EU LIFE Programme project
"Demonstration of climate change mitigation potential of nutrients rich organic soils in Baltic States and Finland"

Report

ON IMPLEMENTATION OF THE PROJECT

Demonstration of climate change mitigation measures in nutrients rich drained organic soils in Baltic States and Finland

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LIFE OrgBalt compiled the first regional Baltic/Finnish GHG emission factors for managed nutrient-rich organic soils (current and former peatlands), which have been made available for the customary scientific review and further verification for national GHG inventories in the hemiboreal region in Finland and the Baltic countries. While the project analysed selected CCM measures for drained organic soils in agriculture and forestry and developed spatial models and tools, it also identified remaining knowledge gaps. To bridge the remaining limitations and fill the gaps, it is essential to continue GHG measurements and model development, as well as to broaden and complete the scope of the evaluated CCM measures in the after-LIFE-project period, notably by including rewetting and restoration of peatlands that are currently considered to be among the most recommended CCM measures on drained peatlands in the EU. In addition, the developed Simulation and PPC models still include limited macroeconomic considerations and lack an assessment of all environmental impacts. For all these reasons, these models should be used carefully in CCM strategy development for the identification of gaps in climate neutrality transition policy and funding frameworks and need further optimization for broader applicability as decision-making tools.

2022

SUMMARY

The first chapter of the report summarises the main conclusions on the theoretical aspects of the concept of ecosystem services, the key points of the methodology of ecosystem services assessment, and also provides a brief explanation of the usage of assessment of ecosystem services in policy developing. Further, soil-based ecosystem services are examined theoretically, what challenges soil resources have, what are the main functions that soil resources provide to society. The chapter describes the Functional Land Management framework, its main principles and theoretical aspects.

The second chapter of the report describes the structure of the Simulation tool. The Simulation tool is developed in the R programming environment, it is a static tool that can be used to model the effects of different scenarios on land resources spatially. First, the Simulation tool is used to map the current situation. The input data of land use, soil type, coefficients for the calculation of land functions are fed into the Simulation tool. Agricultural land polygons include information on the following: area, type of support, mark if it is organic farming, farm size, crop, group of crops, mark if there is land reclamation, land quality. Forest land polygons include information on the following: area, dominant specie, forest type, site index, stand volume, stand basal area, height of tree species, and number of trees, stand density, restrictions, and last management activity. It is also necessary to have information about protected areas and on economic activity in these areas. Subchapters 2.1 and 2.2 describe the methodology of how land function coefficients are calculated using the example of Latvia. In this project activity, two land functions are studied – socio-economic function and climate function. In this project activity, two land functions are calculated – socio-economic function and climate function. The socio-economic function is divided into two parts: economic with indicator of profit (euro per hectare) and social with indicator of employment (full-time equivalent). Profit depends on soil quality, land use, crop, yield, price, support payments and expenses. For example, a higher yield in tons per hectare can be obtained from vegetables and fruits compared to cereals. Employment depends on size of the farm, amount of work required, land use and crop. For example, growing vegetables requires a much larger amount of labor than growing grains.

The third chapter describes the steps for the application of the Simulation tool. In order to map the current situation, spatial data for each agricultural and forestry land polygon is needed. First, the agricultural and forestry land polygons, where the organic soil is located, are identified. Then the calculation of land functions according to the methodology described above is performed for each land polygon. Once the current situation has been mapped, then the scenarios selected within the LIFE OrgBalt project are implemented. Scenario analysis is carried out for the Baltic States. The impact of 15 scenarios on the performance of socioeconomic function and climate functions is determined. For each scenario, selection criteria for areas have been identified in order to spatially locate those land areas to which the specific scenario can be applied. The type of land use after the implementation of the scenario has also been identified. This step uses the results from activities C3 and C4.

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1. ECOSYSTEM SERVICES

Different ecosystems provide a set of different ecosystem services [1]. Ecosystem services are at the core of human existence and well-being. Ecosystem services can be directly usable materials such as food, drinking water, raw materials, solar energy, wind energy, minerals, etc. Ecosystem services can also be indirectly provided, such as air and water purification, flood risk mitigation, wind and water erosion mitigation, temperature regulation, and ecosystems provide various types of physical and mental enjoyment[2].

Ecosystem services are divided into three groups: provisioning services, regulation and maintenance services, cultural services[3]. Provisioning services include water, food, fuel, minerals. People use these services on a daily basis. Because of the biodiversity, we can grow various fruits and vegetables, pick berries and mushrooms in the forests, and catch fish in the sea, rivers and lakes. Climate regulation, nutrient cycling, water cycling, soil formation processes are regulation and maintenance services. Regulation and maintenance services are the sustaining processes of the ecosystem itself. These services do not have a fixed market value, but they play an important role in the well-being of mankind and the existence of ecosystems. But aesthetic inspiration, tourism, health promotion in nature are cultural services[4]. People are more familiar with this type of service as an opportunity to enjoy beautiful landscapes, go hiking, do sports, swim in the sea, lakes and rivers.

Ecosystems adapt to human-induced changes and are capable of regeneration, but their possibilities are not endless. As a result of human activity, nature is no longer able to sufficiently produce high-quality ecosystem services, so it is necessary to evaluate ecosystem services so that, when deciding on the use of the territory, we have information about what will happen to the territory in 10-20 years. There are different approaches to the assessment of ecosystem services – biophysical assessment, social assessment, economic assessment. Biophysical assessment characterizes ecosystem structure and functions in relation to the provision of ecosystem services. Biophysical assessment is most often used in ecosystem service mapping with the aim of determining what ecosystem services a given area provides depending on various factors. When carrying out the assessment, expert assessment, and direct measurements of biophysical parameters, long-term monitoring data, modelling/mapping of ecosystem services are used. Land cover data, land use data, biological information and abiotic information are used as basic data in the mapping of ecosystem services. It determines the hypothetical assessment based on expert knowledge, and quantitative assessment using statistical or monitoring data, modelling. As a result, spatial and statistical information on the provision of ecosystem services in the selected land uses are obtained. This type of evaluation helps to make various decisions in planning the development of territories, which is often carried out with the aim of ensuring sustainable development of territories. Social assessment involves society and assesses the importance of different services for different groups of society. With the social assessment method, it is possible to describe what benefits ecosystems are able to provide to the entire society, how important these services are to society, as well as to what extent society is informed about the ecosystem services available close to the place of residence. When performing a social assessment, it is useful to combine the obtained results with the results of the biophysical assessment, so that in this way, the needs and requirements of the society, which can

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[2] Peršēvica A., Brūniņa L., Konstantinova E., Skudra S. (2019) Rekomendācijas ekosistēmu pakalpojumu pieejas integrēšanai teritoriju plānošanā. Sigulda: Dabas aizsardzības pārvalde.

[3] Common International Classification of Ecosystem Services (CICES), https://cices.eu/

[4] Fisher B., Turner R. (2008) Ecosystem services: classification for valuation. Biological Conservation, 141(5), pp. 1167-1169.

directly affect the welfare of the society, are taken into account when making decisions about sustainable land management. Economic evaluation measures the total economic value of various ecosystem services in monetary terms. It is a descriptive assessment based on market mechanisms and personal preferences[5].

Evaluating ecosystem services can provide various advantages, for example, you can look at the possible development scenarios of the territory and evaluate which types of management are better to use for different ecosystems, it is possible to determine and also compare the efficiency of investments and calculate the necessary investment funds for nature conservation, as well as it is possible to choose the most profitable and sustainable scenario for territory development. With this approach, it is also possible to find out the economic value of nature, what contribution it gives to society, and it is also possible to argue and communicate with different stakeholders about the importance of nature and create a common public understanding of ecosystem services and how they affect society's economic and social prosperity[6].

1.1. Functional Land Management

Food production may be considered as a basic ecosystem services for the functioning of society. Given the growing population, this makes it difficult for scientists and policy makers to come up with solutions how to increase food production while achieving environmental objectives, such as water quality, biodiversity conservation and climate change mitigation. Agricultural and environmental stakeholders prioritize ecosystem services differently depending on national and international commitments, knowledge, and experience. The European Commission has published the European Green Deal, a cross-cutting plan to make its economy sustainable, which also includes specific strategies related to sustainable land use, biodiversity conservation, GHG emission reduction (Farm-to-Fork Strategy, Biodiversity Strategy for 2030, Fit for 55, Forest Strategy, Soil Strategy for 2030). In order to reach policy objectives and to preserve the values that are important to the wide range of stakeholders, it is necessary to focus on multi-functionality as a shared goal in addition to seeking local land use solutions[7]. This challenge requires meeting multiple policy targets at national level, while solutions and diverging societal expectations may be found at local and regional scales.

The most crucial resource for supplying food, feed, fiber, regulating water and nutrient cycles, storing and regulating carbon, and providing habitat for biodiversity is soil[8,9]. The capacity of soils to provide each of these ecosystem services differs. All soils cannot simultaneously provide all of these ecosystem services everywhere at the same time, but it is possible to optimise the delivery of multiple soil-based ecosystem services in order to meet policy objectives[10]. In this context, Functional

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[7] Hölting, L., Komossa, F., Filyushkina, A., Gastinger, M.M., Verburg, P.H., Beckmann, M., Volk, M., Cord, A.F., 2020. Including stakeholders' perspectives on ecosystem services in multifunctionality assessments. Ecosyst. People 16, 354–368. https://doi.org/10.1080/26395916.2020.1833986/SUPPL_FILE/TBSM_A_1833986_SM9845.PDF

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[10] Schulte, R.P.O., O'Sullivan, L., Vrebos, D., Bampa, F., Jones, A., Staes, J., 2019. Demands on land: Mapping competing societal expectations for the functionality of agricultural soils in Europe. Environ. Sci. Policy 100, 113–125. https://doi.org/10.1016/J.ENVSCI.2019.06.011

Land Management (FLM) framework was developed by Schulte et al., (2014) aiming to optimise rather the maximise the supply of soil functions to meet agronomic and environmental demands, namely primary productivity, water purification and regulation, carbon sequestration and regulation, the provision of habitats for biodiversity, and the provision and cycling of nutrients[11]. The European Research Project LANDMARK (LAND Management: Assessment, Research, Knowledge Base), funded by the European Union’s Horizon 2020 research and innovation programme, described each soil function and developed definitions[12]:

1) Primary productivity is a capacity of soils to produce plant biomass for human use, providing food, feed, fibre and fuel within natural or managed ecosystem boundaries;
2) Water purification and regulation is a capacity of a soil to remove harmful compounds from the water that it holds and to receive, store and conduct water for subsequent use and the prevention of both prolonged droughts and flooding and erosion;
3) Climate regulation and carbon sequestration is a capacity of a soil to reduce the negative impact of increased greenhouse gas (i.e., CO_2, CH_4, and N_2O) emissions on climate;
4) Soil biodiversity and habitat provisioning is a multitude of soil organisms and processes, interacting in an ecosystem, making up a significant part of the soil’s natural capital, providing society with a wide range of cultural services and unknown services;
5) Provision and cycling of nutrients is a capacity of a soil to receive nutrients in the form of by-products, to provide nutrients from intrinsic resources or to support the acquisition of nutrients from air or water, and to effectively carry over these nutrients into harvested crops.

Considering the suitability of a specific soil type for a land use is the first step towards achieving a balance between demand and supply of soil functions. Synergies do exist between soil functions, but when the maximisation of one soil function happens, then the trade-offs occur and other soil functions are negatively affected[13]. For instance, the intensification of agricultural production is one of the ways to quickly and efficiently meet the demand for primary productivity, but such actions would reduce the ability of biodiversity and climate regulation functions to meet the demand[14,15]. Optimisation of individual functions can lead to state where all needs have been taken into consideration. Policies are required for the careful management of our soils and land, in order to meet the demand for all the various socio-economic and climate policy requirements at national scale. The inclusion of soil multi-functionality and targeted incentives for sustainable land management in policy development ensures sustainability in the long-term.

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[12] http://landmark2020.eu/soil-functions-concept/

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1. STRUCTURE OF THE SIMULATION TOOL FOR LAND MANAGEMENT

The simulation tool analysis two land functions:

- Socio-economic function
  - (1) Economic (profit);
  - (2) Social (employment);
- (3) Climate function (net GHG emissions).

Simulation tool consists of algorithms for land functions calculations, which are written in R language, using "dplyr" package. For spatial data manipulations "sf" package is used.

Separate R scripts are written to calculate each of the socioeconomic outputs per each agricultural land polygon and per each forest land polygon (those socioeconomic outputs are employment, profit and net GHG emissions). All results per each agricultural and forest polygon are written in a separate dataset. Calculation results for the actual land use are aggregated into baseline scenario results. Results are visualised using R "tmap" package, before that aggregating data into quadrants.

The methodology for calculating land function assessment coefficients described in the following subsections is shown on the example of Latvia. Similar to what was described, the coefficients were also obtained for the other Baltic countries.

2.1. Socio-economic function

Two indicators have been used to assess the socio-economic impact: profit (EUR) and jobs (full-time equivalent (FTE)). The economic function is characterized by profit, which is the difference between revenue and costs (Figure 1). Given that land polygons with a socio-economic impact, have a different area, these indicators are first determined per hectare and then multiplied by the land polygon. Using this approach, each land polygon has an assessment of both profit and work hours investment.

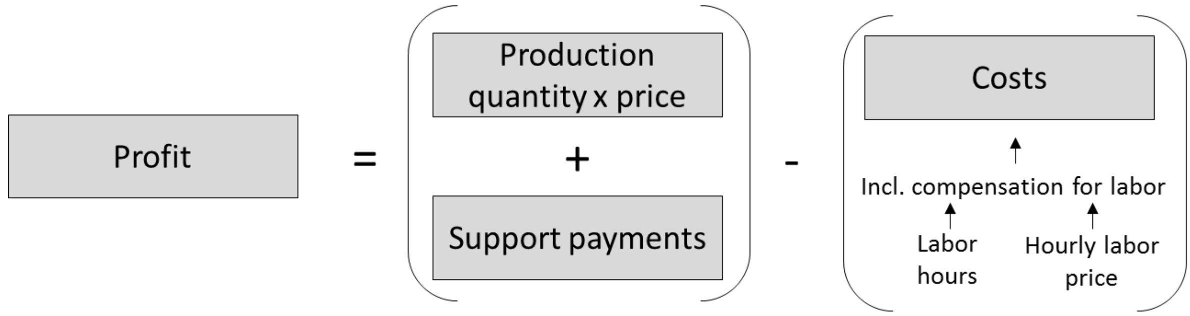

Figure 1. *Profit and Jobs Calculation Scheme*

2.1.1. Agricultural land

Revenues in agriculture consist of both sales of products (the product quantity multiplied by the price of the product) and support payments in agriculture. Support payments are included in the revenue mix, as they are largely an element of the balance of the existing EU agricultural market – if there was no support system at EU level, the price level for agricultural products would be higher in the EU.
Costs include all costs directly or indirectly related to production, including intermediate consumption, depreciation of fixed assets, labor compensation and real estate tax. The

compensation for the labor has been assessed both as the total amount per hectare and as a labor force contribution in hours per hectare. Profits and compensation for the labor are fixed before tax. Profits and compensations paid to the labor are related indicators, such as increasing labor productivity (with hourly rates and other headings unchanged), the same amount of production can be produced with fewer employees and lower labor costs, leading to increased profits. In this case, there is a reallocation between jobs and profits, but overall profitability remains unchanged.
It is typical for small farms that the owner of the holding is also an employee, so in theory, earned on the holding can be removed both as a compensation and as a profit when working without compensation or with a minimum wage, so the calculation measures the real contribution of the labor even if the formal compensation is removed in the form of a profit. That profit (or share of profits) is added to labor compensations by reducing accounting profits. Such "net" profits describe the economic performance of the land.
For the purposes of determining the profits in agriculture, the latest available data for the gross coverings from Latvian Rural Advisory and Training Centre (LLKC) and data from Farm Accountancy Data Network (FADN) are used, which allows for the establishment of profits in the agricultural sectors, depending on the various factors affecting the size of profits.
Profit is defined as a function of a number of factors:

$$Profit = f(P_{s,b}, Y_{s,b,r}, A_{s,b}, L_s, Z_{s,b}, N_{s,b})$$

where

P – price of goods,
Y – Productivity,
A – support,
L – labour costs,
Z – other costs,
N – depreciation,
s - group of the farm size,
b — organic production,
r – the quality of the land calculated in rating points.

In order to ensure that calculated data do not differ significantly from agricultural statistics, a calibration of simulated data has been performed.
The compensation for labor investment varies from size to size for holdings, which on large holdings is equal to the average compensation of the agricultural sector in the year concerned (and is higher than the median value of the compensation in the sector). As the size of the holdings decreases, the rate of compensation is also reduced, since these holdings also have lower labor productivity (Table 1).

Table 1. Labor price assumption in 2021, EUR per hour

Price in EUR per hour	Large farms	Medium farms	Small farms	Very small farms
Labor price	8.5	7.0	5.6	4.2

Taking into account the fluctuations of prices in the agricultural sector, the average price for the last 3 years has been used in the calculation. The function used for the determination of average yields is the quality of the soil in the points. Labor costs are determined using the hours of labor investment and the labor price assumption (from Table 2 to Table 14).

Table 2. Assumptions for determining profit and compensation for labor in crop production

Factor	Large farms	Medium farms	Small farms	Very small farms
Conventional farms				
Price (EUR/t)	171.9	171.9	154.71	137.52

Average yield (t/ha)	points/10 * 0.92			
Support (EUR/ha)	154	154	154	154
Labor costs (EUR/ha)	127.5	126	134.4	134.4
Other costs and depreciation	470	470	450	420
Organic farms				
Price (EUR/t)	237.6	237.6	213.84	190.08
Average yield (t/ha)	points/10 * 0. 375			
Support (EUR/ha)	271	271	271	271
Labor costs (EUR/ha)	127.5	126	134.4	134.4
Other costs and depreciation	451	451	431	401

Table 3. Assumptions for the determination of profit and compensation for the labor force in the grains, oilseeds, and pulses (GOP) production

Factor	Large farms	Medium farms	Small farms	Very small farms
Conventional farms				
Price (EUR/t)	350.1	350.1	315.09	280.08
Average yield (t/ha)	points/10 * 0.65			
Support (EUR/ha)	170	170	170	170
Labor costs (EUR/ha)	127.5	126	134.4	134.4
Other costs and depreciation	575	575	555	525
Organic farms				
Price (EUR/t)	545.4	545.4	490.86	436.32
Average yield (t/ha)	points/10 * 0. 104			
Support (EUR/ha)	267	267	267	267
Labor costs (EUR/ha)	127.5	126	134.4	134.4
Other costs and depreciation	194	194	174	144

Table 4. Assumptions for the determination of profit and compensation for the labor in the production of legumes

Factor	Large farms	Medium farms	Small farms	Very small farms
Conventional farms				
Price (EUR/t)	193.5	193.5	174.15	154.8
Average yield (t/ha)	points/10 * 0.725			
Support (EUR/ha)	222	222	222	222
Labor costs (EUR/ha)	127.5	126	134.4	134.4
Other costs and depreciation	462	462	442	412
Organic farms				
Price (EUR/t)	317.7	317.7	285.93	254.16
Average yield (t/ha)	points/10 * 0. 269			
Support (EUR/ha)	319	319	319	319
Labor costs (EUR/ha)	127.5	126	134.4	134.4
Other costs and depreciation	447	447	427	397

Table 5. Assumptions for establishing profit and compensation for labor in potato production

Factors	Large farms	Medium farms	Small farms	Very small farms
Conventional farms				
Price (EUR/t)	152.1	152.1	152.1	152.1

Average yield (t/ha)	36	32	24	18
Support (EUR/ha)	150	150	150	150
Labor costs (EUR/ha)	612	1155	1248.8	1323
Other costs and depreciation	1462	2033	2397	2974
Organic farms				
Price (EUR/t)	216	216	216	216
Average yield (t/ha)	15	12	10	8
Support (EUR/ha)	680	680	680	680
Labor costs (EUR/ha)	612	1155	1248.8	1323
Other costs and depreciation	2382	1805	1441	870

Table 6. Assumptions for the determination of profit and compensation for the labor in vegetable production

Factors	Large farms	Medium farms	Small farms	Very small farms
Conventional farms				
Price (EUR/t)	504	504	504	504
Average yield (t/ha)	13	11	11	9
Support (EUR/ha)	680	680	680	680
Labor costs (EUR/ha)	2414	2590	3052	2457
Other costs and depreciation	4319	3781	2689	2437
Organic farms				
Price (EUR/t)	789.3	789.3	789.3	789.3
Average yield (t/ha)	11	11	9	8
Support (EUR/ha)	1079	1079	1079	1079
Labor costs (EUR/ha)	2414	2590	3052	2457
Other costs and depreciation	3767	3229	2137	1885

Table 7. Assumptions for the determination of profit and compensation for the labor in the production of perennial plantations

Factor	Large farms	Medium farms	Small farms	Very small farms
Price (EUR/t)	785.7	785.7	785.7	785.7
Average yield (t/ha)	7.8	7.8	7.8	7.8
Support (EUR/ha)	286	286	286	286
Labor costs (EUR/ha)	3230	3150	3080	2310
Other costs and depreciation	3259	2800	2212	2212

Table 8. Assumptions for establishing profits and compensation for the labor for fallow land

Factor	Large farms	Medium farms	Small farms	Very small farms
Conventional farms				
Revenue (EUR/ha)	0	0	0	0
Support (EUR/ha)	150	150	150	150
Labor costs (EUR/ha)	51	49	67.2	92.4
Other costs and depreciation	79	79	59	49
Organic farms				
Revenue (EUR/ha)	0	0	0	0
Support (EUR/ha)	247	247	247	247
Labor costs (EUR/ha)	51	49	67.2	92.4

Other costs and depreciation	110	110	90	60

Table 9. Assumptions for the determination of profit and compensation for the labor for grasslands

Factor	Large farms	Medium farms	Small farms	Very small farms
Price (EUR/t)	9.9	9.9	9.9	9.9
Average yield (t/ha)	8	8	8	8
Support (EUR/ha)	150	150	150	150
Labor costs (EUR/ha)	136	133	140	142.8
Other costs and depreciation	254	253	200	113

Table 10. Assumptions for determining profit and compensation for the labor for meadows and pastures

Factor	Large farms	Medium farms	Small farms	Very small farms
Price (EUR/t)	36.9	36.9	36.9	36.9
Average yield (t/ha)	1.49	1.49	1.49	1.49
Support (EUR/ha)	150	150	150	150
Labor costs (EUR/ha)	51	56	61.6	96.6
Other costs and depreciation	246	241	230	192

Table 11. Assumptions for determining profit and compensation for labor in the production of other crops

Factor	Large farms	Medium farms	Small farms	Very small farms
Price (EUR/t)	2700	2700	2700	2700
Average yield (t/ha)	0.16	0.16	0.16	0.16
Support (EUR/ha)	150	150	150	150
Labor costs (EUR/ha)	765	805	896	945
Other costs and depreciation	293	287	241	168

Table 12. Assumptions for determining profit and compensation for labor in milk production

Factor	Large farms	Medium farms	Small farms	Very small farms
Price (EUR/animal)	0.297	0.288	0.261	0.225
Average yield (t/animal)	11000	9000	5500	5000
Support (EUR/animal)	236	236	236	236
Labor costs (EUR/animal)	595	630	1008	1806
Other costs and depreciation	1626	1578	672	300

Table 13. Assumptions for determining profit and compensation for labor in the suckler cow sector

Factor	Large farms	Medium farms	Small farms	Very small farms
Price (EUR/animal)	2.52	2.52	2.52	2.52
Average yield (t/animal)	240	240	200	200
Support (EUR/animal)	132	132	132	132
Labor costs (EUR/animal)	127.5	105	128.8	189
Other costs and depreciation	564	589	422	352

Table 14. Assumptions for determining profit and compensation for labor in the sheep farming sector

Factor	Large farms	Medium farms	Small farms	Very small farms
Price (EUR/animal)	2.25	2.25	2.25	2.25
Average yield (t/animal)	36	36	36	36
Support (EUR/animal)	34	34	34	34
Labor costs (EUR/animal)	76.5	63	100.8	151.2
Other costs and depreciation	50	50	20	20

Data from the Farm Accountancy Data Network (FADN) in Latvia are used to determine labor input. For the calculations the published LLKC gross coverage data for determining the contribution of labor hours and the unpublished information on the time capacity of the activities to be performed are also used.
In order to determine the proportions between the labor consumption for the GOP area, fallow land, grasslands and meadows and pastures, LLKC information on the activities to be performed and their time capacity was used.
Different farms have different labor productivity indicators, so farms are divided into 4 groups: large farms, medium farms, small farms and very small farms.

Table 15. Farm size groups in different agricultural sectors

Type of farming	Farm size groups			
	Large farms	Medium farms	Small farms	Very small farms
GOP (grains, oilseeds, pulses), ha	>300	>100, ≤300	>20, ≤100	≤20
Potatoes, ha	>30	>10, ≤30	>2, ≤10	≤2
Vegetables, strawberries, flowers, ha	>30	>10, ≤30	>2, ≤10	≤2
Perennial plantations, ha	>30	>10, ≤30	>2, ≤10	≤2
Other crops, ha	>150	>50, ≤150	>10, ≤50	≤10
Fallow land, ha	>300	>100, ≤300	>20, ≤100	≤20
Grasslands, ha	>300	>100, ≤300	>20, ≤100	≤20
Meadows and pastures, ha	>300	>100, ≤300	>20, ≤100	≤20
Dairy cows, number	>200	>30, <=200	>4, <=30	<=4 dz.
Suckler cows, number	>200	>30, <=200	>4, <=30	<=4 dz.
Horses, number	–	>30	>4, <=30	<=4 dz.
Goats, number	–	>50	>5, <=50	<=5 dz.
Sheep, number	–	>50	>5, <=50	<=5 dz.
Pigs, number	>=1000	>=100, <1000	>=5, <100	<5 dz.
Poultry, number	>=50k	>=1k, <50k	>=20, <1k	<20 dz.
Bees, number	>=150	>30, <=150	>5, <=30	<=5

Different farms have significantly different labor input for production. Although individual small farms are ahead of individual large farms in terms of labor productivity, in general, there is a trend - the smaller the farm, the greater the labor input, calculated per hectare of area or per animal.

Table 16. Average labor input per hectare or per animal in farms of different sizes, hours

Type of farming	Labor input			
	Large farms	Medium farms	Small farms	Very small farms
GOP (grains, oilseeds, pulses)	15	18	24	32

Potatoes	72	165	223	315
Vegetables, strawberries, flowers	284	370	545	585
Perennial plantations	380	450	550	550
Other crops	90	115	160	225
Fallow land	6	7	12	22
Grasslands	16	19	25	34
Meadows and pastures	6	8	11	23
Wood plants	10	12	18	25
Dairy cows (with calves)	70	90	180	430
Suckler cows (with calves)	15	15	23	45
Horses	17	17	25	50
Goats	42	42	70	200
Sheep	9	9	18	36
Pigs	4,1	16	54	90
Poultry	0,7	2	3	5
Bees	20	32	44	69

Data calibration was carried out when assessing labor input for different agricultural sectors and farm size groups. The purpose of calibration is to ensure that, when applying the estimated hours of labor input to all areas and animals, the total calculated labor input in agriculture coincides with the total labor input according to statistical data. Agricultural labor input statistics are be used to calibrate the data[16].

2.1.2. Forest land

Unlike agriculture, profits in forestry are not available annually, but on average 2 to 3 times during one rotation cycle (average cycle of 30 to 100 years depending on the prevailing species and stand quality class). Gross profit is the difference between all revenues from logging and the expenses incurred in logging operations and forest regeneration. The profit per m^3 depends on the dominant species of the stand, stand quality class and type of forest, therefore it is calculated for each forest polygon separately. Information on the type and volume of logging is obtained from the annual reports of the State Forest Service, which is then spatially linked to the database of the State Forest Register[17].

It is assumed that income from logging is generated by selling wood assortments, performing main felling and stock maintenance felling, while the amount of wood and its distribution in assortments depends on the type of felling and the dominant species in the area. The expenses consists of the expenses arising from the preparation of these assortments, as well as forestry measures after the main felling - soil preparation, purchase of planting material, planting, agrotechnical maintenance and fellings for maintenance of the composition. Revenues have been calculated based on the assumption that the same proportion of assortments can be obtained in the stands of the same dominant species and it depends on the dominant species.

Table 17. Proportion of wood assortments from wood to be obtained, depending on the species prevailing in the section

Dominant tree species	Type of assortments, proportion

[16] Eurostat, Agricultural labor input statistics, available at: http://ec.europa.eu/eurostat/web/products-datasets/-/aact_ali01

[17] https://www.vmd.gov.lv/lv

	Saw logs of conifers	Saw logs of leaf tree	Paper wood	Firewoodod
Pine	0.75	0.02	0.19	0.04
Spruce	0.51	0.12	0.29	0.09
Birch	0.23	0.28	0.39	0.10
Aspen	0.00	0.36	0.01	0.63
Black alder	0.00	0.67	0.00	0.33
White alder	0.00	0.22	0.00	0.78
Other species	0.25	0.28	0.15	0.33

The annual volume of logging is multiplied by the proportion of assortments and by the price for the respective assortment, obtaining revenues. It is assumed that the price depends on the species, assortment and type of felling.

Table 18. Prices of different wood assortments depending on the prevailing species

Dominant tree species	Price, EUR/m^3			
	Saw logs of conifers	Saw logs of leaf tree	Paper wood	Firewoodod
Pine	75	57	52	35
Spruce	75	57	50	35
Birch	75	57	51	35
Aspen	0	50	0	35
Black alder	0	57	51	35
White alder	0	50	0	35
Other species	75	57	51	35

The expenses related to the management of forest lands consist of two items. Firstly, the expenses that arise during logging, when the wood is extracted. During logging, expenses are generated during three work operations - sawing wood, bringing wood to the warehouse and taking away the wood. It is assumed that the expenses during the logging operations are equal to those that would be incurred during the main felling - logging - (6.05 EUR m^3), bringing wood from the felling to the road (4.7 EUR m^3) and transporting timber from the road to the point of purchase (6.7 EUR m^3). The total potential costs of the polygon are formed by multiplying the costs of logging with the growth of the stock. The Central Statistical Bureau (CSB) data for the period from 2018 to 2020 are used for the calculations[18].

Secondly, the expenses are generated during forest restoration after the main felling, which includes expenses for such silvicultural measures as soil preparation, planting and planting material, agrotechnical care, protection of young trees (for example, against hooves), composition maintenance fellings. Restoration costs depend on the dominant species and forest type (forest land quality group). Taking into account that this calculation is made for the potential profit and costs for the annual growth of the stock, the amount of forestry expenses is divided by the duration of the rotation cycle, obtaining the costs of one year.

Table 19. Costs of forestry activities according to forest type and quality group

Forest type	Forest land quality	Price, EUR/m ^{3}				
		Soil	Planting	Thinning	Planting	Improvement

[18] https://www.csp.gov.lv/en

	group	preparation	material			felling
Cladinoso–callunosa (Sils)	2	146	358	127	111	145
Vacciniosa (Mētrājs)	3	146	450	125	115	142
Myrtillosa (Lāns)	3	146	450	125	115	142
Hylocomiosa (Damaksnis)	4	155	432	131	124	210
Oxalidosa (Vēris)	4	155	432	131	124	144
Aegopodiosa (Gārša)	4	155	432	131	124	144
Cladinoso–sphagnosa (Grīnis)	1	155	356	130	130	136
Vaccinioso–sphagnosa (Slapjais mētrājs)	2	145.76	358.15	127.12	110.66	144.76
Myrtilloso–sphagnosa (Slapjais damaksnis)	2	145.76	358.15	127.12	110.66	144.76
Myrtilloso–polytrichosa (Slapjais vēris)	2	145.76	358.15	127.12	110.66	144.76
Dryopteriosa (Slapjā gārša)	2	145.76	358.15	127.12	110.66	144.76
Sphagnosa (Purvājs)	1	154.975	356.21	129.52	129.52	135.98
Caricoso–phragmitosa (Niedrājs)	2	145.76	358.15	127.12	110.66	144.76
Dryopterioso–caricosa (Dumbrājs)	2	145.76	358.15	127.12	110.66	144.76
Filipendulosa (Liekņa)	2	145.76	358.15	127.12	110.66	144.76
Callunosa mel. (Viršu ārenis)	2	145.76	358.15	127.12	110.66	144.76
Vacciniosa mel. (Mētru ārenis)	3	146.15	450.1025	124.98	115.12	141.98
Myrtillosa mel. (Šaurlapu ārenis)	4	154.52	431.6625	131.11	124.06	143.76
Mercurialiosa mel. (Platlapu ārenis)	4	154.52	431.6625	131.11	124.06	143.76
Callunosa turf. mel. (Viršu kūdrenis)	2	145.76	358.15	127.12	110.66	144.76
Vacciniosa turf. mel. (Mētru kūdrenis)	3	146.15	450.1025	124.98	115.12	141.98
Myrtillosa turf.mel. (Šaurlapju kūdrenis)	4	154.52	431.6625	131.11	124.06	143.76
Oxalidosa turf. mel. (Platlapju kūdrenis)	4	154.52	431.6625	131.11	124.06	143.76

2.2. Climate function

In order to determine the performance of land for the assessment of GHG emissions and carbon sequestration, GHG emissions in agriculture are analysed, as well as GHG emissions and CO_2 removals in the LULUCF sector. GHG emissions are recalculated in CO_2 equivalent and the amount of GHG emissions or CO_2 removals are determined for each land polygon.

2.2.1. Agricultural land

1. **Livestock**

The GHG emissions for the category of animals are determined per livestock per year in CO_2 equivalent. If the category of animals presented is composed of different animals (e.g. poultry including laying hens, broilers, turkeys, ducks, geese and others), the value of the category obtained is the weighted average per animal, taking into account the number of individual animals and the resulting proportions.

1.1. *CH_4 emissions from enteric fermentation*

The emissions from the enteric fermentation of the **dairy cows and other** bovine animals are determined after the 2006 update of the Intergovernmental Panel on Climate Change (IPCC) for the 2006 guidelines on national greenhouse gas inventories[19] **in equation 10.21:**

$$EF_{(T)} = \frac{GE_{(T)} \times (\frac{Y_{m(T)}}{100}) \times 365}{55.65},$$

where

EF_T - emission factor for animal category T, kg CH_4 per animal per year;

GE_T - gross energy consumed for animal category T, MJ per animal per day;

$Y_{m(T)}$ - methane conversion factor for animal category T,% of the gross energy of feed converted into methane;

55.65 - methane energy content, MJ per kg CH_4.

The calculation is used for dairy cows, milk calves, meat calves, dairy cows, beef cattle, suckler cows, heifers over 2 years and bulls of the average gross energy (*GE*) values from **tables 5.11** and 5.12 of the Latvian national inventory report (NIR)[20].
In order to carry out individual calculations on dairy cows that graze (up to 80 dairy cows) and dairy cows that do not graze (above 80 dairy cows), as well as dairy cows in organic farming, a regression equation is used that characterises the gross energy (*GE*) taken according to the milk yield (1990).-2020, $r = 0.988$, $p < 0.01$).
In the calculation, the methane conversion factor (Y_m) is used in accordance with the conditions **of Table 10.12 (**updated) of the IPCC 2019 specification: for dairy cows, depending on the number of milking and lactation days, the other bovine animals, according to the digestibility of the feed 65% (NIR, (2022)), and the fact that the calves who eat only milk (up to 3 months), Y_m are 0.
For other animals, the default values (*ef*) for methane emission factor (EF) are used according to Tier 1 approach from IPP 2019 update **10.10 (**updated):

Type of animal	EF, kg CH_4 per animal per year
Horses	18
Goats	*7**
Sheep	9
Pork	1,5
Poultry	-
Deer	20

* to ensure the use of the same live weight as CH_4 emissions from manure management (36 kg), the goat EF is adjusted according to the principle set out in Chapter 10.2.4 of the IPCC 2019 update

A factor of 25 is used to quantify methane emissions in CO_2 equivalents.

1.2. *CH_4 emissions from manure management*

The methane emissions resulting from the manure management process, dairy cows, other bovine animals and pigs are determined according to equation 10.23 of THE IPCC 2019 update:

[19] 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories

[20] LATVIA 'S NATIONAL INVENTORY REPORT (2022). Greenhouse Gas Emissions in Latvia from 1990 to Common Reporting Formats (CRF)

$$F_{(T)} = \left(VS_{(T)} \times 365\right)\left[B_{0(T)} \times 0.67 \times \sum_{S,k} \frac{MCF_{S,k}}{100} \times AWMS_{(T,S,k)}\right],$$

where

EF $_{(T)}$ - emission factor for animal category *T*, kg CH_4 per animal per year;

V $_{(T)}$ - with excreted volatile solids for animal category *T*, kg dry matter per day;

B $_{o\,(T)}$ - maximum methane production capacity for animal categories T manure, m^3 CH_4 per kg of COW;

0.67 - conversion factor to convert m^3 CH_4 to kg CH_4;

MCF $_{(S,\,k)}$ - methane conversion factor *for* manure management system in climate zone *k*;

AWMS $_{(T,\,S,\,k)}$ - part of the animal category *T* manure that is managed in the manure system *in the* climate zone *k*.

In the calculation, THE average values of volatile solids (*VS*) for dairy cows, dairy calves, fattening cows, heifers over 2 years, bulls and pigs are used in the (5.18, 5.19, 5.20) of volatile solids (COWS) (5.18, 5.19, 5.20).

In order to carry out individual calculations on dairy cows that graze (up to 80 dairy cows) and dairy cows that do not graze (over 80 dairy cows), as well as dairy cows in organic farming, a regression equation is used which characterises the size of volatile solids (*VS*) depending on the gross energy absorbed (*GE*) (1990.-2020, $r = 0.992$, $p < 0.01$).

The values of the maximum methane production capacity (B_o) are taken from THE IPCC 2019 update of Table 10.16 (updated).

Methane conversion factor (*MCF*) values for each manure management system — liquid manure, litter manure and pasture — are determined in accordance with the values and conditions of Table 10.17 (updated) (climate zone — cool and wet temperate climate zone (*Cool temperate moist*)). In contrast, manure used in the bioreactor has a national value of 2%, NIR (2022).

The distribution of manure by system is based on the assumptions shown below for each category of livestock manure management from the Latvia University of Life Sciences and Technologies survey on manure management systems in Latvia[21]:

Type of animal	Pasture	Solid manure	Liquid manure	Manure without litter
Dairy cows	x	x	x	
Dairy cows (up to 1 year)	x	x		
Dairy cows (1-2 years)	x	x		
Beef cattle calves (up to 1 year)	x	x		
Beef cattle (1-2 years)	x	x		
Other bovine animals (over 2 years)	x	x		
Sows, breeding boars		x	x	
Piglets (up to 4 months)		x	x	
Fattening pigs (from 4 months)		x	x	
Sheep	x	x		
Goats	x	x		
Horses	x	x		
Laying hens	x	x		x
Broilers		x		
Geese	x	x		
Ducks	x	x		

[21] Development of Latvia University of Life Sciences and Technologies research "Methodologies for calculation of GHG emissions calculation methodologies and data analysis with modelling tools, integrating climate change" (2016)

Turkeys	x	x		
Deer	x			

The distribution between slurry and litter manure dairy cows is based on the assumption that, from cows in grazing (up to 80 dairy cows), litter manure is obtained, but the cows who do not graze (above 80 dairy cows) receive slurry. It should also be noted that litter manure from pigs is assumed to be obtained when they are up to 500.
The grazing factors (the part of the manure remaining in the pasture) are used as pasture coefficients: the dairy cows that graze (up to 80 dairy cows) - 0.188 (the cows are assumed to graze 165 days per year at 10 h per day); the dairy cows' calves and young animals are accepted if the grazing cows, pasture cows and young animals; the other cattle – 0.537 (it is assumed that cattle are grazing in 196 days per year at 24 h per day, in winter).
For the other animals, the grazing factor is determined: horses – 0.521 (it is assumed that horses graze 190 days per year at 24 h per day); goats – 0.146 (it is assumed that goats graze 160 days per year at 8 h per day); sheep – 0.499 (it is assumed that sheep grazing in 182 days per year by 24 h day); laying hens that graze (10% of laying hens) and turkeys – 0.329 (are assumed to graze 240 days per year at 12 h per day); ducks and geese – 0.356 (is assumed to be grazing 240 days per year by 13 hours per day). The assumptions on manure distribution and grazing period are based on the above-mentioned Latvia University of Life Sciences and Technologies study.
In the case of livestock manure in the bioreactor, according to the Latvia University of Life Sciences and Technologies study, it is assumed that part of the manure of the dairy cows and pig manure is used, part of the manure of the milk calves and the litter of the livestock (if the cows are obtained from the dairy cows), as well as a part of the dung of the decontaminants without litter. The proportion of manure entering the bioreactor is determined by the proportions between the bioreactor and the corresponding manure system, as the manure for the particular animal type is used in the bioreactor (e.g., for dairy cows, the proportion between the liquid system and the bioreactor), which exists IN Annex A.3 .6 of the NIR (2022).
For other animals, methane emissions per animal are determined by Tier 1 approach based on equations 10.22[22] and 10.22 A of IPCC 2019 (updated):

$$CH_{4(mm)(T)} = \left[\sum_S \frac{VS_{(T)} \times AWMS_{(T,S)} \times EF_{(T,S)}}{1000}\right],$$

$$VS_{(T)} = (VS_{rate(T)} \times \frac{TAM_T}{1000}) \times 365,$$

where

$CH_{4\,(mm)\,(T)}$ - CH_4 emissions from manure management animal category *T*, kg CH_4 per animal per year;
$V_{(T)}$ - with excreted volatile solids for animal category *T*, kg *vs* animal per year;
$AWMS_{(T,\,S)}$ - part of animal category *T* volatile solids which are managed in the manure system;
$EF_{(T,\,S)}$ - emission factor for animal categories *T* CH_4 emissions from manure management system *S*, g CH_4 per kg *VS*;
$V_{Rate\,(T)}$ - default *VS* animal category *T*, kg *w* per day per 1000 kg of animal mass;
$IT_{(T)}$ - typical animal category *T* live weight, kg per animal.

In order to make the necessary calculations, a methane emission factor (*EF*) per volatile solids (*v*) (Table 10.14 (updated)), the quantity of volatile solids (*VS*) per unit of animal weight (Table 10.13 A (new)), as well as animal weight (10A) is used from the IPCC 2019 update. Table 5 (new) according to the conditions of the tables. For laying hens with manure used in biogas production, *the EF* value is determined by equation 10.23 using tables 10.13 A (new) and 10A.The estimated quantity (*VS*) of volatile solids calculated in Table 5 (new). Deer uses default (*Default*) *EF* value per animal from Table 10.15 (updated).
A factor of 25 is used to quantify methane emissions in CO_2 equivalents.

[22] Custom for this calculation

1.3. *N_2O emissions from manure management*

Direct N_2O emissions:

Direct N_2O emissions from manure management per animal are determined on the basis **of equation 10.25 of** THE IPCC 2019 update (updated)[23]:

$$2.\quad N_2O_{D(mm)} = \left[\sum_S \left(Nex_{(T)} \times AWMS_{(T,S)} \times EF_{3(S)}\right)\right] \times \frac{44}{28},$$

where

$N_2O_{D(mm)(T)}$ - direct N_2O emissions from manure management animal category *T*, kg N_2O per animal per year;

$Nex_{(T)}$ - with excreted N animal category *T*, kg per animal per year;

$AWMS_{(T,S)}$ - part of animal category *T* manure N which is managed in the manure system;

$EF_{3(S)}$ - emission factor for direct N_2O emissions from manure management system *S*, kg N_2O-N per kg N;

44/28 - conversion factor to convert N_2O-N emissions to N_2O emissions.

The calculation uses NIR (2022) as well as the national values used in local studies (tables 5.22, 5.23, 5.24) - the average values of the N excreted during the year with excrement (feces and urine).
In order to carry out individual calculations on dairy cows that graze (up to 80 dairy cows) and dairy cows that do not graze (above 80 dairy cows), as well as dairy cows in organic farming, a regression equation is used that characterizes the quantity of the exported N according to the yield (1990).- 2020, $r = 0.930$, $p < 0.01$).
N_2O emission factor (EF_3) values for each manure storage system are determined according to Table 10.21 (updated): liquid (0.005), litter manure (0.01) and bioreactor (0.0006).
For N_2O emissions expressed in CO_2 equivalent, a factor of 298 is used.

Indirect N_2O emissions from evaporation:

Indirect N_2O emissions resulting from N evaporative NH_3 and $FROM_x$ forms, which in turn come from atmospheric soil and water, resulting in N_2O emissions are determined on the basis **of equations[24] 10.28** and 10.26 of THE IPCC 2019 specification:

$$N_2O_{G(mm)(T)} = \left(N_{volatilization-MMS(T)} \times EF_4\right) \times \frac{44}{28},$$

$$N_{volatilization-MMS(T)} = \sum_S \left[Nex_{(T)} \times AWMS_{(T,S)} \times Frac_{GasMS(T,S)}\right],$$

where

$N_2O_{G(mm)(T)}$ - indirect N_2O emissions from N evaporation in manure management process, kg N_2O per animal per year;

$N_{volatilization-MMS(T)}$: the quantity of N for the category *of* animals disappearing as evaporated NH_3-N and $FROM_x$-N, kg N per year per animal;

EF_4 - emission factor for indirect N_2O emissions from atmospheric N to soil and water surfaces, kg N_2O-N per kg evaporated NH_3-N and $FROM_x$-N;

$Nex_{(T)}$ - with excreted N animal category *T*, kg per animal per year;

$AWMS_{(T,S)}$ - part of animal category *T* manure N which is managed in the manure system;

$Frac_{gasMS(T,S)}$ — part of the livestock category of livestock manure, which evaporates as NH_3-N and $FROM_x$ - N manure management system *S*;

44/28 – conversion factor to convert N_2O-N emissions to N_2O emissions.

The N parts which evaporate NH_3 and $FROM_x$ in forms should be determined according to the values

[23] Custom for this calculation

[24] Custom for this calculation

and conditions of Table 10.22 (updated) for each animal type and manure storage system. The bioreactor is assumed to be lost as liquid manure, which is covered.
The value of the emission factor (*EF_4*) is taken from the IPCC 2019 update of Table 11.3 (updated), wet climate – 0.014.
For N_2O emissions expressed in CO_2 equivalent, a factor of 298 is used.

Indirect N_2O emissions from leaching:

Indirect N_2O emissions resulting from leaching of N are determined on the basis of equations[25] 10.29 and 10.27 of the IPCC 2019 specification:

$$N_2O_{L(mm)(T)} = \left(N_{leaching-MMS(T)} \times EF_5\right) \times \frac{44}{28},$$

$$N_{leaching-MMS(T)} = \sum_{S}\left[Nex_{(T)} \times AWMS_{(T,S)} \times Frac_{LeachMS(T,S)}\right],$$

where
$N_2O_{L\ (mm)\ (T)}$ - indirect N_2O emissions from N leaching in manure management process, kg N_2O per animal per year;
$N_{leaching\text{-}MMS\ (T)}$ - N for category *of* animals disappearing as a result of N leaching, kg N per animal;
EF_5 - emission factor for indirect N_2O emissions from N leaching, kg N_2O-N per kg rinsed N;
$Nex_{(T)}$ - with excreted N animal category *T*, kg per animal per year;
$AWMS_{(T,\ S)}$ - part of animal category *T* manure N which is managed in the manure system*;*
$Frac_{LeachMS\ (T,\ S)}$ - part of the livestock category of livestock manure that is leaked in the manure management system*;*
44/28 - conversion factor to convert N_2O-N emissions to N_2O emissions.

Part N rinsing, each of the animal types and manure storage systems is determined by the values and conditions of Table 10.22 (updated).
The value of the emission factor (*EF_5*) is taken from the IPCC 2019 update of Table 11.3 (updated), wet climate – 0.011.
For N_2O emissions expressed in CO_2 equivalent, a factor of 298 is used.

N losses and available N input into soil:

Total N losses from manure storage are determined in accordance with IPCC 2019 update 10.34 A and 10.34.B. equations (new):

$$FRAC_{LOSS_{MS(T,S)}} = FRAC_{GAS_{MS(T,S)}} + FRAC_{LEACHS_{MS(T,S)}} + FRAC_{N_2MS_{(S)}} + EF_{3_{(S)}},$$

$$FRAC_{N_2MS_{(S)}} = R_{N_{2(N_2O)}} \times EF_{3(S)},$$

where
$Frac_{LossMS\ (T,\ S)}$ - the total part of the livestock category of livestock manure, which disappears *in* the manure management system;
$Frac_{\ asMS\ (T,\ S)}$ - part of the managed manure N category *of* animals which evaporates as NH_3-N and $FROM_x$ - N manure management system S;
$Frac_{LeachMS\ (T,\ S)}$ - part of the livestock category of livestock manure that is leaked in the manure management system*;*
$EF_{3(S)}$ - emission factor for direct N_2O emissions from manure management system *S*, kg N_2O-N per kg N;
$FRAC_{N_2MS_{(S)}}$ - part of the managed manure N which disappears from the manure management system as N_2;

[25] Custom for this calculation

$R_{N_{2(N_2O)}}$ - N_2 and N_2O emission ratio, default value is 3.

The amount of N available for incorporation into soil should be determined from the total N in storage systems for all animals included in the calculation, minus N losses on the basis of equation 10.34 of the IPCC 2019 update (updated)[26]:

$$N_{MMS_{Avb}} = \sum_{S}\left\{\sum_{T}[(N_{(T)} \times Nex_{(T)} \times AWMS_{(T,S)}) \times (1 - FRAC_{LOSS_{MS(T,S)}}]\right\},$$

N_{MMSAvb} - total quantity of N managed, available for incorporation in soil, kg N per year;

$N_{(T)}$ - total number of animals for category *T*;

$Nex_{(T)}$ - with excreted N animal category *T*, kg per animal per year;
$AWMS_{(T, S)}$ - part of animal category *T* manure N which is managed in the manure system*;*

$Frac_{LossMS (T, S)}$ - total part of the manure n of the managed manure *in T*, which disappears in the manure management system.

The total number of animals comes from the Central Statistical Bureau data, while the data on the number of organic animals are derived from the Ministry of Agriculture.

2.3. N_2O emissions from animal grazing

N_2O emissions from animal grazing are calculated on the animal but are further attributed to the grassland and pasture area according to animal density.

Direct N_2O emissions:
N_2O direct emissions from animal grazing are calculated on the basis of equations[27] 11.1 and 11.5 of the IPCC 2019 specification:

$$N_2O_{D(PRP)(T)} = \mathrm{F}_{\mathrm{PRP(T)}} \times \mathrm{EF}_{\mathrm{3PRP}} \times \frac{44}{28},$$

$$F_{PRP(T)} = Nex_T \times MS_{T,PRP} \ ,$$

where

$N_2O_{D\ (PRP)\ (T)}$ - direct N_2O emissions from urine and manure left in grazing, animal category *T*, kg N_2O per animal per year;

$F_{PRP\ (T)}$ - for the category of urine and manure N, which remains pasture, kg N per animal per year;

EF_{3PRP} - emission factor for direct N_2O emissions from urine and manure remaining in pasture, kg N_2O-N per kg N; different factor *IN CPP* for cattle, pigs, poultry and *SO* for sheep and other animals;

$Nex_{(T)}$ - with excreted N animal category *T*, kg per animal per year;
$MS_{(T,\ PRP)}$ - part of animal category *T* manure N which is left in pasture;

44/28 - conversion factor to convert N_2O-N emissions to N_2O emissions.

Emission factor (EF_3) is taken from the IPCC 2019 update of Table 11.1 (updated), wet climate – 0.006 (cattle, birds and pigs), 0.003 – others.
For N_2O emissions expressed in CO_2 equivalent, a factor of 298 is used.

Indirect N_2O emissions from evaporation:

Indirect N_2O emissions resulting from N evaporative NH_3 and $FROM_x$ forms, which in turn come from atmospheric soil and water, resulting in N_2O emissions are determined on the basis of equation 11.9 of[28] the IPCC 2019 update:

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[26] Custom for this calculation

[27] Adapted for this calculation

[28] Custom for this calculation

$$N_2O_{(ATD,PRP)(T)} = F_{PRP(T)} \times Frac_{GASM} \times EF_4 \times \frac{44}{28},$$

where

$N_2O_{(ATD,\ PRP)\ (T)}$ - indirect N_2O emissions from N evaporative grazing as a result of the animal category *T*, kg N_2O per animal per year;

$F_{PRP(T)}$ - for the category *of* urine and manure N, which remains pasture, kg N per animal per year;

$Frac_{GASM}$ - part of the incorporated organic N and the dried urine and manure N evaporated as NH_3-N and FROM $_x$ - N;

EF_4 - emission factor for indirect N_2O emissions from atmospheric N to soil and water surfaces, kg N_2O-N per kg evaporated NH_3 - N and FROM $_x$ - N;
44/28 - conversion factor to convert N_2O-N emissions to N_2O emissions.

Part N, which evaporates ($Frac_{GASM}$) as well as emission factor EF_4, is taken from the IPCC 2019 update of Table 11.3 (updated), wet climate – according to 0.21 and 0.014.
For N_2O emissions expressed in CO_2 equivalent, a factor of 298 is used.

Indirect N_2O emissions from leaching:

Indirect N_2O emissions resulting from leaching of N are determined on the basis of equation 11.10 of[29] the IPCC 2019 update:

$$N_2O_{(L,PRP)(T)} = F_{PRP(T)} \times Frac_{LEACH(-H)} \times EF_5 \times \frac{44}{28},$$

where

$N_2O_{(L,\ PRP)\ (T)}$ - indirect N_2O emissions from grazing urine and manure N leaching for animal category T, kg N_2O per animal per year;

$F_{PRP\ (T)}$ - for the category of urine and manure N, which remains pasture, kg N per animal per year;

$Frac_{LEAC\ (-\ H)}$ - part of the urine and manure N left in the pasture and pasture;

EF_5 - emission factor for indirect N_2O emissions from N leaching, kg N_2O-N per kg rinsed N;
44/28 - conversion factor to convert N_2O-N emissions to N_2O emissions.

For part N leaching ($Frac_{LEACH}$), the national value 0.23 (NIR (2022)) is used, while the emission factor EF_5 is taken from the IPCC 2019 update of Table 11.3 (updated) – 0.011.
For N_2O emissions expressed in CO_2 equivalent, a factor of 298 is used.

Table 20. Emission factors for the different livestock sectors, kg CO_2 equivalent/animal

Type of animal	GHG per animal, kg per animal, CO_2 eq.	GHG per hectare of pasture, kg per animal, CO_2 eq.
Dairy cows	4 587	58
non-grazing	5 970	0
non-grazing (bioreactor)	4 362	0
grazing	4 073	114
Bio	3 712	106
Suckler cow	2 535	190
Other bovine animals	966	36,9
non-grazing: lazy bovine animals	854	0
non-grazing (bioreactor): ladder bovine animals	726	0
grazing: bovine animals of the bovine species, bovine animals of the bovine species, others	1 037	56

[29] Custom for this calculation

Horses	631	91
Goats	257	9
Sheep	272	30
Pigs	134	0,0
non-grazing	197	0
non-grazing, bioreactor	67	0
Poultry	2,7	0,07
non-grazing	3,5	0
non-grazing (bioreactor)	1,3	0
grazing	3,1	1
Deer	506	48

3. Agricultural area

GHG emissions for crop areas are established per ha per year in CO_2 equivalents (Table 21). Where the eligible area includes areas of different crops, the value of the category obtained should be the weighted average per ha, taking into account the proportion of the individual areas. In some cases, the average value of the total area of the sowing fields is used for areas.

2.1. *N_2O emissions from manure incorporation into soil*

In order to determine the N_2O emissions from manure incorporation into soil per ha, the total quantity of livestock manure N available for incorporation and the emissions resulting therefrom, which are further attributed to the total area (consisting of the total area of the sowing fields and permanent plantations), are calculated at the beginning.

Direct N_2O emissions:

N_2O direct emissions from manure incorporation into soil are calculated on the basis of equations 11.1 and 11.4 of[30] the IPCC 2019 specification:

$$N_2O_{D(AM)} = F_{AM} \times EF_1 \times \frac{44}{28},$$
$$F_{AM} = N_{MMS\ Avb}$$

where

$N_2O_{D(s)}$ - direct N_2O emissions from manure N in soil, kg N_2O per year;
F_{AM} - total amount of livestock manure N incorporated into soil, kg N per year;

EF_1 - emission factor for direct N_2O emissions from soil n, kg per year;

N_{MMSAvb} - total quantity of N managed, available for incorporation in soil, kg N per year;

44/28 - conversion factor to convert N_2O-N emissions to N_2O emissions.

The emission factor (EF_1) is taken from the IPCC 2019 update of Table 11.1 (updated), organic N in wet climate – 0.006.
For N_2O emissions expressed in CO_2 equivalent, a factor of 298 is used.

Indirect N_2O emissions from evaporation:

Indirect N_2O emissions resulting from N evaporative NH_3 and from x forms, which in turn come from atmospheric soil and water, resulting in N_2O emissions are determined on the basis **of equation 10.9**

[30] Adapted for this calculation

of[31] the IPCC 2019 update:

$$N_2O_{(ATD,AM)} = F_{AM} \times Frac_{GASM} \times EF_4 \times \frac{44}{28},$$

where

N_2O (ATD, AM) - indirect N_2O emissions from evaporation of manure N in soil, kg N_2O per year;

F_{AM} - total amount of livestock manure N incorporated into soil, kg N per year;

$Frac_{GASM}$ - part of the incorporated organic N and the dried urine and manure N evaporated as NH_3-N and from x - N;

EF_4 - emission factor for indirect N_2O emissions from atmospheric N to soil and water surfaces, kg N_2O-N per kg evaporated NH_3-N and from x - N;
44/28 - conversion factor to convert N_2O-N emissions to N_2O emissions.

Part N, which evaporates (*$Frac_{GASM}$*) as well as emission factor *EF_4*, is taken from the IPCC 2019 update of Table 11.3 (updated), wet climate – according to 0.21 and 0.014.
For N_2O emissions expressed in CO_2 equivalent, a factor of 298 is used.

Indirect N_2O emissions from leaching:

Indirect N_2O emissions resulting from leaching of N are determined on the basis of equation 11.10 of[32] the IPCC 2019 update:

$$N_2O_{(L,AM)} = F_{AM} \times Frac_{LEACH(-H)} \times EF_5 \times \frac{44}{28},$$

where

N_2O (L, AM) - indirect N_2O emissions from manure N leaching, kg N_2O per year;

F_{AM} - total amount of livestock manure N incorporated into soil, kg N per year;

$Frac_{LEAC\,(-H)}$ - part of the urine and manure N left in the pasture and pasture;

EF_5 - emission factor for indirect N_2O emissions from N leaching, kg N_2O-N per kg rinsed N;
44/28 - conversion factor to convert N_2O-N emissions to N_2O emissions.

For part N leaching (*$Frac_{LEACH}$*), the national value 0.23 (NIR (2022)) is used, while the emission factor *EF_5* is taken from the IPCC 2019 update of Table 11.3 (updated) – 0.011.
For N_2O emissions expressed in CO_2 equivalent, a factor of 298 is used.

2.2. *N_2O emissions from mineral fertilizers in soil*

N_2O emissions from mineral fertilizer N in soil per ha per crop are determined by the amount of synthetic N applied to the total crop type and the emissions resulting there from, as well as the area of the corresponding crops without organic farming area.

Direct N_2O emissions:

N_2O direct emissions from mineral fertilizer N in soil are calculated on the basis of equation 11.1 of[33] the IPCC 2019 update:

$$N_2O_{D(SN)} = F_{SN} \times EF_1 \times \frac{44}{28},$$

where

N_2O D (SD) - direct N_2O emissions from mineral fertilizer N in soil, kg N_2O per year;
F_{SN} - total amount of mineral fertilizer N incorporated into soil, kg N per year;

EF_1 - emission factor for direct N_2O emissions from soil n, kg per year;

44/28 - conversion factor to convert N_2O-N emissions to N_2O emissions.

[31] Custom for this calculation
[32] Custom for this calculation
[33] Custom for this calculation

The data source for the amount of mineral fertilizer N per main crop is the Central Statistical Bureau. The emission factor (*EF_1*) is taken from the IPCC 2019 update of Table 11.1 (updated), the synthetic N imposed in wet climate – 0.016.
For N_2O emissions expressed in CO_2 equivalent, a factor of 298 is used.

Indirect N_2O emissions from evaporation:

Indirect N_2O emissions resulting from N evaporative NH $_3$ and from $_x$ forms, which in turn come from atmospheric soil and water, resulting in N_2O emissions are determined on the basis of equation 10.9 of[34] the IPCC 2019 update:

$$N_2O_{(ATD,SN)} = F_{SN} \times Frac_{GASM} \times EF_4 \times \frac{44}{28},$$

where

$N_2O_{(ATD,\,SN)}$ - indirect N_2O emissions from the evaporation of mineral fertilizer N in soil, kg N_2O per year;

F_{SN} - total amount of mineral fertilizer N incorporated into soil, kg N per year;

$Frac_{GASM}$ - part of the mineral fertilizer N which evaporates as NH_3-N and from x - N;

EF_4 - emission factor for indirect N_2O emissions from atmospheric N to soil and water surfaces, kg N_2O-N per kg evaporated NH_3-N and NO_x-N;
44/28 - conversion factor to convert N_2O-N emissions to N_2O emissions.

Part N, which evaporates (*$Frac_{GASM}$*) as well as emission factor *EF_4*, is taken from the IPCC 2019 update of Table 11.3 (updated), wet climate – according to 0.11 and 0.014.
For N_2O emissions expressed in CO_2 equivalent, a factor of 298 is used.

Indirect N_2O emissions from leaching:

Indirect N_2O emissions resulting from leaching of N are determined on the basis of equation 11.10 of[35] the IPCC 2019 update:

$$N_2O_{(L,SN)} = F_{SN} \times Frac_{LEACH(-H)} \times EF_5 \times \frac{44}{28},$$

where

$N_2O_{(L,\,SN)}$ - indirect N_2O emissions from soil fertilizer N leaching, kg N_2O per year;

F_{SN} - total amount of mineral fertilizer N incorporated into soil, kg N per year;

$Frac_{LEAC\,(-H)}$ - part of the urine and manure N left in the pasture and pasture;

EF_5 - emission factor for indirect N_2O emissions from N leaching, kg N_2O-N per kg rinsed N;
44/28 - conversion factor to convert N_2O-N emissions to N_2O emissions.

For part N leaching (*$Frac_{LEACH}$*), the national value 0.23 (NIR (2022)) is used, while the emission factor *EF_5* is taken from the IPCC 2019 update of Table 11.3 (updated) – 0.011.
For N_2O emissions expressed in CO_2 equivalent, a factor of 298 is used.

2.3. N_2O emissions from crop residues

Direct N_2O emissions:

N_2O direct emissions from crop residues are calculated on the basis of equations 11.1 and 11.6 of[36] the IPCC 2019 specification:

[34] Custom for this calculation
[35] Custom for this calculation
[36] Adapted for this calculation

$$N_2O_{D(CR)(T)} = F_{CR(T)} \times EF_1 \times \frac{44}{28},$$
$$F_{CR(T)} = \left[AGR_T \times N_{AG(T)} \times \left(1 - Frac_{Remove(T)}\right)\right] + \left[BGR_T \times N_{BG(T)}\right]$$
$$BRG_T = \left(Crop_T + AG_{DM(T)}\right) \times RS_T \times Frac_{Renew(T)}$$
$$AG_{DM(T)} = Crop_{(T)} \times R_{AG(T)}$$
$$AGR_T = Crop_{(T)} \times R_{AG(T)} \times Frac_{Renew(T)}$$

where

$N_2O_{D\ (CR)\ (T)}$ - direct N_2O emissions from crop residues N crop category *T*, kg N_2O per ha per year;
$F_{CR\ (T)}$ - total quantity of crop residues N for crop category *T*, kg N per ha per year;
EF_1 - emission factor for direct N_2O emissions from soil n, kg per year;
$AGR_{(T)}$ - amount of aboveground residue for crop category *T*, kg dry matter per ha per year;
$N_{AG(T)}$ - N quantity in aboveground residues for crop category *T*, kg N per kg dry matter;
$Frac_{Remove\ (T)}$ - the part of the aboveground residue for the crop category that is harvested from the field;
$BGR_{(T)}$ - quantity of belowground residues for crop category *T*, kg dry matter per ha per year;
$N_{BG\ (T)}$ - N quantity of subsoil residues for crop category *T*, kg N per kg dry matter;
$Crop_{(T)}$ - harvested crop categories *in* dry matter, kg per ha;
$R_{AG(T)}$ - part of aboveground residue against the dry crop category of harvested harvest *T*;
$RS_{(T)}$ - part of belowground residues against surface biomass for crop category *T*;
$Frac_{Renew(T)}$ - part describing the renovation *of* crop category T (for annual crops it is 1, grassland and grazing is adopted every fourth year (i.e. 1/4));
44/28 – conversion factor to convert N_2O-N emissions to N_2O emissions.

For crop yield per ha, CSP data are used, Table 5.32 from NIR (2022) and LLKC "Aggregation of fodder analysis" are used for the determination of the dry matter quantity of crops, while the part of the surface residue against the yield (R_{AG}), the subsoil part of the aboveground biomass (*RS*), the N content in aboveground and belowground residues comes from the IPCC 2019 update 11.1.A. tables (new). For wheat R_{AG}, N_{AG} and N_{BG}, national values are used from NIR (2022).
Emission factor (EF_1) taken from IPCC 2019 update 11.1 (updated), organic N in wet climate – 0.006.
For N_2O emissions expressed in CO_2 equivalent, a factor of 298 is used.

Indirect N_2O emissions from leaching:

Indirect N_2O emissions resulting from leaching of N are determined on the basis of equation 11.10 of[37] the IPCC 2019 update:

$$N_2O_{(L,CR)(T)} = F_{CR(T)} \times Frac_{LEACH(-H)} \times EF_5 \times \frac{44}{28}$$

where

$N_2O_{(L,\ CR)\ (T)}$ - indirect N_2O emissions from crop category *T* residue N leaching, kg N_2O per ha per year;
$F_{CR\ (T)}$ - total quantity of crop residues N for crop category *T*, kg N per ha per year;
$Frac_{LEAC\ (-H)}$ - part of the urine and manure N left in the pasture and pasture;
EF_5 - emission factor for indirect N_2O emissions from N leaching, kg N_2O-N per kg rinsed N;
44/28 - conversion factor to convert N_2O-N emissions to N_2O emissions.

For part N leaching ($Frac_{LEACH}$), the national value 0.23 (NIR (2022)) is used, while the emission factor EF_5 is taken from the IPCC 2019 update of Table 11.3 **(**updated) – 0.011.
For N_2O emissions expressed in CO_2 equivalent, a factor of 298 is used.

2.5. N_2O emissions from organic soils

[37] Custom for this calculation

For the determination of N_2O emissions from organic soils, national emission factors (EF) from NIR (2022) are used: 7.1 kg N_2O-N per ha per year for arable land, 0.3 kg N_2O-N per ha per year for meadows and pastures. N_2O-N is expressed in N_2O form using factor 44/28, while emissions in CO_2 equivalents are obtained by multiplying by 298.

2.6. CO_2 emissions from the incorporation of carbamide into soil

In order to determine the CO_2 emissions from the incorporation of carbamide into the soil, equation 11.13 of the IPCC 2006 Guidelines is used[38]:

$$CO_{2\ Emission} = M \times EF \times \frac{44}{12},$$

where

$CO_{2Emission}$ - CO_2 emissions from the incorporation of carbamide into soil, kg C per year;

M - the quantity of carbamide incorporated, kg of carbamide per year;

EF - emission factor, kg C per kg carbamide;

44/12 - conversion factor to convert C emissions to CO_2 emissions.

The total amount of carbamide used in agriculture is shown in Table 5.39. According to IPCC guidelines, the emission factor (*EF*) for carbamide is 0.20 kg C per kg carbamide. The total emissions from the use of carbamide are attributed to the total area of the volumes (without organic farming area) ha.

2.7. CO_2 emissions from soil liming

In order to determine CO_2 emissions from soil liming, equation 11.12 of the IPCC 2006 Guidelines is used:

$$CO_{2\ Emission} = (M_{Limestone} \times EF_{Limestone}) + (M_{Dolomite} \times EF_{Dolomite}) \times \frac{44}{12},$$

where

$CO_{2Emission}$ - CO_2 emissions from liming in soil, kg C per year;

M - the amount of limestone and dolomite incorporated, kg per year;

EF - emission factor, kg C per kg limestone or dolomite;

44/12 - conversion factor to convert C emissions to CO_2 emissions.

The total amount of limestone and dolomite used in agriculture comes from the Central Statistical Bureau. According to IPCC guidelines, the emission factor (*EF*) for limestone is 0.12 kg C per kg limestone, dolomite – 0.13 kg C per kg dolomite. The total emissions from the use of liming material are attributed to the total area of the total area and permanent plantations, ha.

Table 21. Emission factors for the different crop sectors, kg CO_2 equivalent/ha

Type of land use	Emission factor	
	Conventional farms	Organic farms
GOP (grains, oilseeds, pulses)	1 115	249
Potatoes	626	336
Vegetables, strawberries, flowers	588	222
Permanent crops	143	125
Other crops	823	381
Fallow	0	0

[38] 2006 IPCC Guidelines for National Greenhouse Gas Inventories

Grassland in arable land	305	177
Grassland and pasture	0	0
Organic soils in arable land	3 325	3325
Organic soils in grassland and meadows	140	140

Table 22. Emission factors for organic soils

Country	Soil	Land use	Emission factor in agriculture, kg/ha CO_2 equivalent
LV	Organic soil	Arable	2115.8
		Grassland	89.4
LT		Arable	2384
		Grassland	2384
EE		Arable	2384
		Grassland	2384

2.2.2. Forest land

Calculations have been performed according to the methodology used in the national GHG inventory. Forest state register data from 2.8 million forest plots are used for calculations.

The input data is the type of forest, the dominant species, the area of the plot, the number of trees, the age of the stand, the average tree diameter, the height of the average tree, the cross area and the stock. The average wood stocking characterization in non-living wood and timber products uses national 2021 GHG inventory data.

The calculation includes information on changes in carbon stock in living biomass, non-living wood, subsoil, soil and wood products and GHG emissions from soil. GHG emissions from forest fires are not included in the calculation because the forest state register does not contain information regarding sanitary felling as a result of forest fires.

Calculation input data

1. Type of forest;
2. The dominant species;
3. The area of the plot, ha;
4. Number of trees, pcs. ha^{-1};
5. Age of the stand, years;
6. Average tree diameter, cm;
7. Average tree height, m;
8. Cross area of the compartment, m^2 ha^{-1};
9. Plot stock, m^3 ha^{-1}.

In order to calculate the current average growth of the current average periodic accumulation, the previous LVMI Silava-developed stock growth factors are used, which are shown in Table 23 and depend on the species ruling.[39] The rest of the species shall be used for the other species. Calculation performed using equation 1:

[39] Donis, J., Sņepst, G., Zdor, L., & Shenhoff, R. (2013). Determination of the growth and growth of forest stands using the surveyed forest statistical inventory data (5.5.-5.1/000t/101/11/13; p. 73). LVMI Silava.

$$Z_M = a_1 * A * a_1^B * G^a \quad (1)$$

where

Z_M - the actual current average periodic stock increase of the stand, m^3 ha^{-1} per year;
A - age of the dominant tree species of the first floor of the stand, years;
B – site index;
G - stand basal area, m^2 ha^{-1}.

Table 23. Coefficients for calculation of current average current average periodic accumulation

Species	a 1	a 2	a 3	a 4
Pine	3.9049	-0.4473	0.8518	0.8571
Spruce	8.7959	-0.5371	1.0000	0.6810
Birch	9.6997	-0.4776	0.8772	0.6097
Black alder	10.7240	-0.5133	0.8822	0.6234
Aspen	12.4910	-0.3753	1.0000	0.4480
White alder	11.5837	-0.4727	1.0000	0.4737
Other species	12.4910	-0.3753	1.0000	0.4480

For the calculation of the annual dead wood, the species-specific coefficients shown in Table 24 are used. The equations of aspen are used for other species. Calculation performed using equation 2:

$$Z_M(-) = \frac{A*G}{a+b*A+c*G} \quad (2)$$

where

Z_M (-) - the actual current average periodic dead wood of the stand, m^3 ha^{-1} per year;
A - age of the dominant tree species of the first floor of the stand, years;
G - stand basal area, m^2 ha^{-1};
a,b,c – coefficients.

Table 24. Coefficients for the calculation of natural mortality

Species	a	b	c
Pine	300.9422	24.7226	-26.7706
Spruce	196.7658	5.9993	-2.7184
Birch	173.0441	7.7145	-4.2013
Black alder	293.6707	4.7260	-0.6546
Aspen	-29.1374	10.3157	0.2453
White alder	32.2068	2.5164	0.9835
Other species	-29.1374	10.3157	0.2453

Biomass for growing trees is calculated for both aboveground and belowground. For all species and biomass other than birch belowground biomass is calculated using equation 3 but for birch belowground biomass equation 4 is used. The equation coefficients are given in Table 25.

$$B = \left(k * \exp\left(a + \frac{b*D}{D+m} + c*H + d*\ln(H)\right)\right) * \frac{N}{1000} \quad (3)$$

Where
B – biomass (AGB, SB, BB, BGB, SRB), tonnes ha^{-1};
D - diameter of the average tree of the stand, cm;
H - the average tree height of the stand, m;
N - the number of trees in stand, pcs ha^{-1};
a,b,c,d,m,k – coefficients.

$$B = (k * \exp(a + \ln(D) * b)) * \frac{N}{1000} \quad (4)$$

Where
B – belowground biomass of birch (BGB), tonnes ha^{-1};

D - diameter of the average tree of the stand, cm;
N - the number of trees in stand, pcs ha^{-1};
a,b,k – coefficients.

Table 25. Coefficients for biomass calculation equations

Species	Biomass	a	b	c	d	m	k
Spruce	AGB	-0.5244	8.8563	0.0000	0.3879	19.0000	1.0127
Spruce	SB	-2.5842	7.0769	0.0232	0.9631	15.0000	1.0022
Spruce	BB	0.3300	12.0986	0.0000	-1.0682	16.0000	1.0121
Spruce	BGB	-2.4967	10.8184	0.0000	0.0000	14.0000	1.0388
Spruce	SRB	-3.3454	7.5401	0.0000	0.0000	9.0000	1.0680
Pine	AGB	-1.4480	8.7399	0.0000	0.5624	16.0000	1.0086
Pine	SB	-2.8125	7.1368	0.0118	1.1270	15.0000	1.0053
Pine	BB	-1.6032	14.7696	0.0000	-1.5888	11.0000	1.0415
Pine	BGB	-3.2937	9.0334	0.0000	0.5353	14.0000	1.0350
Pine	SRB	-4.1683	1.4686	0.4263	0.0000	0.0000	1.0613
Birch	AGB	-2.1284	9.3375	0.0221	0.2838	11.0000	1.0041
Birch	SB	-2.9281	8.2943	0.0184	0.7374	11.0000	1.0020
Birch	BB	-1.0091	16.9249	0.0000	-2.0462	12.0000	1.0745
Birch	BGB	-3.6432	2.5127	0.0000	0.0000	0.0000	1.0060
Birch	SRB	-4.1485	8.6630	0.0000	0.0000	7.0000	1.0090
Aspen	AGB	-1.9434	9.7506	0.0337	0.0000	11.0000	0.9900
Aspen	SB	-2.8955	8.3896	0.0226	0.6148	11.0000	1.0058
Aspen	BB	-2.3703	14.3352	0.0000	-1.0849	12.0000	1.0040
Aspen	BGB	-2.3114	10.3644	0.0000	0.0000	15.0000	0.9917
Aspen	SRB	-2.2732	14.1612	0.0000	-1.7449	10.0000	0.9945
Black alder	AGB	-2.1284	9.3375	0.0221	0.2838	11.0000	1.0041
Black alder	SB	-2.9281	8.2943	0.0184	0.7374	11.0000	1.0020
Black alder	BB	-1.0091	16.9249	0.0000	-2.0462	12.0000	1.0745
Black alder	BGB	-3.6432	2.5127	0.0000	0.0000	0.0000	1.0060
Black alder	SRB	-4.1485	8.6630	0.0000	0.0000	7.0000	1.0090
White alder	AGB	-2.1284	9.3375	0.0221	0.2838	11.0000	1.0041
White alder	SB	-2.9281	8.2943	0.0184	0.7374	11.0000	1.0020
White alder	BB	-1.0091	16.9249	0.0000	-2.0462	12.0000	1.0745
White alder	BGB	-3.6432	2.5127	0.0000	0.0000	0.0000	1.0060
White alder	SRB	-4.1485	8.6630	0.0000	0.0000	7.0000	1.0090
Other species	AGB	-1.9434	9.7506	0.0337	0.0000	11.0000	0.9900
Other species	SB	-2.8955	8.3896	0.0226	0.6148	11.0000	1.0058
Other species	BB	-2.3703	14.3352	0.0000	-1.0849	12.0000	1.0040
Other species	BGB	-2.3114	10.3644	0.0000	0.0000	15.0000	0.9917
Other species	SRB	-2.2732	14.1612	0.0000	-1.7449	10.0000	0.9945

The conversion of the biomass of growing trees to the amount of carbon is carried out using equation 5:

$$C = B * 50\% \tag{5}$$

where
C – carbon stock in biomass (AGB, SB, BB, BGB, SRB), tonnes ha^{-1};
B – biomass (AGB, SB, BB, BGB, SRB), tonnes ha^{-1}.

Calculation of aboveground biomass growth (equation 6) and belowground biomass (equation 7) are carried out using the forest field stock, the pre-estimated accumulation increase and biomass.

$$B_A(AGB) = \frac{B_{ABi}}{M} * M_A \tag{6}$$

where
B_A(AGB)- aboveground biomass on the rise, tonnes ha^{-1};
B_{ABi} - aboveground biomass of growing trees, tonnes ha^{-1};
M - stock of growing trees, m^3 ha^{-1};
M_A - stock increase m^3 ha^{-1}.

$$B_B(BGB) = \frac{B_{BBi}}{M} * M_B \tag{7}$$

where
B_B(AGB)- belowground biomass on the rise, tonnes ha^{-1};
B_{BBi} - belowground biomass of growing trees, tonnes ha^{-1};
M - stock of growing trees, m^3 ha^{-1};
M_B - stock increase, m^3 ha^{-1}.

The increase in the biomass of natural mortality (equation 8) and belowground (equation 9) is calculated by using the aboveground and belowground biomass of growing trees, the stock of growing trees and natural mortality.

$$B_D(BGB) = \frac{B_{DBi}}{M} * M_D \tag{8}$$

where
B_D(AGB)- dead wood aboveground biomass, tonnes ha^{-1};
B_{DBi} - aboveground biomass of growing trees, tonnes ha^{-1};
M - stock of growing trees, m^3 ha^{-1};
M_D – dead wood, m^3 ha^{-1}.

$$B_{DB}(BGB) = \frac{B_{DBBi}}{M} * M_{DB} \tag{9}$$

where
B_{DB}(AGB)- dead wood belowground biomass, tonnes ha^{-1};
B_{DBBi} - belowground biomass of growing trees, tonnes ha^{-1};
M - stock of growing trees, m^3 ha^{-1};
M_{DB} – dead wood, m^3 ha^{-1}.

Also the calculation of carbon content in the natural mortality in aboveground and belowground biomass is done using equation 5, as the carbon concentration in these biomass units is 50%. However, the change in carbon stock is calculated by deducting mortality from the increase.

The calculation of GHG emissions from organic soils includes an organic soil (the approach adopted in the national inventory). So far, organic soils and mineral deposits are assumed to be in balance. In order to obtain soil emissions, first calculate CO_2, CH_4 from ditches, soil CH_4, N_2O and DOC emissions. Total GHG emissions from soil are the sum of these emissions. The emission factors for organic soil are shown in Table 26, while calculations are performed using equations 10-15.

$$CO_2 = EF_x * \frac{44}{12} \tag{10}$$

where
CO_2 - CO_2 emissions from soil, tonnes CO_2 ha^{-1};
$EF_{(x)}$ – emission factor, tonnes CO_2-C ha^{-1}.

$$CH_4(ditches) = EF_{CH_4dithes} * \frac{25}{1000} * area\ of\ ditches \tag{11}$$

where
CO_4 (ditches) – CH_4 emissions from ditches, tonnes CO_2 eq. ha^{-1};
$EF_{(CH4)}$ (ditches) – emission factor, kg CH_4 ha^{-1};
Area of ditches – proportion of ditch area, %;
25 – CO_2 emission eq.

$$CH_4 = (EF_{CH_4} * \frac{25}{1000}) * (100\% - area\ of\ ditches) \quad (12)$$

where
CH_4 – CH_4 emissions from soil, tonnes CO_2 eq. ha^{-1};
$EF_{(CH4)}$ (ditches) – emission factor, kg CH_4 ha^{-1};
Area of ditches – proportion of ditch area, %;
25 – CO_2 emission eq.

$$N_2O = EF_{N_2O} * \frac{298}{1000} \quad (13)$$

where
N_2O - N_2O emissions from soil, tonnes CO_2 eq. ha^{-1};
$EF_{(N2O)}$ – emission factor, kg N_2O ha^{-1};
298 – CO_2 emission eq.

$$DOC = EF_{XX} * \frac{44}{12} \quad (14)$$

where
DOC - DOC emissions from soil, tonnes CO_2 ha^{-1};
$EF_{(XX)}$ – emission factor for ditches, kg C ha^{-1}.

$$GHG_{total} = CO_2 + CH_4(ditches) + CH_4 + N_2O + DOC \quad (15)$$

where
GHG – total GHG emissions from soil, tonnes $CO_{2\ eq.}$ ha^{-1}.

Table 26. Emission factors for organic soils

Dominant species	Forest types	CH_4 emissions from ditches, kg CH_4 ha $^{-1}$ per $^{-1}$	Proportion of the ditch area	CH_4 emissions, kg CH_4 ha $^{-1}$ per year $^{-1}$	N = emissions, kg N per ha $^{-1}$ per $^{-1}$	CO-emission (respiratory), tonnes CO_2 $^{-}$ per year $^{-1}$	DOC emissions, tonnes CO_2 $^{-}$ in $^{-1}$
Spruce	Cp, Cs	217	3%	-6.2857	1.5714	12.3200	1.1
	Km, kV	217	3%	25.5898	-0.0751	4.2120	1.1
	Lk, dB			-2.7429	0.9429	10.6700	0.9
	Nd, Pv			32.4505	0.0680	6.7820	0.9
Pine	Cp, Cs	217	3%	-1.5887	0.9764	9.5333	1.1
	Km, kV	217	3%	25.5898	-0.0751	4.2120	1.1
	Lk, dB			-2.7429	0.9429	10.6700	0.9
	Nd, Pv			32.4505	0.0680	6.7820	0.9
Birch	Cp, Cs	217	3%	-1.9429	1.4143	15.0700	1.1
	Km, kV	217	3%	25.5898	-0.0751	4.2120	1.1
	Lk, dB			-4.2286	4.2429	11.4620	0.9
	Nd, Pv			32.4505	0.0680	6.7820	0.9
Aspen	Cp, Cs	217	3%	-1.9429	1.4143	15.0700	1.1
	Km, kV	217	3%	25.5898	-0.0751	4.2120	1.1
	Lk, dB			228.3429	3.9286	13.4200	0.9
	Nd, Pv			32.4505	0.0680	6.7820	0.9
Alder	Cp, Cs	217	3%	7.7714	0.9429	10.1017	1.1
	Km, kV	217	3%	25.5898	-0.0751	4.2120	1.1
	Lk, dB			228.3429	3.9286	13.4200	0.9
	Nd, Pv			32.4505	0.0680	6.7820	0.9

The initial carbon stock in non-living wood and wood products is calculated using the average coefficients of the area unit according to tree species and growing conditions. The rest of the species should be used for the other species. The average figures are given in Table 27.

Table 27. Average carbon stocks for non-living wood and wood products

Dominant species	Growth conditions	Initial carbon stock in non-living wood, tonnes C ha^{-1}	Carbon stock in coniferous sawn materials, tonnes C ha^{-1}	Carbon stock in wood sawn materials, tonnes C ha^{-1}	Carbon stock in wood pulp, tonnes C ha^{-1}
Spruce	On drained organic soils, drained mineral soils, dry mineral soils	60.2	33.9	0.0	2.6
	On organic soils, wet mineral soils	47.7	21.6	0.0	11.2
Pine	On drained organic soils, drained mineral soils, dry mineral soils	42.5	41.0	0.0	10.0
	On organic soils, wet mineral soils	42.0	22.3	0.0	7.8
Birch	On drained organic soils, drained mineral soils, dry mineral soils	32.8	0.0	17.9	34.7
	On organic soils, wet mineral soils	24.6	0.0	9.0	29.3
Aspen	On drained organic soils, drained mineral soils, dry mineral soils	37.5	0.0	22.1	0.0
	On organic soils, wet mineral soils	25.6	0.0	14.5	0.0
Alder	On drained organic soils, drained mineral soils, dry mineral soils	37.5	0.0	22.1	0.0
	On organic soils, wet mineral soils	25.6	0.0	14.5	0.0

Carbon stock in vegetation and carbon inputs with plant residues are calculated for organic soils, assuming that the carbon stock is at steady state in mineral deposits. The calculation is based on input data from various sources[40,41 and 42,43,4445,46,47] and calculation equations (Table 28, Table 29, Table 30) are different for pine, spruce and deciduous trees.

Table 28. Carbon stock in ground cover plants and input in soil with plant residues in pine stands

Abr.	Indicator	Calculation	Data source
a.	Age of stand, years	-	Input data
b.	G, m^2 ha^{-1}	-	Input data
c.	Stem biomass, tons ha^{-1}	-	Input data
d.	Litter biomass, t ha^{-1} per $year^{-1}$	$d=0{,}597*b^{0{,}489}$	Unpublished REstore study data
e.	C input with tree litter, t C ha^{-1} per $year^{-1}$	$e=0{,}323*b^{0{,}489}$	Unpublished REstore study data
f.	Smallest root biomass, t ha^{-1}	$f=0{,}02*c$	Neumann et Al., 2019
g.	Mortality of smallest root biomass, t ha^{-1} per $year^{-1}$	$g=f*0{,}61$	Neumann et Al., 2019; Yuan, Chen, 2012
h.	Carbon content in smallest roots, t t^{-1}	0,5	Lamlom, Savidge, 2003; IPCC, 2006
i.	Carbon input with smallest root, t C ha^{-1} per $year^{-1}$	$i=g*h$	Neumann et Al., 2019; Yuan, Chen, 2012; Lamlom, Savidge, 2003; IPCC, 2006
j.	Small bush aboveground biomass, kg ha^{-1}	$j=(16{,}68+0{,}219*2+0{,}0004*a^2)^2-0{,}5$	Muukkonen, Mäkipää, 2006
k.	Grassland biomass, kg ha^{-1}	$k=(11{,}725-0{,}098*a^2)^2-0{,}5$	Muukkonen, Mäkipää, 2006
l.	Moss biomass, kg ha^{-1}	$l=(27{,}329+0{,}138*a-0{,}0005*a^2)^2-0{,}5$	Muukkonen, Mäkipää, 2006
m.	Lichens biomass, kg ha^{-1}	$m=(7{,}975-0{,}0002*a^2)^2-0{,}5$	Muukkonen, Mäkipää, 2006
n.	Biomass of small shrubs litter, kg ha^{-1}	$n=j*0{,}25$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006

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Abr.	Indicator	Calculation	Data source
	per $^{-1}$		
o.	Aboveground litter of grassland, kg ha $^{-1}$ per $^{-1}$	$o = k * 1$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
p.	Mortality of moss surface biomass, kg ha $^{-1}$ per year $^{-1}$	$p = 1 * 0{,}33$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
q.	Mortality of lichen surface biomass, kg ha $^{-1}$ per year $^{-1}$	$q = m * 0{,}1$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
r.	Total biomass input of ground cover plants, kg ha $^{-1}$ per year $^{-1}$	$r = n + o + p + q$	-
s.	Biomass input of ground cover plants, kg ha $^{-1}$ per year $^{-1}$	$s = \frac{r * 100}{30} * 0{,}7$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; Mälkönen, 1974; Havas, Kubin, 1983; Palviainen et Al., 2005
t.	Carbon input with aboveground residues of plants, kg C ha $^{-1}$ per $^{-1}$	$t = r * 0{,}475$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; FAO, 2005
u.	Carbon input with belowground residues of plants, kg C ha $^{-1}$ per $^{-1}$	$t = s * 0{,}475$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; Mälkönen, 1974; Havas, Kubin, 1983; Palviainen et Al., 2005
v.	Total carbon input with ground cover plant residues, t C ha $^{-1}$ per $^{-1}$	$v = \frac{t + u}{1000}$	-
w.	Total carbon input with litter, t C ha $^{-1}$ per $^{-1}$	$w = v + i + e$	-
x.	Total carbon stock in biomass of ground cover plants, t C ha $^{-1}$ per year $^{-1}$	$x = (j + k + 1 + m) * 0{,}7 * 0{,}475$	-

Table 29. Carbon stock in ground cover plants and input in soil with plant residues in spruce stands

Abr.	Indicator	Calculation	Data source
a.	Age of stand, years	-	Input data
b.	G, m ^{2} ha $^{-1}$	-	Input data
c.	Stem biomass, tons ha $^{-1}$	-	Input data
d.	Litter biomass, t ha $^{-1}$ per year $^{-1}$	$d = 0{,}404 * b^{0{,}726}$	Unpublished REstore study data
e.	C input with tree litter, t C ha $^{-1}$ per $^{-1}$	$e = 0{,}211 * b^{0{,}726}$	Unpublished REstore study data
f.	Smallest root biomass, t ha $^{-1}$	$f = 0{,}02 * c$	Neumann et Al., 2019
g.	Mortality of smallest root biomass, t ha $^{-1}$ per year $^{-1}$	$g = f * 0{,}84$	Neumann et Al., 2019; Yuan, Chen, 2012
h.	Carbon content in	0,5	Lamlom, Savidge,

Abr.	Indicator	Calculation	Data source
	smallest roots, t t $^{-1}$		2003; IPCC, 2006
i.	Carbon input with smallest root, t C ha $^{-1}$ per year $^{-1}$	$i = g * h$	Neumann et Al., 2019; Yuan, Chen, 2012; Lamlom, Savidge, 2003; IPCC, 2006
j.	Small bush aboveground biomass, kg ha $^{-1}$	$j = (10{,}375 - 0{,}033 * a + 0{,}001 * a^2 - 0{,}000004 * a^3)^2 - 0{,}5$	Muukconen, Mäkipää, 2006
k.	Grassland aboveground biomass, kg ha $^{-1}$	$k = (15{,}058 - 0{,}113 * a + 0{,}0003 * a^2)^2 - 0{,}5$	Muukkonen, Mäkipää, 2006
l.	Moss aboveground biomass, kg ha $^{-1}$	$l = (19{,}282 + 0{,}164 * a - 0{,}000001 * a^3)^2 - 0{,}5$	Muukkonen, Mäkipää, 2006
m.	Lichens biomass, kg ha $^{-1}$	0	Muukkonen, Mäkipää, 2006
n.	Biomass of small shrubs litter, kg ha $^{-1}$ per $^{-1}$	$n = j * 0{,}25$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
o.	Aboveground litter of grassland, kg ha $^{-1}$ per $^{-1}$	$o = k * 1$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
p.	Mortality of moss surface biomass, kg ha $^{-1}$ per year $^{-1}$	$p = l * 0{,}33$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
q.	Mortality of lichen surface biomass, kg ha $^{-1}$ per year $^{-1}$	$q = m * 0{,}1$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
r.	Total biomass input of ground cover plants, kg ha $^{-1}$ per year $^{-1}$	$r = n + o + p + q$	-
s.	Biomass input of ground cover plants, kg ha $^{-1}$ per year $^{-1}$	$s = \frac{r * 100}{30} * 0{,}7$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; Mälkönen, 1974; Havas, Kubin, 1983; Palviainen et Al., 2005
t.	Carbon input with aboveground residues of plants, kg C ha $^{-1}$ per $^{-1}$	$t = r * 0{,}475$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; FAO, 2005
u.	Carbon input with belowground residues of plants, kg C ha $^{-1}$ per $^{-1}$	$t = s * 0{,}475$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; Mälkönen, 1974; Havas, Kubin, 1983; Palviainen et Al., 2005
v.	Total carbon input with ground cover plant residues, t C ha $^{-1}$ per $^{-1}$	$v = \frac{t + u}{1000}$	-
w.	Total carbon input	$w = v + i + e$	-

Abr.	Indicator	Calculation	Data source
	with litter, t C ha $^{-1}$ per $^{-1}$		
x.	Total carbon stock in biomass of ground cover plants, t C ha $^{-1}$ per year $^{-1}$	$x=(j+k+l+m)*0,7*0,475$	-

Table 30. Carbon stock in ground cover plants and input in soil with plant residues in leaf tree stands

Abr.	Indicator	Calculation	Data source
a.	Age of stand, years	-	Input data
b.	G, m ^{2} ha $^{-1}$	-	Input data
c.	Stem biomass, tons ha $^{-1}$	-	Input data
d.	Litter biomass, t ha $^{-1}$ per year $^{-1}$	$if b \leq 10 ; d=0,013*b$ $if b>34 ; d=-0,00639*34^2+0,433*34-2,391$ $if 10>b \leq 34 ; d=-0,00639*b^2+0,433*b-2,391$	Unpublished REstore study data
e.	C input with tree litter, t C ha $^{-1}$ per $^{-1}$	$if b \leq 10 ; d=0,007*b$ $if b>34 ; d=-0,00344*34^2+0,233*34-1,286$ $if 10>b \leq 34 ; d=-0,00344*b^2+0,233*b-1,286$	Unpublished REstore study data
f.	Smallest root biomass, t ha $^{-1}$	$f=0,02*c$	Neumann et Al., 2019
g.	Mortality of smallest root biomass, t ha $^{-1}$ per year $^{-1}$	$g=f*1,22$	Neumann et Al., 2019; Yuan, Chen, 2012
h.	Carbon content in smallest roots, t t $^{-1}$	0,5	Lamlom, Savidge, 2003; IPCC, 2006
i.	Carbon input with smallest root, t C ha $^{-1}$ per year $^{-1}$	$i=g*h$	Neumann et Al., 2019; Yuan, Chen, 2012; Lamlom, Savidge, 2003; IPCC, 2006
j.	Small bush aboveground biomass, kg ha $^{-1}$	$j=(7,102+0,0004*a^2)^2-0,5$	Muukconen, Mäkipää, 2006
k.	Grassland aboveground biomass, kg ha $^{-1}$	$k=(20,58-0,423*a+0,004*a^2-0,00002*a^3)^2-0,5$	Muukkonen, Mäkipää, 2006
l.	Moss aboveground biomass, kg ha $^{-1}$	$l=(13,555-0,056*a)^2-0,5$	Muukkonen, Mäkipää, 2006
m.	Lichens biomass, kg ha $^{-1}$	0	Muukkonen, Mäkipää, 2006
n.	Biomass of small shrubs litter, kg ha $^{-1}$ per $^{-1}$	$n=j*0,25$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
o.	Aboveground litter of grassland, kg ha $^{-1}$ per $^{-1}$	$o=k*1$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
p.	Mortality of moss surface biomass, kg ha $^{-1}$ per year $^{-1}$	$p=l*0,33$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006

Abr.	Indicator	Calculation	Data source
q.	Mortality of lichen surface biomass, kg ha $^{-1}$ per year $^{-1}$	$q = m * 0{,}1$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006
r.	Total biomass input of ground cover plants, kg ha $^{-1}$ per year $^{-1}$	$r = n + o + p + q$	-
s.	Biomass input of ground cover plants, kg ha $^{-1}$ per year $^{-1}$	$s = \frac{r * 100}{30} * 0{,}7$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; Mälkönen, 1974; Havas, Kubin, 1983; Palviainen et Al., 2005
t.	Carbon input with aboveground residues of plants, kg C ha $^{-1}$ per $^{-1}$	$t = r * 0{,}475$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; FAO, 2005
u.	Carbon input with belowground residues of plants, kg C ha $^{-1}$ per $^{-1}$	$t = s * 0{,}475$	Muukkonen, Mäkipää, 2006; Muukkonen, 2006; Mälkönen, 1974; Havas, Kubin, 1983; Palviainen et Al., 2005
v.	Total carbon input with ground cover plant residues, t C ha $^{-1}$ per $^{-1}$	$v = \frac{t + u}{1000}$	-
w.	Total carbon input with litter, t C ha $^{-1}$ per $^{-1}$	$w = v + i + e$	-
x.	Total carbon stock in biomass of ground cover plants, t C ha $^{-1}$ per year $^{-1}$	$x = \frac{(j + k + l + m) * 0{,}7 * 0{,}475}{1000}$	-

The calculation of CO_2 emissions from the decomposition of non-living wood (the period of mineralisation of deciduous trees – 20 years, coniferous trees – 40 years) and the calculation of carbon stock at the end of the year are indicated in equations 16 and 17.

$$DW_{(x)} = \frac{DW_{IN}^{1} + DW_{SI}^{-1}}{Years} \tag{16}$$

where
$DW_{(x)}$ – CO_2 emission from dead wood, tonnes CO_2 ha^{-1};
DW^{1}_{IN} – CO_2 increase with dead wood in the current year, tonnes CO_2 ha^{-1};
DW^{-1}_{SI} – CO_2 stock in dead wood in the end of last year, tonnes CO_2 ha^{-1};
Years - period of decomposition (40 years for coniferous and 20 years for deciduous).

$$DW_{SI}^{1} = DW_{IN}^{1} + DW_{SI}^{-1} - DW_{(x)} \tag{17}$$

where
DW^{-1}_{SI} – C stock in dead wood, tonnes CO_2 ha^{-1};
DW^{1}_{IN} – CO_2 increase with dead wood in the current year, tonnes CO_2 ha^{-1};
DW^{-1}_{SI} – CO_2 stock in dead wood in the end of last year, tonnes CO_2 ha^{-1};

$DW_{(x)}$ – CO_2 emission from dead wood during the year, tonnes CO_2 ha^{-1};

Average CO_2 emissions from wood products in 2020 were -0.7 tonnes CO_2 ha^{-1} per year (Ministry of Environmental Protection and Regional Development, 2021[48]). Carbon input with wood products is forecasted only in areas where economic activity is not restricted.

A summary of GHG emissions calculation is carried out for four emission categories: living biomass, non-living wood, wood products and soil emissions.

The sum of living biomass emissions is calculated using equation 18.

$$CO_{2\,\text{living biomass}} = \frac{C_{\text{increase of ABG}} + C_{\text{increase of BGB}} - C_{\text{dead wood and litter of ABG}} - C_{\text{dead wood of BGB}}}{44/12} \tag{18}$$

where
$CO_{2\,\text{living biomass}}$ - living biomass emissions CO_2 equivalent, tonnes CO_2 ha $^{-1}$;
$C_{\text{increase of ABG}}$ - carbon stock in aboveground biomass increase, tonnes C ha $^{-1}$;
$C_{\text{increase of BGB}}$ - carbon stock in belowground biomass increase, tonnes C ha $^{-1}$;
$C_{\text{dead wood and litter of ABG}}$ - carbon stock in aboveground biomass of dead wood, tonnes C ha $^{-1}$;
$C_{\text{dead wood BGB}}$ - carbon stock in belowground biomass of dead wood, tons C ha $^{-1}$.

The sum of non-living biomass emissions is calculated using equation 19.

$$CO_{2\,\text{dead biomasa}} = \frac{C_{\text{accumulation changes in natural mortality}}}{44/12} \tag{19}$$

where
$CO_{2\,\text{dead biomass}}$ - non-living biomass emissions CO_2 equivalent, tonnes CO_2 ha $^{-1}$;
$C_{\text{accumulation changes in natural mortality}}$: changes in carbon stock in natural mortality in tonnes C ha $^{-1}$.

GHG emissions from soil are calculated using pre-calculated soil emissions and carbon stocks in ground cover vegetation and carbon input with plant residues using equation 20.

$$CO_{2\,\text{soil}} = \frac{CO_{2\,\text{from soil}} - C_{\text{input}}}{44/12} \tag{20}$$

where
$CO_{2\,\text{soil}}$ — total soil emissions in CO_2 equivalent, tonnes CO_2 ha $^{-1}$;
$CO_{2\,\text{from soil}}$ - CO_2 emissions from soil, tonnes CO_2 ha $^{-1}$;
C_{Input}: carbon input with ground cover vegetation and plant residues, tonnes C ha $^{-1}$.

The sum of emissions from wood products is calculated by 2020, with average CO_2 emissions from -0.7 tonnes CO_2 ha $^{-1}$.

The total GHG emissions balance is calculated by summing the amounts of living biomass, non-living biomass, soil and wood products using equation 21.

$$CO_{2\,\text{NETTO}} = -(CO_{2\,\text{living biomass}} + CO_{2\,\text{non-living biomass}} + CO_{2\,\text{soil}} + CO_{2\,\text{wood products}}) \tag{21}$$

Given that no data on harvesting are included in this calculation, the calculation model is calibrated using the 2020 data on total harvested wood and logging residues. Carbon losses from tree stems 15 160 310 tonnes CO_2 added to felling areas as well as 6 718 579 tonnes CO_2 from forest residues for all felling. These carbon losses are included in the living biomass emissions category.

[48] Ministry of Environmental Protection and Regional Development. (2021). Latvia's National Inventory Report submission under UNFCCC and the Kyoto Protocol Common Reporting Format (CRF) 1990 – 2019 (p. 545). Ministry of Environmental Protection and Regional Development of the Republic of Latvia. https://unfccc.int/documents/271530

3. Application of Simulation tool

1.2. Data description

The Simulation tool requires spatial data for land function calculations. For each country, there are two datasets: one for agricultural land fields and another for forest land parcels. Agricultural land dataset also includes abandoned agricultural land. The spatial information in both datasets is of the highest possible resolution. The spatial information in these datasets (layers) does not overlap. The most comprehensive spatial data for obtaining detailed information on agricultural areas is for the institutions that implement and monitor the implementation of agricultural and rural support policies. Before the use of spatial data, it is necessary to create an attribute table with specific data column names. An attribute table is created from the agricultural database with the following information:

- Nr – identification number;
- Area – size if the field in hectares;
- Farmer_ID – fake ID number for farmer to identify the sizes of farms;
- Crop – crop name according to support payment agency classification;
- CropCode – crop code according to support payment agency classification;
- CropGroup – all of the crops are divided into 9 groups ("GrassesPerennial", "CerOilLeg", "Other", "GrassesArable", "Vegetables", "Potatos", "Fallow", "PlantingsPerennial", "EnergyPlants");
- Support – type of support payments received for this area;
- BioFarmSupport – support payment for organic farming (derived from Support);
- BioDiversitySupport - support payment for habitat (derived from Support);
- Geom – geometry of field;
- MunicipalityCode – municipality code where field is located;
- OrganicSoil – whether on field is organic soil;
- SoilQualityPoints – soil quality evaluation;
- SPNA – specially protected natural areas;
- NITRASENS – nitrate sensitive area;
- Melioration – whether field is ameliorated;
- QUADRANT_ID – layer of 100 ha large quadrants;
- AREA_TOTAL – total area of the farm (derived using Farmer_ID);
- CerOilLeg_TOTAL – total area of cereals, oilseed and legumes of the farm (derived using Farmer_ID);
- Other_TOTAL – total area of other crops of the farm (derived using Farmer_ID);
- GrassesArable_TOTAL – total area of grasslands in arable land of the farm (derived using Farmer_ID);
- Vegetables_TOTAL – total area of vegetables of the farm (derived using Farmer_ID);
- Potatos_TOTAL – total area of potatoes of the farm (derived using Farmer_ID);
- Fallow_TOTAL – total area of fallow land of the farm (derived using Farmer_ID);
- PlantingsPerennial_TOTAL – total area of perennial plantations of the farm (derived using Farmer_ID);
- EnergyPlants_TOTAL – total area of energy crops of the farm (derived using Farmer_ID).

Spatial information on forest areas is maintained by the state administrative institution, which maintains the state forest register and collects information on the economic activities taking place in the forests. An attribute table is created from the forest database with the following information:

- Field_ID –forest field polygon ID;
- Spiecie – dominant specie (pine, birch, grey alder etc.);
- Forest_type – forest growing type (Vacciniose, Myrtyllosa, etc.]
- Forest_type_group – forest type group (edaphyc group) (5 groups: on dry mineral soils, on wet mineral soils, on wet mineral soils with organic layer >30 cm, on drained mineral soils, on drained organic soils);
- Area_ha –field area in ha;
- Site_index –site index (a unit for characterizing the productivity of a forest stand, which is determined by the height of trees at a certain age);
- Stand_m3_ha – standing volume, m3/ha;
- Specie_yr – dominant specie age, years;
- Age_group – age group (young stand, seasoning stand etc.);
- Stand_basal_m2_ha – stand basal area, m2/ha;
- Diameter_cm – dominant specie tree diameter in cm;
- Height_m – height of the dominant trees specie;
- Number_trees_ha – number of trees per ha;
- Stand_density –the ratio of the current number of trees to the normative number or the degree of closure of tree crowns;
- Restrictions – restrictions (all forestry activities, main felling and maintenance, main felling, clearcutting, seasonally prohibited, no restrictions);
- Last_activity_yr – year, when last action is done in forest stand (harvesting, thinning, reforestarion, planting)
- Last_activity – the type of last activity (clearcut, thinning, deforestation, planting).

1.3. Scenario analysis

Scenario analysis plays an essential role in outlining development directions for management of organic soil and achieving socio-economic and environmental objectives. Scenario analysis provides an idea of the possible impact of the measures on the national and regional economy as well as local economy. One of the main tasks of the Simulation tool is to help policymakers assess the suitability of organic soil management scenarios for achieving socio-economic and environmental objectives and predict to what extent the suite of land function can increase or decrease and how specific actions can affect the development of the national and regional economy as well as local economy. Scenario analysis has a hypothetical construction, it is not a forecast or prediction, but outlines possible future elements and key factors for management of organic soils.
In this activity, the scenario analysis first looks at the baseline. The baseline scenario describes the current situation in organic soil management. This activity will use the agricultural land, forest land and wetland scenarios identified in activity C3, and the economic indicators from the activity C4. The overview of the scenarios are given in Table 31, Table 32, and Table 33. All scenarios apply to nutrient-rich organic soil with peat thickness at least 30 cm, groundwater level at least 30 cm during the growing season. Current land use and future land use are identified for each scenario.

Table 31. Overview of scenarios in agricultural land

Scenario	Name of scenario	Description
LVC301	Conversion of cropland used for cereal production to grassland considering periodic	Cropland with nutrient-rich organic soil conversion to grassland. Increased carbon stock in soil and below-ground biomass, reduced risks of nutrient leaching and soil erosion. Existing land use is cropland, planned land use is grassland.

Scenario	Name of scenario	Description
	ploughing	
LVC304	Introduction of legumes in conventional farm crop rotation	Introduction of legumes in crop rotation. Reduced N_2O emissions from soil reported in agriculture sector because of avoided mineral fertilizer application and gradual nitrogen input by symbiotic organisms. Increased carbon input with plants ensuring increased soil carbon stock. Existing and planned land use is cropland.
LVC302	Conventional afforestation considering shorter rotation conventional afforestation (spruce)	Demonstration of the reduction of GHG emissions from area previously used as pasture or perennial grassland for fodder production by afforestation with spruce. Reduced GHG emissions from soil. Accumulation of CO_2 in living and dead biomass, soil and litter and replacement effect of forest biofuel and harvested wood products. Shorter rotation and more intensified management ensures higher yield and replacement effect, as well as reduces carbon losses due to root rot and other disturbances. Existing land use is game animal feeding glade, planned land use is forest stand.
LVC303	Paludiculture – afforestation of grassland with black alder and birch	Reduction of GHG emissions by establishing forest paludiculture (dominant species - black alder and birch) in game animal feeding glade with nutrient –rich organic soil and increased groundwater level. Existing land use is game animal feeding glade, planned land use is forest stand.
LVC305	Controlled drainage of grassland considering even groundwater level during the whole vegetation period	Reduction in GHG emissions from organic soils due to limited fluctuations of groundwater level during and outside the growing season, reduced leaching of nutrients to surface water bodies as drainage water will be stored in the field. It is expected that during the summer season additional water will be available to meet crop demand thus ensuring higher carbon inputs into soil. Existing and planned land use is grassland.
LVC306	Agroforestry – fast growing trees and grass	GHG emissions reduction through transformation of cropland to tree plantation. Projected reduction of GHG emissions is related to the decrease of N_2O and CO_2 emissions from soil as well as to the increase of CO_2 removals in living biomass and other carbon pools. Existing land use is cropland, planned land use is plantation forest.
LVC310	Fast growing species in riparian buffer zones	GHG emissions reduction through transformation of strip areas along drainage diches in cropland to tree plantation areas that avoid nutrient leaching and increase carbon removals in living biomass and other carbon pools. Projected reduction of GHG emissions is related to the decrease of N_2O and CO_2 emissions from soil as well as to the increase of CO_2 removals in living biomass and other carbon pools. Existing land use is cropland, planned land use is plantation forest.

Table 32. Overview of scenarios in forest land

Scenario	Name of scenario	Description
LVC307	Application of wood ash after commercial thinning in spruce stand	GHG emissions reduction in spruce stands on organic soils and lowered ground water table by implementation of wood ash after thinning thus enhancing stand growing conditions. Projected reduction of GHG emissions is related to groundwater level reduction, related to increase in growing stock increment and increased water amount used for transpiration processes – thus decreasing CH_4 emissions and increasing CO_2 removals in living biomass. Existing and planned land use is forest stand.
LVC308	Continuous forest cover	GHG emissions reduction in spruce stand by replacing clear felling

Scenario	Name of scenario	Description
	as a forest regeneration method in spruce stand	with selective felling. Projected reduction of GHG emissions is related to the increase of groundwater level in an alternative – clear felling scenario. Increase of groundwater level is associated with significant increase of CH_4. In the case of selective felling increase of groundwater levels should be smaller thus also increase of GHG emissions is smaller. Existing and planned land use is forest stand.
LVC309	Semi-natural regeneration of regeneration felling site with grey alder without reconstruction of drainage systems	GHG emissions reduction in black alder or birch stand by using genetically selected planting material and improving hydrological regime. Projected reduction of GHG emissions is related to groundwater level stabilizing during forest regeneration phase and better growth conditions and increased CO_2 removals in forest biomass and other carbon stocks. Existing and planned land use is forest stand.
LVC311	Riparian buffer zone in forest land planted with black alder	GHG emissions reduction in deciduous tree stands on organic soils with increased ground water table by enhancing tree growing conditions, using high quality planting material and preparing soil with mounding method including establishing of deep furrows for excess surface water drainage in spring time and after rainfalls. Projected reduction of GHG emissions is related to groundwater level reduction, related to establishment of deep furrows - as a result decreasing CH_4 emissions and increasing CO_2 removals in living biomass. Existing and planned land use is forest stand.
LVC312	Forest regeneration (coniferous trees) without reconstruction of drainage systems	GHG emissions reduction in coniferous stands on organic soils and increased ground water table by application of forest regeneration with high quality coniferous planting material and by using mounding method for soil preparation. Projected reduction of GHG emissions is related to groundwater level reduction, related to establishment of deep furrows - as a result decreasing CH_4 emissions and increasing CO_2 removals in living biomass because of enhanced forest growing conditions. Existing and planned land use is forest stand.
LVC313	Strip harvesting in pine stand	GHG emissions reduction in pine stand by replacing clear felling with strip harvesting. Projected reduction of GHG emissions is related to the increase of groundwater level in an alternative – clear felling scenario. Increase of groundwater level is associated with significant increase of CH_4. In the case of strip harvesting increase of groundwater levels should be smaller thus also increase of GHG emissions is smaller. Existing and planned land use is forest stand.

Table 33. Overview of scenarios in wetlands

Scenario	Name of scenario	Description
RESTORE	Growing blueberries and cranberries in wetlands	Conversion of former peat extraction sites to agricultural land where tall highbush blueberry *Vaccinium corymbosum*, lowbush blueberry *Vaccinium angustifolium* or large cranberry *Vaccinium macrocarpon* are grown. Existing land use is former peat extraction, planned land use is perennial plantation in agricultural land.

For each scenario, its impact on socio-economic and climate function will be determined. To each policy scenario Simulation tool creates copies of initial datasets, and then attributes of some polygons are changed, based on policy criteria (for instance, conversion of cropland used for cereal production to grassland in certain regions, with certain soil quality points, with organic soil attribute, without environmental restrictions, and owned by the farmers of certain size). Then the same algorithms are used to calculate socioeconomic outputs per each polygon and saved into, for instance, Scenario LVC301 results. The difference between baseline scenario and LVC301 scenario results is considered as scenario impact.