe Reiman, Madli Linder, Mae Alviste, Margit Tennokene, Marek Maasikmets, Maris Kruuse, Mati Valgepea, Meelis Leivits, Merit Otsus, Merje Põlma, Peep Siim, Priit Penu, Tauri Arumäe, Robert Kond, Üllas Ehrlich

1. Introduction
   1.1. Overview of ecosystem accounting (Kaia Oras)
   Kaia Oras gave an overview of the framework of the ecosystem accounting beginning with UN SEEA to the current state of the new proposed modules of regulation EU 691/2011, including ecosystem accounting module. The detailed reporting requirements are now and in the coming years being discussed in the EU with the aim that the first data transmission is in 2026 on the account for year 2024. Statistics Estonia with the support of Estonian stakeholders has been contributing to the improvement of the regulation and to the work of Eurostat Task Force on ecosystem accounting.
      - Slides: Kaia_Oras_ökosüsteemide lõpuseminar_22_05_2023_ 19_40.pdf

   1.2. ELME 2 project overview (Madli Linder)
   Madli Linder, who is the project lead, introduced ELME 2 project, which purpose is the socioeconomic assessment of terrestrial ecosystems in Estonia. The work is built on ELME 1 (National Assessment and Mapping of Ecosystems and Ecosystem Services) and is done separately from the work of ecosystem accounting by Statistics Estonia. Results of the ELME 1 were introduced where the work focused on four main terrestrial ecosystems, their extent, condition and supplied services. ELME 2 would improve the previous work and add economic dimension to the ecosystem services. Also potential implementations of the work were introduced such as land use planning, environmental impact assessment, general plans, green network planning, location planning of development areas, e.g. wind and solar parks, furnishing the land use hierarchy, identifying where are the gaps in the ecological and/or social functioning of the green network, where are valuable ecosystems, in restoration of habitats, defence planning, applying support schemes etc. The materials of the work are planned to be published soon and the work is planned to be continued for regular production of the data.
      - Slides: Madli_Linder_STATkoost88seminar_23-05-23_ELMEtutvustus.pptx

1.3. Monitoring component in the Nature Restoration Law (Kadri Möller)

The objective of the proposal of the EU Nature Restoration Law is to restore 20% of European seas (and land) by 2030, and almost all degraded ecosystems by 2050. The regulation was proposed in 22.06.2022 and it is currently in negotiating phase in the EU. Some proposed indicators for monitoring the extent and condition of habitats could be associated or derived from ecosystem accounts, such as the area of urban green space and the coverage of tree canopies in cities, abundance and diversity of pollinator species, grassland butterfly index, organic carbon stock of mineral soils of agricultural lands, share of agricultural land with diverse landscape elements, farmland bird index, dead wood, age structure of forests, coherence of forests, forest bird index. The reporting would be annual for restored areas and in every three years for detailed plan, including monitoring results, beginning in 2031.

- Slides: Kadri_Möller_LTM_statistikaamet.pdf

2. Ecosystem extent account

2.1. Work done in compiling extent account for 2020 and 2021 (Argo Ronk)

An overview of Estonian ecosystem extent account compilation and the details about underlying methodology with the main results was presented. Also delimiting urban areas was described. Extent maps for 2020 and 2021 were compiled using most up to date and relevant spatial data concerning Estonia's ecosystems. The results between land owners and ecosystems and results of opening and closing extent account for 2020-2021 were described.

- Slides: Argo_Ronk_Ecosystem extent account_2023.pptx

2.2. Ecosystem typology (Kätlin Aun)

Overview of EU ecosystem typology was given. EU Typology was developed 2021-2022 to harmonize EU ecosystem accounting reporting. It is based on the most important existing ecosystem classifications: MAES, EUNIS, IUCN Global Ecosystem Typology (GET). The typology consists of three levels where the first level is most generalized and foreseen to be the basis for ecosystem accounts reporting. Level 2 is more detailed and is voluntary reporting. The testing of reporting of ecosystem extent according to EU ecosystem was done at the end of 2022. It required cross walking between Classification of ecosystems for accounting of ecosystems in Estonia and EU ecosystem typology. In most cases the crosswalking was rather straightforward thanks to the already stablished links between EUNIS and IUCN classifications. However classes 1.1 Continuous settlement, 1.2 discontinuous settlement required additional population density analysis because the map units used are smaller (individual buildings, facilities, green areas) than the area corresponding to the class definition. And the classification of forests at level 2 into coniferous, deciduous and mixed forests required additional analysis based on the forest register.

- Slides: Kätlin_Aun_ÖS_tüpoloogia_teenused.pptx

2.3. Results: reporting tables (regulation on environmental accounting 691/2011) (Argo Ronk)

The content and testing results for filling reporting tables of ecosystem extent and conversion matrix based on EU ecosystem typology were presented. The reporting file includes:

- Metadata information.
- Table 1 for ecosystem extent account where reporting the area of ecosystems is mandatory on level 1 of EU typology and voluntary on level 2 of EU typology. For the

majority of classes the distinction could be made on level 2 ecosystem types, excluding marine ecosystems where no work on details have yet to be done.

- Table 2 for conversion matrix where changes in ecosystem areas is foreseen to be reported on level 1 ecosystem types. The matrix was done between years 2019 and 2020.
- Table 3 is ecosystem extent accounts level 3 only (voluntary).

Environmental Agency also made an attempt to fill the reporting tables using European ecosystem typology. As a result of preliminary testing only the first reporting table on level one was completed and with partial results. Analyses of the crosswalking was included and provides future input to the application of the European ecosystem typology.

3. Valuation of ecosystem services

3.1. Agricultural production, pollination, wood supply, air filtration, global climate regulation, local climate regulation, nature-based tourism services (Kätlin Aun)

The valuation of ecosystem services included biophysical and monetary assessment. The services were selected based on the proposed amendment to EU Regulation 691/2011. The methodologies for biophysical assessment are based on the guidance notes prepared by Eurostat. The methods for biophysical and monetary valuation and results for 2020 on the first level of ecosystem types were described, except for the microclimate regulation which is in the list on ecosystem services in the regulation amendment but due to expert and time constraints the service was not separately assessed in the grant work.

- Crop production: physical quantities of used crops were derived from MFA, cropfields and grasslands are supplying ecosystems; monetary valuation is based on rent price and input data is derived from agricultural statistics.
- Crop pollination: the service is calculated to be equal to the increase in the yield of crops that need pollination, which is attributed to the ecosystems that provide the service thanks to the pollinators-insects that live there. The calculation is based on GIS data that uses map of crops, ecosystem extent map, yield of crops by county as input. For monetary valuation in addition to crop yields unit prices for specific crop types were used.
- Wood production: physical indicator is net increment and input data is from Environmental Agency. Monetary valuation is based on stumpage prices and quantities of removed wood. These are based on the calculations made in Statistics Estonia (not finished production).The service indicators should coincide with the data in forest accounts which is also in development.
- Air filtration: The Estonian Environmental Research Center (3.3 Air filtration, cooperation in evaluating services (Marek Maasikmets)) carries out the work on biophysical units based on the methodology described in Eurostat's guidance material. For monetary valuation a benefit transfer is planned to be done based on external costs of air pollution (Baro et al., 2014).
- Global climate regulation: Data on CO_2 removed from the atmosphere was obtained from the National Inventory Report of greenhouse gas emissions. Monetary valuation is based on EU ETS prices. Assessment of stored carbon is still in work with cooperation of ELME project. For monetary valuation of carbon storage EU ETS prices are planned to be used.
- Nature-based tourism services: the physical indicator is overnight stays attributed to ecosystems. Input data is from accommodation statistics and analysis for the contribution of ecosystems was done based on the shares found by Recreation Potential Map (developed by JRC). Monetary valuation of the service is part of the work under “Evaluation of the recreation service using the CVM method” by Üllas Ehrlich.

- Slides: Kätlin_Aun_ÖS_tüpoloogia_teenused.pptx

Questions and discussion:

- Why was wood provisioning in physical units based on increment not harvested wood or timber stock in mature forests?
    - – Answer: Whereas harvested wood or timber stock in mature forests describe the used amounts of wood provisioning better, the increment describes the yearly ecosystem contribution better. It can be theorized that the better alignment with ecosystem contribution was the reason why the indicator was chosen as thus by Eurostat.

3.2. Global climate regulation, cooperation in evaluating services (Aveliina Helm)

The work done on assessing carbon stocks and removal within ELME project works were described. Carbon stocks describe accumulated capital, CO2 and CH4 flows describe the dynamics and changes in the stocks. Carbon stocks were found for soil, above-ground biomass (tea trunks, branches), below-ground biomass (tree roots). It was described how short-term activities (drainage) can have long-lasting effects on stocks and dynamics of carbon flows and connections for maintaining good stock conditions were mentioned. For monetary valuation market price (EU ETS), social costs and avoided damage costs (IPCC) were used for carbon stocks which all gave significantly different results.

The work for assessing carbon flows is still in process.

- Slides: Aveliina_ELME2_kliimaregulatsioon_HELM_KULL.pptx

3.3. Air filtration, cooperation in evaluating services (Marek Maasikmets)

The work was done by Estonian Environmental Research Center based on the guidance materials prepared by Eurostat. Brief background overview how forests "absorb" more air pollutants than ecosystems with lower vegetation was described and how different processes (wet deposition, dry deposition, resuspension) affect the "removal" of fine particles (PM2.5). The work is still in process, the methodology includes input data on PM2.5 concentrations, wind speed and LAI Copernicus data based on which deposition of PM is computed. It was concluded that it can be assumed that the effect of trees on reducing concentrations, specifically in terms of PM2.5, is rather marginal, remaining below 1%, however, vegetation has its own role in the urban environment, especially in terms of CO2 sequestration and recreation

- Slides: Marek_Maasikmets_EKUK_PM_sadenemine.pptx
- Notes: recommended term in Estonian: “sadenemine” instead of “filtratsioon”. Also in general “deposition of PM” is better to describe the essence of the service than “air filtration”.

3.4. Evaluation of recreation service using time use and CVM method (Üllas Ehrlich)

In 2022 an extended contingent valuation survey on nature tourism was carried out in cooperation with Tallinn University of Technology with the purpose to ask willingness to pay of maintaining nature tourism infrastructure and assess the time spent in nature. Time spent in nature was used as an indicator for recreation (short-term). The questionnaire also included questions on the number of nature trips per year, duration of these trips, the number of nature trips with overnight stays and their duration. The latter two were included with the purpose to combine these data with Eurostat proposed indicator “overnight stays”. Contact with different ecosystems was also asked and based on this contribution by different ecosystem types was found. Applying the monetary equivalent of the value of time which is considered 7 EUR/hour, the monetary equivalent of ecosystem recreation service value based on time value was also found.

- Slides: Üllas_Ehrlich_rekreatsioon.pptx

4. Assessment of ecosystem condition indicators

4.1. Forests and woodland: dead wood (Mati Valgepea)

The work was done by Estonian Environmental Agency based on the guidance materials prepared by Eurostat. First overview on concepts and definitions regarding deadwood (Forest Europe/MCPFE) and forest land (Forest Resources Assessment (FRA)) in international reporting was described. In Estonia an already existing framework National Forest Inventory is used to give overview of Estonian Forest resources, including deadwood. It is a statistical estimation with a known statistical error. The estimations are based on observation plots which network covers the whole area and in duration of 5 years data from all plots is collected. Regarding deadwood the parameters of length, diameter and volume are assessed on the plot. The results are divided into deadwood with utility value/deadwood without utility value and upright/ lying (broken) deadwood.

- Slides: Mati_Valgepea_Deadwood.pptx
- Notes: recommended term in Estonian: "surnud puit".

4.2. Estimation of canopy coverage from aerial lidar data (Tauri Arumäe)

The work was done by Tauri Arumäe from NFSC based on the guidance materials prepared by Eurostat and existing scientific work in Estonia. First the definitions and concepts of the indicator and methodology (canopy coverage, lidar, three-dimensional point cloud) were introduced. Estimations of canopy coverage were done using lidar data. Lidar data is collected nationally by Land Board where the whole area is covered in a four year cycle. The data is freely available. Forest canopy can also be assessed by digital hemispherical photography (DHP), which approach was described and results compared with results obtained by using lidar data. The end result included ETAK forest class where for every pixel (10x10 m) canopy coverage was calculated.

- Slides: Tauri_Arumäe_Võrastiku katvuse hinnang aerolidari andmetelt.pdf
- Notes: recommended term in Estonian: "võrastiku katvus".

4.3. Settlements and other artificial areas: air pollution (Kätlin Aun)

The work was done based on the guidance materials prepared by Eurostat. The definitions and concepts of the indicator and methodology were introduced. In the guidance note it is proposed that the indicator is only assessed in cities, not on all urban areas, and that the cities are defined by local administrative units (LAU). Calculation of the indicator was done using already existing data of the map of PM2.5 concentrations (annual average µg/m3) in Estonia 1x1 km, 2020 (EKUK), the map of ecosystem extent to differentiate between all urban areas and map of administrative units (cities according to LAU: Tallinn, Tartu, Narva).

- Slides: Kätlin_Aun_ÖS_tüpoloogia_teenused.pptx

4.4. Settlements and other artificial areas: proportion of green areas (Madli Linder)

The work was done by Estonian Environmental Agency based on the guidance materials prepared by Eurostat. The definitions and concepts of the indicator and methodology were introduced. For the assessment of the indicator of proportion of green areas in the city different approaches were applied. In the guidance note it is proposed that the indicator is only assessed in cities, and that the cities are defined by local administrative units (LAU). The indicator was calculated for cities: Tallinn, Tartu, Narva according to their administrative borders, and also according to borders based on urban areas delineated in ELME project (based on built-up and population density). From ETAK and Copernicus Urban Atlas respective classes that can represent green areas were included in the analysis.

- Slides: Madli_Linder_STATkoost88seminar_23-05-23_urban-condition.pptx

4.5. Cropland and grassland: soil organic carbon stock (Aveliina Helm)

For the condition indicator the same data and methods are used as was described under global climate regulation service regarding carbon stocks. The analysis is based on detailed soil map.

An assumption was made that in croplands and grasslands the whole stock describes the stock in toplayer because of its natural depth. The issue could rise on crop- or grasslands on deep peat soils. It was also noted that even when the top layer limit is applied, the whole supply is ecologically important.

4.6. Cropland and grassland: common farmland bird index (Meelis Leivits)

The work was done by Estonian Environmental Agency based on the guidance materials prepared by Eurostat and already existing framework of calculating bird indices. The definitions and concepts of the indicator and methodology were introduced. The purpose of the breeding bird guild index of the cultural landscape is to reflect the condition of breeding birds nesting in cultivated farmlands and grasslands. The guild index describes the relative abundance of the species belonging to the community. The data is collected by point observations by counting pre-defined species within 5 minutes. The list of breeding birds for cultivated areas is based on PECBMS (Pan-European Common Bird Monitoring Scheme). The list is central to Central Europe, i.e. it does not include some species of cultural landscapes that occur in Estonia (e.g. great hornbill, rye warbler, thistle bird, green finch). The indices are generally geometrical means and are calculated with specific software TRIM. Based on the data general or species-specific trends on abundance can be computed.

- Slides: Meelis_Leivits_20230523 ÖS hindamine linnuindeksid Meelis Leivits.pptx
- Notes: recommended term in Estonian: “Kultuurmaastiku haudelinnustiku gildiindeksi” instead of farmland bird index.

4.7. Coastal beaches, dunes and wetlands: the share of artificial impervious area cover, present in coastal area (Madli Linder)

The work was done by Estonian Environmental Agency based on the guidance materials prepared by Eurostat. The definitions and concepts of the indicator and methodology were introduced. For the assessment of the indicator of share of artificial impervious area cover in coastal ecosystems different approaches were applied. From ETAK, Corine CLC respective classes that represent artificial areas were included in the analysis and also Copernicus Imperviousness Layer was used. In the guidance note it is proposed that the indicator is assessed for the area of municipalities that are bordering or close to a coastline (at least 50 % of their surface area within a distance of 10 km from the coastline). Analysis was done using these municipalities. For comparison, the indicator was also calculated for the area of the buffer of 200 m from the coastline.

Slides: Madli_Linder_STATkoost88seminar_23-05-23_coastal-condition.pptx

4.8. Questions

- The need to define and harmonize the terms used in ecosystem accounting both in English and Estonian was brought out.

5. Ecosystem accounting outputs and metrics

5.1. Ecosystem accounting outputs and metrics (CBD and UNSD) (Kaia Oras, Merit Otsus)

Kaia Oras described indicators of environmental statistics in general. Environmental statistics follows the framework of National Accounting. Statistics can be compiled based on basic statistics (e.g. UN Sustainable Development Indicators) or statistical accounts (e.g. environmental protection expenditures). The same can be said about ecosystem accounts that the data can be used for finding connections with other indicators. It was discussed that ecosystem accounts are planned to provide input for CBD in goal D (regarding expenditures for biodiversity), goal A (changes in ecosystem area), goal B (related to ecosystem services).

- Slides: Kaia_Oras_ökosüsteemide lõpuseminar_22_05_2023_ 19_40.pdf

Merit Otsus who participated in COP 15 gave an overview on The Kunming-Montreal Global Biodiversity Conservation Framework (CBF) and monitoring its implementation was described. CBF outlines long-term goals (until 2050) such as protection of ecosystems, species, genetic diversity, valuing, maintaining, restoration of natural resources and contributions; equal distribution of revenues from the use of genetic resources, adequate resources for nature conservation; and short term-goals (until 2030) which can be summarised as reduction of impacts on biodiversity, sustainable use of natural resources and fair allocation of its revenue; developing means and solutions for meeting the goals and mainstreaming biodiversity.

CBF monitoring framework consists of measurable indicators and is used to assess the meeting the targets of the goals of CBF. Several indicators (mandatory main indicators and voluntary additional indicators) may overlap with ecosystem accounting. For many of the indicators the methodology for monitoring is still being developed and not yet agreed upon Main indicators are:

- Extent of natural ecosystems
- Services provided by ecosystems*
- Proportion of agricultural area under productive and sustainable agriculture
- Average share of the built-up area of cities that is green/blue space for public use for all.

The reporting is foreseen for years 2026 and 2029.

- Slides: Merit_Otsus_CBD indikaatorid 23052023.pdf

6. Future plans and discussion on cooperation

EU regulation 691/2011 reporting on ecosystem accounting was presented by Kaia Oras. Overview of the work done under Eurostat grants on ecosystem accounting in Estonia was given. It has been described how Statistics Estonia with the support of Estonian stakeholders has been testing data and methods for the compilation of ecosystem accounts and also contributing to the improvement of the regulation and to the work of Eurostat Task Force on ecosystem accounting. The timeframe for the first data transmission which are foreseen and proposed currently in 2026 on the account for year 2024 regarding ecosystem extent, services, condition (T+24) were discussed in sense of co-operation. First reporting of ecosystem extent matrix is foreseen for 2027 for changes in extent between 2027 and 2024.

New information was given that the position is yet unclear but the parliament draft report has proposed reporting T+12, which would be foreseen theoretically for 2025 and 2028 respectively, however member states wish to delay the start of reporting.

- Slides: Kaia_Oras_ökosüsteemide lõpuseminar_22_05_2023_ 19_40.pdf

6.1. Future developments: new grant for the development of ecosystem accounting: 2022_EE_EGD; 01.07.2023- 31.12.2024 (Kaia Oras)

Kaia Oras outlined the timeline and the plans of co-operation considering the future development of the topic, co-operation needs and possibilities and the tasks taken under next Eurostat grant (microclimate service, voluntary ecosystem service and condition indicators, etc) for the years 2023-2024.

- Slides: Kaia_Oras_ökosüsteemide lõpuseminar_22_05_2023_ 19_40.pdf

6.2. Cooperation in creating a system involving partners in (Kaia Oras)

Ecosystem accounting is a fast-developing interdisciplinary field, which can help bring ecosystem and biodiversity topics into mainstream statistics and politics. Co-operation is necessary for all aspects of ecosystem accounting: extent, services, condition to further develop and analyse the accounts. Statistics Estonia is seeking the contributions in consultations on ecosystem services and condition regarding data, methodologies, choice of indicators, practical work, participation in task force and discussion on future routine activities starting from 2024.

The beginning seminar of the future work was proposed tentatively on 05.07.2023.

- Slides: Kaia_Oras_ökosüsteemide lõpuseminar_22_05_2023_ 19_40.pdf

6.3. Comments from the participants and the discussion (Kaia Oras, Merit Otsus, Madli Linder, Aveliina Helm):

- Aveliina Helm discussed that there is expectation from society for using data on ecosystems. However, the field is still yet developing, and many questions are unanswered, therefore thoughtful decisions need to be made which indicators are best suited considering all aspects not only that the indicators would be easy and fast to produce.
- Aveliina Helm and Madli Linder added that regarding generalizing of indicators, in some cases it is appropriate and useful, but in other cases there is a threat that ecological meaning could get lost. For example, national average for canopy coverage is not a good indicator because the canopy coverage depends on the age and structure of the forest and the forest can be in a good condition whether the value for the indicator is low or high. For example, heterogeneity, age structure of stands would be more meaningful indicators ecologically. It is better to use less and meaningful indicators than many indicators. They and Merit Otsus agreed that national needs and needs for international reporting may be different. It was also stated that it is understandable that on international level indicators are generalized to support the beginning of the development of ecosystem accounting in countries where no work on the topic has not yet been done.
- Merit Otsus added that ecosystem accounting should be considered a tool that helps to assess the contribution of ecosystems in people’s lives. Therefore it needs to be built accordingly to answer the practical needs.
- Peep Siim concluded that ecosystem accounts have developed in recent years. In future the data should be put into action in practical applications regarding ecosystem services and land use choices.

- It was considered by all parties that co-operation between statistical institutions, national experts and expert institutions has been fruitful in ecosystem accounting and there are hopes for further development in the future.

Composed: 9.06.2023 by Statistics Estonia

ANNEX 3. Summary of the intermediate milestone meeting of the partners

25/05/2022, Microsoft Teams

Participants: Kaia Oras, Merit Otsus, Madli Linder, Aveliina Helm, Peep Siim, Ain Kull, Argo Ronk, Grete Luukas, Kätlin Aun

Topics discussed at the meeting in development of the partnership and the progress of the work done and additional feasible needed input.

1. Overview of changes in the environmental accounting regulation: in terms of ecosystem accounting

- Statistics are compiled and transmitted: in terms of ecosystem extent and ecosystem condition accounts every third year for a three-year reference period; annually in terms of ecosystem service accounts. The statistics are transmitted within 24 months after the end of the reference year. The first expected observation year is 2024, service data will be transmitted in 2026. Clarification, data for 2023 as well.

- An account of the extent of ecosystems. Areas of ecosystem types and their changes.

- Overview of the services which should primarily be evaluated in physical units: Food from agriculture, pollination, wood, air filtration, global climate regulation, local climate regulation, nature-based tourism services. Eurostat's plan is to prepare a separate delegated act within the framework of Regulation 691/2011 regarding the reporting of values in monetary units of ecosystem services

- Work on condition indicators. Settlements and artificial areas: proportion of green areas, PM2.5 concentration; fields: organic carbon content in topsoil, agricultural land bird index; grasslands: organic carbon content in topsoil, agricultural land bird index; forests: percentage of dead wood, canopy coverage; coast: proportion of impervious surface.

- Reporting: the reporting is based on the typology of new established typology of ecosystems, the first level of which reporting is mandatory, the second level is voluntary, and the lower levels serve as an aid in defining ecosystems or making a transition from local classification.

2. Selection of services. In 2022 – 2023 the services will be selected and evaluated by Statistics Estonia is primarily based on the needs of upcoming the regulation. At the moment, Statistics Estonia is working on nature tourism, global climate regulation, which was discussed in more detail.

3. Feedback on Statistics Estonia's work and map application (on service evaluation methods, definitions, data, etc.), which was presented on October 5 were discussed. Materials, additional spatial datasets delivered in November 2021.

4. Discussion of future activities: activities in the direction of creating a system involving partners.

5. Peep Siim, representative of the Environmental Agency, raised the need for the creation of a unified Estonian spatial database regarding information on ecosystems. Peep referred to the National Audit Office's study regarding the area of protected forests. Statistics Estonia was considered to be correct that the reporting obligation, which will begin in the near future and will be annual is on Statistics Estonia based on the Statistics Regulation. In addition to the spatial datasets created within the one-off projects of Statistics Estonia and ELME and financed by the European Commission, sustainable spatial datasets that are updated annually are needed. The analysis to create a system involving partners has been initiated and will continue through this development project.

6. It was discussed that in Estonia, it is still a matter of decision which institution will manage the spatial data on ecosystems in the future. The Environmental Agency could be that place, suggested Aveliina Helm. However, it is important to agree and document clear rules for creating spatial data and make them available for all.

Agreed further actions

1) Statistics Estonia informed that on June 21-22, Eurostat's "Task force on ecosystem accounting" will be held and urged those willing to contribute to note their interest. Documents related to global climate regulation, timber, recreation, grain production and air quality service provision will be discussed:

- Guidance note to compile accounts for the global climate regulating ecosystem services – third draft

- Guidance note on wood provision – second draft

- Use of mobile phone data for recreation-related ecosystem services – EU-level perspective

- Recreation-related ecosystem services (tourism) – first draft guidance note

- Guidance note on crop provision – first draft

- Guidance note on air filtration – first draft

When the documents become available, Statistics Estonia shares them with those who attended the meeting. The discussion of TF instructional materials was booked for June 16.

2) A number of services, which receive guidance materials for evaluation by Eurostat, have been in assessed by both Statistics Estonia and ELME. The idea was to find the best solution for evaluation during ongoing discussions, e.g. separate discussions about global climate regulation or pollination. Ditto for air quality assessment, which has not been studied as thoroughly.

3) Merit and Madli are planning to discuss in the near future those places where harmonization needs to be carried out in terms of ELME and Statistics Estonia work on services

4) Instead of giving general feedback on the work of Statistics Estonia's previous achievements, ELME working group suggested that it would be better to focus on comparisons of the methodology and

results of the extent of ecosystems, including classification. Work on the comparison of the scale and classification of ecosystems could be started in the near future.

5) In 2022, probably during the summer, there will be an Estonian translation of the new planned ecosystem accounting module of EU regulation 691/2011 on European environmental accounting. This would be a good point of reference where Estonian terms can be defined and agreed upon. When the translation becomes public, we will share this with ELME team and Environment Ministry as well.

Tallinn, 26.05.2022

ANNEX 4. Summary of the study visit to Statistics Netherlands, November 1-3, 2022

List of participants:

Statistics Estonia:

- Ms Kaia Oras Team leader of environment statistics and accounts in Environment Economic Statistics Service, responsible for environmental accounts compilation;
- Ms Grete Luukas Leading analyst, responsible for the compiling of the monetary environmental accounts;
- Mr Argo Ronk Leading analyst, responsible for ecosystem extent account and for a certain selection of services
- Ms Kätlin Aun Analyst, responsible for ecosystem extent account and the selection of services
- Mr Raigo Rückenberg Analyst, responsible for the compiling of the environmental subsidies accounts

Statistics Netherlands:

- Mr Sjoerd Schenau - Project leader Environmental Accounts (physical and monetary)
- Mr Patrick Bogaart - Researcher in ecosystem accounts
- Ms Corine Driessen - Researcher in ecosystem/ environmental accounts
- Mr Niels Schoenaker - Researcher in environmental accounts
- Ms Jocelyn van Berkel - Researcher in ecosystem/ environmental accounts
- Mr Redbad Mosterd - Researcher in ecosystem/ environmental accounts

November 1st Room B5068

4.1. Overview

Kaia Oras gave the overview of Estonian work done so far regarding all the topics of the Estonian grant project which include

1) Improving the timeliness and granularity of EPEA/EGSS and expanding EPEA with resource management products and environmental protection goods.
2) Developing and refining ecosystem accounts.
3) Developing environmental subsidies and transfers account.
4) Developing a methodology and compilation of forest accounts (topic not under consultation with Statistics Netherlands).

On the first day of the study the main subjects were ecosystem extent and related ecosystem typology.

4.2. Ecosystem extent

Argo Ronk gave an oral presentation about progress so far about ecosystem extent account compilation in Estonia. This account has been compiled three times now. During this time there has been many methodological and classification changes and special interest has been on delimitation of urban areas. Urban areas have been delimited mainly based on human population density and the share of infrastructure. Also, latest ecosystem conversion matrix was introduced (for period 2019-2020) which showed largest change between cultivated grasslands which were turned into crops. Overall yearly changes were rather small and affected was about 3% of total land area of Estonia. In sense of ecosystem extent account, for future it was foreseen to compile ecosystem extent account for year 2021 (which is currently ongoing), testing Eurostat questionnaire (guidance note) and automate at least some of the steps in compiling the account in sense of using either Phyton or R (foreseen task in next Eurostat grant).

Specific question and suggestion from NL concerning extent:

Q: How was terrestrial land differentiated from marine areas?

Answer: We used administrative borders to define land area.

Q: In case of class “other”, what was included in that class?

Answer: Everything else that we were not able to classify either forest, grassland, cropland, wetland, artificial area, coast or inland waterbody. For example, bare rock with low vegetation.

For automation procedures, it was suggested to use rather Python than R due to technical (memory) reasons.

It was agreed to have further discussions about automation process in compiling the ecosystem extent account using Phyton scripts in the future (time yet to decide but possibly in spring 2023).

There was brief discussion how extent account has been compiled in NL. In short, topographic map is updated based on more detailed datasets. Largest difference between methods (Estonia and Netherlands) is that in NL the geometry of topographic map remains unchanged during updating process. It is vice versa in Estonia; geometries are changed based on geometries in more detailed spatial datasets.

4.3. Ecosystem typology

Kätlin Aun introduced Estonian national ecosystem classification done previously for ecosystem accounts based on testing IUCN Global Ecosystems typology. There ensued a discussion how typology is still very much land cover based on higher levels, but more ecological on lower levels and how the current EE typology would best conform to the ecosystem typology proposed by Eurostat. In general, NL and EE have similar problems with extent map and classification and most likely other countries experience those as well.

NL has started testing extent guidance. Typology is in progress (attempt to apply level 2), conversion matrix planned to do. Revisions of previous years accounts should be done, when methodology changes, NL does revisions. NL has automated process for extent compilation.

1) EE has no data for marine ecosystems yet (classes 10, 12).
   NL county borders include some sea and in ES accounts there is only one class: sea, without further division. In marine accounts it is more detailed; EUNIS map is used there. NL uses EUC map (2020). That is available for all Europe. EMODnet- repository for marine data (seabed habitats).
   Marine policies and ecological reporting are more international than anything concerning terrestrial ecosystems. When accounting for marine ecosystems, it needs to be looked at other surrounding states for sea. Baltic sea countries, maybe HELCOM.

2) Classes 1.1 Continous settlement, 1.2 discontinous settlement need additionl work, our mapping units consist of lesser units such as singular buildings, facility objects or green areas.
   NL has the same issue. Such distinction is most likely derived from Corine Land Cover map.

3) Cannot classify all forests on level 2 between decidous, broad-leaved or mixed forest based on existing data (also an issue for EUNIS and IUCN classification).
   Such distinction is most likely derived from Corine Land Cover map. There is no issue for level 1, which is mandatory. Data should be analysed how ecosystem types fit into proposed level 2 and 1.

4) Transitional forests and woodland shrub, including temporarily cleared forest (4.5). Should clearings of other forest classes be reported here?
   Classifying cut forest depends on its future. When it is supposed to be still forest it is forest, when it is cleared for grasslands, it moves to grassland. Seems like it stays in its original class. Comment to add to TF in 4.5.

4.4. Development of the partner-inclusive system for national ecosystem accounting in Estonia.

There are several ecosystem (or related) maps and processes in Netherlands. Each has its own purpose. In fact, it is good to have several maps that could be used and combined for different uses: land cover, ecosystems. E.g for amenity service you need land cover (vegetation) in addition to ecosystem extent (urban area) to get service value. Reality is that you cannot put all data on one map, it would be better to produce layers with different data that could be easily combined.

In NL land management map is being done by spatial statistics in CBS, map is produced in 2 years and it is used for reporting (LUCAS, INSPIRE). The maps distinguishes what is land cover, land use, but does not represent ecology. Ecological map was built on land management map and has now turned into an independent workflow as ecosystem extent map in CBS. There is collaboration to improve both workflows.

WUR produces at least two ecosystems related maps. First, land cover map is used for internal use. It is very detailed, has a very long timeframe, it’s a commercial product.

NL Environmental Assessment Agency also makes a map in WUR and has done services assessment. Natural capital modelling and long-time scenario analysis is based on this. Because of these they have made also several maps (specific map layers) on services etc. CBS EA wishes to align with NL Environmental Assessment Agency, esp. for services.

For reporting on statistics in future and for the policy uses CBS produced map would be used.

In Estonia the workflow on creating partner inclusive system for ecosystem accounts has been started as a teamwork with Environmental Ministry and Estonian Environmental Agency. The principle of creating one spatial data set for ecosystem extent account on country levelis discussed and tested. The compilation of the Eurostat extent tables will be carried out based on both ecosystem maps (Statistics Estonia and Estonian Environmental Agency). The pros and cons of both datasets will be discussed during current grant work.

Alternatives were discussed. Statistics Netherlands emphasized that as Statistics Estonia would be responsible for the fulfilment of the future needs of statistical regulations, the ecosystem map that would be a bases also for the services statistics compilation should be in principle be compiled in statistical organization.

November 2nd, Room B3022

On the second day of the study visit the main subjects were ecosystem condition, services and related topics.

4.5. Ecosystem condition

Statistics Netherlands (CBS) gave an overview on their work on ecosystem condition accounts. The last condition account for 2015-2018 was compiled in 2020. Some indicators are spatial, some not. Relation between the work on condition account at its usability to produce data for condition accounts proposed in Eurostat regulation was discussed

NL condition accounts includes the following categories.

- Vegetation (trees, shrubs, grass cover; cropland excluded, tree line density). Data from natural capital atlas based on lidar data. Dataset was existing, CBS assigned to ecosystems. Matrix done for e.g semi-natural forest, production forest etc. Tree lines as line object, when >=2 meters wide then polygon objects on topographic map. Converted polygons to line objects with length for the condition account. Only tree lines as polygons in topographic map are marked on extent map. The distinction is important when looking at services. Some Eurostat proposed indicators could be calculated based on these existing data, such as tree cover, urban green.
- Biodiversity category includes indicators: protected nature %, living planet index (looks at the abundance of species, CBS collects the data and the number can be taken to be used in ecosystem accounts, maybe reported in the SDG, divided only to higher ES classes, characteristic species (done by Environmental Assessment Agency in NL), structure and function of ecosystems (comes from Natura habitat assessment). Soil organic matter in the soil (map done in 1990-2000, new map is coming, it includes depths up to 30 cm, 30-50 cm), soil carbon content. It was discussed that indicators are reporting at different times (ecosystem accounts asks for the indicator after every 3 years, FAO asks after every 6 years, some other reporting after 10 years) and that poses a problem.
- Water. Indicators taken from the water framework biological, chemical etc. Data is compiled per waterbody, map also done Environmental Assessment Agency in NL. Used in EA, division by status of all types of waterbodies by class in % based on area was done for EA.
- Air quality (PM2.5, PM10, NO_2, SO_2), covers all of the country, average for a year, Concentrations and map is produced by National Institute of public Health and Environment.

Eurostat proposed condition indicator could be calculated based on the existing data, it need identifying the settlements and calculate average of all of the squares of the settlement.

- Pressure indicators (eutrophication for natural terrestrial ecosystems, e.g. bogs, acidification (deposition combined with the sensitivity of the ecosystem type), urbanization % (how nature is surrounded by built-up or infrastructure, distance between nature and built up, based on extent map), urban heat islands (amount of days where temperature exceeds heatwave temp).

There was a discussion on the topic of one aggregated condition indicator and discussion on **Eurostat proposed indicators** followed.

- Settlements and other artificial areas:
  - green areas in cities and adjacent towns and suburbs shall be reported in % of total area, calculated for the entire area of the cities and adjacent towns and suburbs, including all ecosystem types in that area;
  - concentration of particulate matter, with a diameter up to 2.5 μm in cities, shall be reported in μg/m3 as a national average for the reporting period.

1) What is the definition of the city? "Cities, towns and suburbs are local administrative units, categorised according to the degree of urbanisation typology set out under Regulation (EU) 2017/2391".
2) NL has urban green on extent map but it excludes green in private yards.
3) What is the definition of green area, what is a single tree on a paved square with a big crown - green or artificial? It depends also on the data source, e.g. EOB gives crown area, topographic map artificial area.
4) PM should be calculated as yearly average of all areas of cities, i.e. settlements and artificial areas in the municipality of the city.

- Cropland:
  - soil organic carbon stock in topsoil shall be reported in tonne/ha, as a national average for the reporting period. Vaadake iga mullatüüpi ja omistage mullatüübile. Ja kasutada m ullakaarti.

1) Topsoil could be 30 cm in grassland and/or cropland, it needs specification by guidance note.
2) Average for reporting year? Is it average over 3 years or only one measure or calculation per 3 years? This need specification.
3) Most likely the indicator is already in international reporting. When such an indicator is already reported what is the reasoning to also have it here?
4) The indicator could be found based on soil map or by looking at soil C for specific soil types.

- Grassland:
  - soil organic carbon stock in topsoil shall be reported in tonne/ha, as a national average for the reporting period.

- Cropland and grassland together:
  - common farmland bird index shall be reported as a national aggregate index for the reporting period.

1) When such an indicator is already reported what is the reasoning to also have it here?
2) Distinguish between crop and grassland could be done by looking at specific species for cropland and grassland.
3) Index per ecosystem type could be done by in situ surveys at all sites, which requires a lot work. It is complicated to do it even by province level because data for trends is unreliable (too few records).

- Forest and woodland:
    - dead wood shall be reported in m3/ha, as a national average for the reporting period;
    - tree cover density shall be reported in %, as a national average for the reporting period.

- Coastal beaches, dunes and wetlands:
    - the share of artificial impervious area cover, present in coastal area that includes ecosystem type coastal beaches, dunes and wetlands shall be reported in % as a national average for the reporting period.

Discussion on **additional items** or improved wording proposed by Estonia for ecosystem condition

- Settlements and other artificial areas:
  - ratio of particulate matter between cities and background stations
  1) In this case attention should be paid that you compare areal indicator with areal indicator not areal with point indicators when comparing city and background.
- Cropland:
    - share of organic farming (%);
    - share of high diversity landscape features
  1) What is the purpose of additional indicators?. E.g. organic farming is management, it is indirect condition. But similarly, The share of area of protected area is also management.
  2) NL approves of landscape features that give good info. Good for analysis at landscape scale. Need to figure out how to assess it. There should be an international/European data source. In order to make accounts relevant on policy scale, esp. in relation to green deal, this is a good indicator. Agricultural subsidies require these kind of green elements, therefore, this could be a data source. Also remote sensing applications could be used to check these elements.
- Grassland:
    - share of Annex I habitats in favourable conservation status
  1) Natura habitats data is available for all ecosystem classes.
- Forest and woodland:
    - -share of forest land (%) with tree cover density less than 30%
  1) Indicators for forest condition such as forest age, eneven age structure were also discussed. It raised the issue that even though condition indicators that show naturalness or intrinsic value is good but it should be consistent with services.
- Coastal beaches, dunes and wetlands:
    - -the share of artificial area cover
- Inland wetlands
    - share of inland wetlands area influenced by drainage (distance to drainage ditch <100 m) from total area of organic soils/wetlands
    - -share of Annex I habitats in favourable conservation status
    - -share of inland wetland ecosystem in natural or near natural status
  1) Wetlands also need indicators and drainage is a good indicator. Ditches data can be found on topographic or EOB data. But in addition to drainage ditches, the land could be drained by drainage pipes also, esp. grasslands, and these are hidden.
  2) Pressure is activity of drainage, proxy is distance to drainage, condition is oxidation. These indicators are connected, which one and how to use should be analysed more.

Relation between condition account and **nature restoration law** monitoring mechanism was discussed. CBS do not know details of nature restoration law yet. But they are of the opinion that it would be useful to test what you want include in the condition account, whether it is written for future Eurostat mandatory reporting, related to international reporting or national needs.

4.6. Ecosystem services

Statistics Estonia gave an overview of the current status of services assessment and proceeded with discussions on specific problems with services assessment where the focus was on the methodology proposed by Eurostat.

- Crop provision
  1) Separating human contribution from final production in physical terms. NL has no experience with finding ecological contribution. Currently NL has included all crop production in physical units, greenhouses excluded. It seems like there is not much value added in the work to separate human contribution
  2) For monetary valuation NL uses rent price (of the land) and plans to continue to use it.
  3) Separating the use by sectors in physical units. Only need to fill final consumption and household final consumption, others have no data.
- Pollination
  1) Eurostat guidance note not available yet. Possibly method similar to the one already applied.
  2) Estonian ministry of Environment would like to see that the intrinsic value of the service is better reflected in the assessment. NL thinks that it is impossible to quantify.
- Wood provision
  1) NL previously assessed harvested wood, now the regulation requires net increment as an indicator for the service, method has to be renewed. This service is done by WUR *(Wageningen* University & Research).
  2) Consistency between the assessment of the provision of crop and wood is questionable. To be precisely concordant with crop provision, the yield should be taken. Forest grows long, ecosystem contributes to increment, not the product that is made of wood, therefore crops and wood are basically different.
  3) Discussion of using "resource rent" instead of stumpage price. The latter gives lower value.
- Air filtration
  1) NL has assessed air filtration, done by WUR (Marjolein). NL has working model for the capture of PM2.5 by vegetation (for two types of forest and other vegetation). It includes weather condition, vegetation capture rates etc. The methodology can be read in the latest report (may 2022)
  2) Monetary valuation: damage effects and health cost for EU. Price x captured concentration.
- Global climate regulation
  1) Relevance of 30 cm threshold for stock. NL thinks that a limit should exist, if not 30 cm, then what depth should it be. EE thinks as deep as there are stocks. NL has data for 30 cm from national data, also it is included in the carbon account. EE should look into what is internationally reported, 30 cm depth could be a requirement and therefore, the data exists, at least for some ecosystem classes.
  2) Method for monetary valuation. NL calculated asset value by multiplying carbon price and 30 cm storage and calculated back to flow value by adding net present value. For sequestration sequestrated account times carbon price (efficient price, which is higher than ETS). NL has not looked into negative values yet.
- Local climate regulation.
  1) NL recently developed the assessment, could be looked up in the last report. Model was made by WUR (Marjolein). NL looks at only urban area, where they compare situation with only urban environment with the situation with urban environment with existing green areas and the output is average reduction in degrees.
  2) Is 25 degrees a good threshold. Definition of heatwave in NL is 5 days over 25 degrees. In Estonia heatwave is 27 degrees in 3 days. Therefore heatwave is different than a day exceeding 25 degrees and the service's relevance could be affected by this.

3) NL has no monetary valuation yet. UK has done monetary values (health effect), their report could be of use.

- Flooding mitigation.
  1) It is an additional service proposed by national stakeholders in EE.
  2) NL has done protection against heavy rainfall (infiltration capacity), and coast protection. No monetary valuation.
  3) The assessment and modelling of the service could be difficult considering that the service is supplied upstream but used somewhere downstream. NL thinks that it suffices to define that all what happens upstream affects downstream.
- Nature-based tourism-related services
  1) Physical valuation: how to improve the data provided by Eurostat (local data sources), how to combine them. NL has the same approach as Eurostat suggests. They can divide between provinces. Survey data also available on municipality, but it's not good (too few cases to generalize).
  2) From time use based valuation based on visitation data to expenditure-based valuation methods based on overnight stays data. NL has found monetary value by expenditures. UK has detailed report on recreation considering health effects (Adam Dotten).

Work on development of the methods for monetary valuation of ecosystem service flows were discussed.

For meaningful results and improved valuation of ecosystem services, validation of the data and monetary valuation methods was considered important.

In Estonia the valuation workflow includes filling data gaps that were revealed in previous works and analysing monetary valuation methods (methods that give exchange values and also those that result in welfare values) with the objective to find the most suitable methods among alternatives, in the light of knowledge achieved from SEEA EEA revision process- Also the questions on analysing whether the whole value should be considered as ecosystem service value or whether the residual would be tackled. Principles of the proposed new ecosystem accounts module of the regulation environmental accounts EU 691/2011 were planned to be tested as well plus the capturing welfare values of the ecosystem services in addition to exchange values or if the exchange values:

Statistics Netherlands thinks that the IPBES report gives now a good matrix view of the plural values.

In addition in order to find the links between possible outputs of ecosystem accounting with global reporting, the analysis of the possible indicators that could be derived from ecosystem accounting in Estonia have been initially analysed. Still the consultation with stakeholders in underway in connection with one or several of the following:

1. Science- Policy Platform on Biodiversity and Ecosystem Services, https://ipbes.net/),
2. UN SDGs (UN Sustainable Development Goals, https://www.un.org/sustainabledevelopment/) reporting,
3. The European Green Deal. Main idea here was trying to grasp the best knowledge.

Presentations on LG meetings on environmental accounting on valuation issues, ONEECOSYSTEM paper on valuation are on half way, participation and lesson learned from MAIA workshop on valuation issues were touched upon.

Patrick however highlighted the work of the IPBES values reporting as use ful source of guidance. Concepts and feasibility of reflecting plural values were discussed in sense of integrating the different valuation methods.

4.7. Future workflows

There is ongoing work on a collaborative article between NL and EE for One Ecosystem on exchange and CVM values for ecosystem services. For this work a consultation with Alejandro Caparros should be made in neartime future.

Now more specifically the IPBES values reporting framework will be looked at. It will be discussed if considering the semantics and principles of IPBES proposals on integrating the different valuation methods would be feasible.
November 3rd, Room B3022

ANNEX 5. Details of data used in order of compiling ecosystem extent map.

Table 1 attributes for the data used in order of compiling ecosystem extent map for the year 2020

Priorit y	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	18.01.2021	https://kls.pria.ee/kaart/
2	Forest types	Forest registry of Estonia	Original/local	32	Vector	15.02.2021	https://register.metsad.ee/#/
3	Wetlands	Estonian Nature Foundation	Natura 2000 habitats	57	Vector	03.01.2021	EELIS (Eesti Looduse infosüsteem – Keskkonnaregister): Keskkonnaagentuur
4	Semi-natural habitats which are eligible for support	Estonian Nature Information System	Natura 2000 habitats	15	Vector	03.01.2021	EELIS (Eesti Looduse infosüsteem – Keskkonnaregister): Keskkonnaagentuur
5	Natura 2000 habitats (Annex I habitats)	Estonian Nature Information System	Natura 2000 habitats	60	Vector	03.01.2021	EELIS (Eesti Looduse infosüsteem – Keskkonnaregister): Keskkonnaagentuur
6	Meadows	Estonian Seminatural Community Conservation Association	Natura 2000 habitats	12	Vector	03.01.2021	EELIS (Eesti Looduse infosüsteem – Keskkonnaregister): Keskkonnaagentuur
7	Estonian Topographic Database	Land Board of Estonia	Original/local	34	Vector	02.01.2021	https://geoportaal.maaamet.ee/est/Ruumiandmed/Eesti-topograafia-andmekogu-p79.html

Table 2 attributes for the data used in order of compiling ecosystem extent map for the year 2021

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	14.01.2022	https://kls.pria.ee/kaart/
2	Forest types	Forest registry of Estonia	Original/local	32	Vector	04.03.2022	https://register.metsad.ee/#/
3	Wetlands	Estonian Nature Foundation	Natura 2000 habitats	57	Vector	09.03.2022	EELIS (Eesti Looduse infosüsteem – Keskkonnaregister): Keskkonnaagentuur
4	Semi-natural habitats which are eligible for support	Estonian Nature Information System	Natura 2000 habitats	15	Vector	09.03.2022	EELIS (Eesti Looduse infosüsteem – Keskkonnaregister): Keskkonnaagentuur
5	Natura 2000 habitats (Annex I habitats)	Estonian Nature Information System	Natura 2000 habitats	60	Vector	09.03.2022	EELIS (Eesti Looduse infosüsteem – Keskkonnaregister): Keskkonnaagentuur
6	Meadows	Estonian Seminatural Community Conservation Association	Natura 2000 habitats	12	Vector	09.03.2022	EELIS (Eesti Looduse infosüsteem – Keskkonnaregister): Keskkonnaagentuur
7	Estonian Topographic Database	Land Board of Estonia	Original/local	34	Vector	29.01.2022	https://geoportaal.maaamet.ee/est/Ruumiandmed/Eesti-topograafia-andmekogu-p79.html