OrgBalt LIFE project

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 THE BALTIC STATES AND FINLAND

WORK PACKAGE

STRATEGIES AND ACTION PLANS

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EU LIFE Programme project
"Demonstration of climate change mitigation potential of nutrients rich 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 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 assessment of all environmental impacts. For all these reasons, these models should be used carefully in CCM strategy development for identification of gaps in climate neutrality transition policy and funding frameworks and need further optimization for broader applicability as decision-making tools."

Contents

List of Abbreviations and Acronyms

PPC	Private Public Communication
CCM	Climate Change Mitigation
GHG	Greenhouse gas
CO_2	Carbon dioxide
N2O	Nitrous oxide
ROI	Return on investment
CCF	Continuous cover forestry
CBA	Cost-benefit analysis

INTRODUCTION

The goal of this analysis is to identify and evaluate the potential socio-economic impact of the CCM mitigation measures investigated within the project LIFE OrgBalt. Advantages and disadvantages have been evaluated to evaluate which measures could be of greatest use for society and/or which are the most cost-effective. By impacts we consider potential changes caused directly or indirectly, adverse or beneficial by the applied CCM measures.

Soil carbon sequestration and the conservation of existing soil carbon stocks is an important mitigation pathway to achieve the less than 2 °C global target of the Paris Climate Agreement, given its multiple benefits including improved food production. [1] With the European Climate Law, the EU made climate neutrality by 2050 a legally binding goal, set an interim target of a net 55% emission reduction by 2030 and is now working to set a new target to be reached by 2040. In order to reach the 55% proposed threshold, the European Union is working to bring EU legislation in line with the 2030 goal. [2]

There are numerous research studies in relation to the impact of different CCM measures. A number of those provide insights on benefits and also adverse effects. The agriculture, forestry and land-use sectors are responsible for 22% of global greenhouse gas emissions, and deforestation is a major driver[3]. Therefore, afforestation is perceived as one of the potential solutions for mitigating climate change. Within the LIFE OrgBalt project different measures related to afforestation have been implemented and studied. Further details on each CCM measures characteristics and practical implementation schemes can be found in the reports "Report on implementation of CCM measures in demo sites in Latvia" and "Report on implementation of CCM measures in demo sites in Finland" . The present document will focus on the socio-economic impacts of these measures which will be also further analyzed in the Final monitoring of the socio-economic impact of the project actions which will be completed by the end of the project.

Research suggests that the increase in carbon stored in tree biomass of afforested areas could be offset by strong growth of natural forests. Broadleaf afforestation was associated with much smaller effects on albedo and thus contributed to significant local and regional cooling. Therefore, while afforestation may provide many benefits to

[1] https://www.nature.com/articles/s41598-017-15794-8
[2] https://www.eea.europa.eu/en/topics/in-depth/climate-change-mitigation-reducing-emissions#:~:text=With%20the%20European%20Climate%20Law,line%20with%20the%202030%20goal.
[3] https://wwf.panda.org/discover/our_focus/forests_practice/forest_climate/

ecosystems and societies, it has a smaller impact on mitigating the effects of climate change being the resulting reduction in GHG emissions not so high as expected.[4]

A finite global land area implies that fulfilling these strategies requires increasing global land-use efficiency of both storing carbon and producing food.[5] Improved land management, without changing land use, may be an additional carbon sequestration option that does not require more land conversion. [6] Various agricultural practices including addition of organic manures, cover cropping, mulching, reduced tillage, improved crop rotations, agroforestry, and rotational grazing provide significant climate benefits.[7] Some of these measures have been also implemented in the LIFE OrgBalt project. Further details on each CCM measures characteristics and practical implementation schemes can be found in the reports "Report on implementation of CCM measures in demo sites in Latvia". The present document will focus on the socio-economic impacts of these measures which will be also further analyzed in the final monitoring of the socio-economic impact of the project actions which will be completed by the end of the project.

Additionally, forests are less reflective than croplands, and the absorption of incoming solar radiation is greater over afforested areas. Afforestation can therefore result in net climate warming, particularly at high latitudes. [8]

Summarized issues provide insights on the necessity to seek opportunities also for CCM measures for agricultural lands and forest lands. Therefore, a number of various CCM measures that don't require land use change, but rather new land management solutions are included in the LIFE OrgBalt project.

It's also important to stress that the estimations that resulted from the project's research, data collection and data analysis, show that some of the most beneficial CCM measures are related to continuous cover forestry (CCF). By applying this land management practice, it is expected to reduce the negative environmental impacts of peatland forestry in comparison with rotation forestry. Moreover, this measure is an economically feasible forest management alternative for Norway spruce.[9] Although some other evidence suggests that when volume yield is maximized, the optimal steady state is a nearly pure Norway spruce stand at all site types, producing slightly higher yields than single-species stands. [10]

[4] https://ui.adsabs.harvard.edu/abs/2016AGUFMGC21B1080L/abstract
[5] https://www.nature.com/articles/s41586-018-0757-z
[6] https://www.nature.com/articles/s41586-021-03523-1
[7] https://www.nature.com/articles/s41598-017-15794-8
[8] https://www.nature.com/articles/ngeo1182 and https://www.nature.com/articles/s43247-023-00866-7
[9] https://cdnsciencepub.com/doi/full/10.1139/cjfr-2020-0305 and https://www.sciencedirect.com/science/article/pii/S1389934118301576
[10] https://cdnsciencepub.com/doi/abs/10.1139/cjfr-2014-0552

Increasing the harvesting interval decreases the annual volume yield. Assuming natural regeneration, this suggests that volume yield and also carbon removal from the atmosphere is maximized by uneven-aged rather than even-aged management. [11]

Correlation of site carbon balance with harvested roundwood indicates that there is a significant trade-off between maintaining carbon in drained peatland forests and providing harvest revenues. In general peatland forest acts as a carbon sink with low and middle harvest intensity, while it turns into a carbon source with high harvesting intensities.[12]

The present document analyzes the benefits of the main groups of CCM measures implemented in the LIFE OrgBalt project. A first socio-economic analysis is also provided by taking into consideration the impact of these measures basing on two main indicators: changes in GHG emissions to evaluate the potential environmental but also economic benefits of the applied CCM measures on one hand and cash flow on the other, to evaluate the financial return of the same CCM measures.

COST BENEFIT ANALYSIS CBA OF THE PROPOSED MEASURES

In this report the main focus is on two indicators – costs and income opportunity related to the implementation of the analyzed CCM measures on one hand and reduction of greenhouse gas (GHG) emission. The two indicators are analyzed by comparing specific sets of measures with reference sites which have similar characteristics and conditions. The "costs of inaction" are compared with the expected results in implementing the proposed CCM measures.

FOREST SECTOR CCM MITIGATION MEASURES

Measures that aim at increase forest carbon stocks (in soil and biomass) through the modification of forest management practices

All of these sites are located on nutrient-rich organic soils (low bog peat soil according to Latvian classification) with peat layer thickness at least 30 cm. There are various climate change mitigation measures implemented and researched. Some of the measures are implemented in dryer conditions. In those cases, the water table (ground water) level is at least 30 cm deep during the vegetation season. There are also measures implemented in wetter conditions. In these sites and their reference sites the water table is less than 30 cm below soil surface during the vegetation season. In peatland forests, tree growth decreases if the water table level is too high. The conventional solution to this problem is to maintain adequate drainage artificially by means of ditch network maintenance. Drainage is needed to maintain the stand growth only when the post-

[11] https://www.tandfonline.com/doi/full/10.1080/02827581.2014.982166

[12] https://www.sciencedirect.com/science/article/abs/pii/S0378112721005685

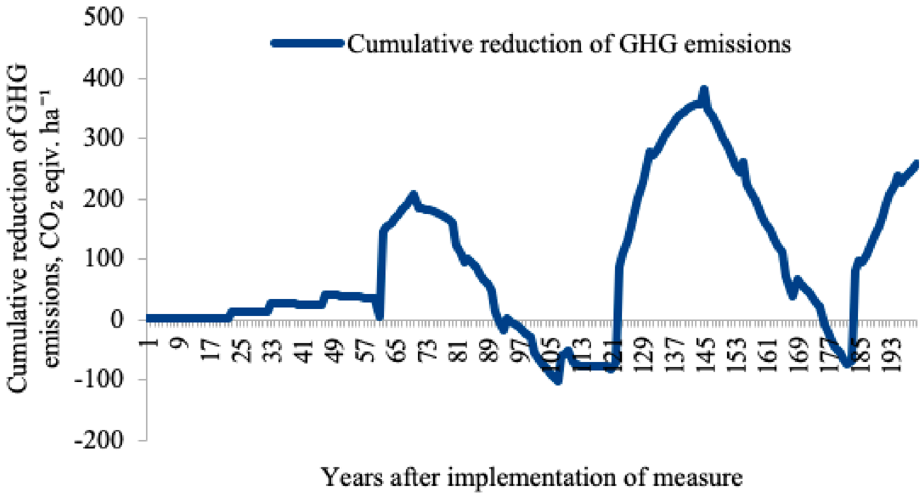
harvest basal area is smaller than 10 $m^2 \cdot ha^{-1}$. This, however, entails costs and causes negative environmental impacts such as the deterioration of water quality.[13]

Climate change mitigation measures in the forest sector aim at increasing carbon stocks in both – soil and biomass – by changing the forestry practice. Research task for these measures is to demonstrate reduction of GHG emissions in comparison to their reference sites (with common forestry practice).

Common forestry practice in the region is mainly focused on even age forestry which may be described by clear-cuts or, so called, regenerative harvesting as the main harvesting practice. Usually it involves regeneration (natural or by planting seedlings), thinning and commercial thinning. It may require tending as well as maintenance of drainage systems.

So far it is estimated that within this group of measures the biggest potential in increasing carbon storage and therefore also for GHG reduction within 200 years, in comparison to reference sites, is given by measures related to continuous cover forestry (Norway spruce stands).

The chart below indicates the estimated cumulative reduction of GHG emissions in continuous cover forestry compared to common forestry practice. Common forestry practice may be characterized by strong impact of rotation period where GHG emissions are related to higher water table level in reference site after clear felling. Higher water table level is associated with significant increase of methane emissions. In the case of selective felling water table levels should be deeper thus also the increase of GHG emissions is smaller. This comparison results in significant differences of reduced GHG emissions depending on the specific period in which these measures are implemented, or on the number of years they have been practiced.

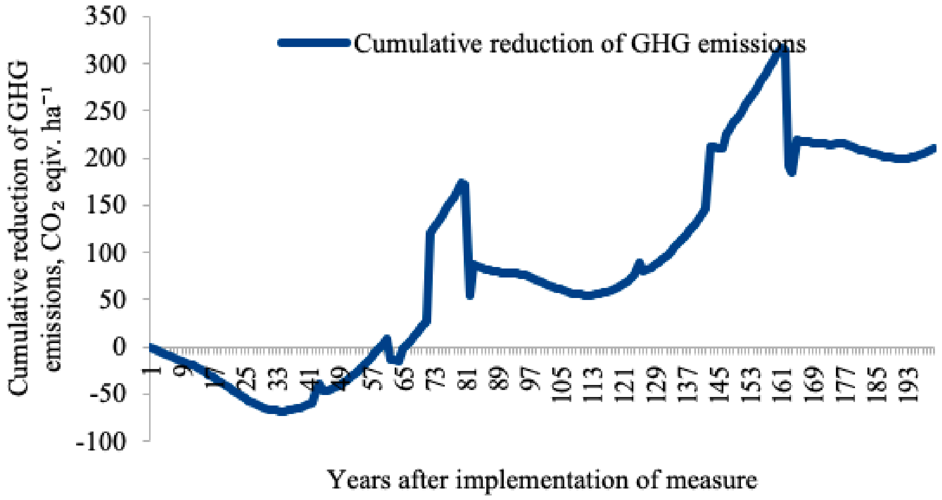


There are two other sets of measures that are estimated to provide slightly smaller but still significant reduction of GHG emissions in comparison to those of their reference sites. One of those is related to growing coniferous stands and increased ground water

[13] https://cdnsciencepub.com/doi/full/10.1139/cjfr-2020-0305

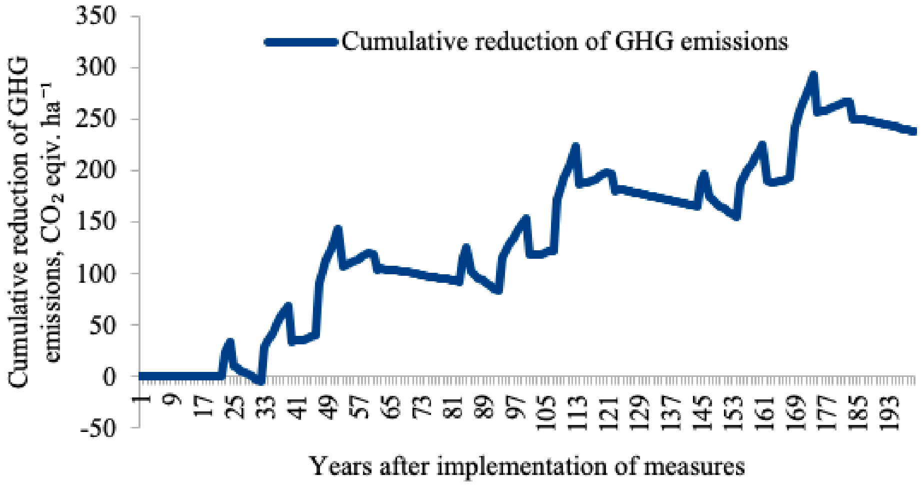
table by application of forest regeneration with high quality coniferous planting material and by using mounding method (and deep furrows to drain excess surface water during springtime and after heavy rains) for soil preparation.

The chart below indicates estimated cumulative reduction of GHG emissions for this set of measures compared to coniferous stands in naturally wet growing conditions. For this set of measures projected reduction of GHG emissions is mainly related to groundwater level reduction, which is due to establishment of deep furrows. This results in decreasing methane emissions and increasing CO2 removals in living biomass because of enhanced forest growing conditions.

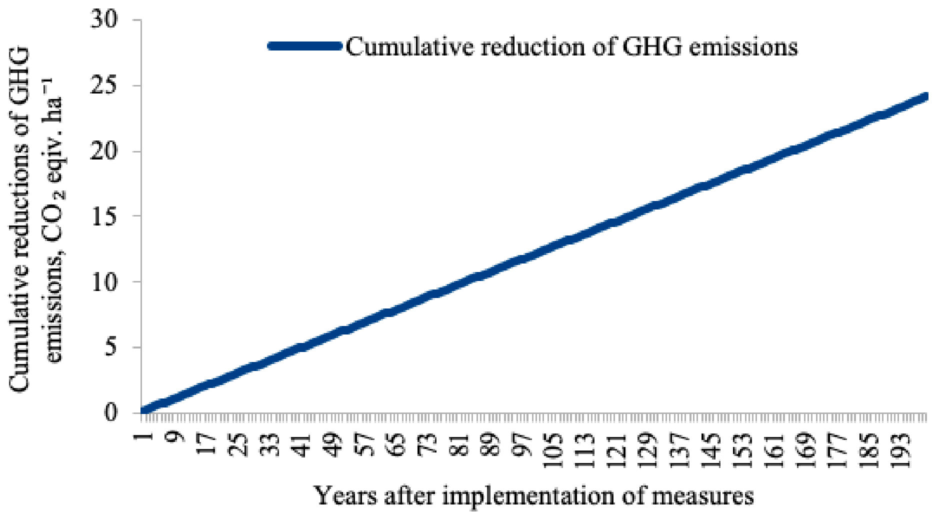


Another set of forest sector measures with comparatively high estimated results in GHG emission reductions is related to spruce stands and lowered ground water table by application of wood ash after thinning thus enhancing stand growing conditions. Projected reduction of GHG emissions is related to groundwater level reduction, related to increase in growing stock increment and increased water amount used for transpiration processes – thus decreasing methane emissions and increasing CO2 removals in living biomass.

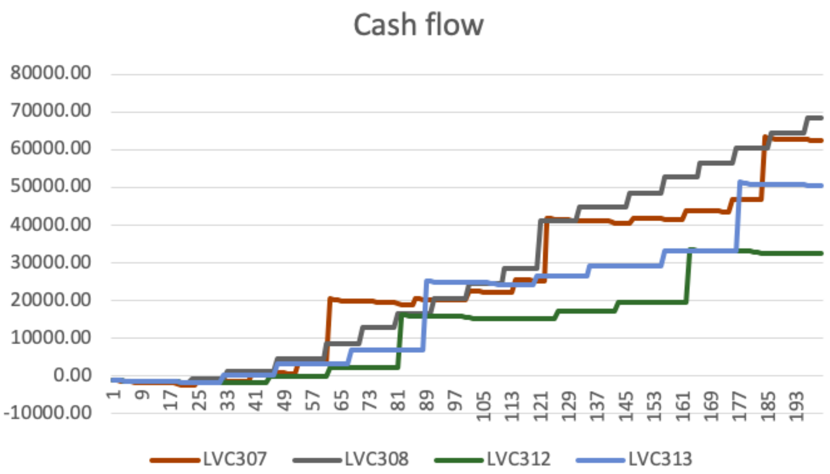
The chart below indicates estimated cumulative reduction of GHG emissions for these measures compared to similar practice but without application of wood ash.



The smallest reduction of GHG emissions within forestry measures were related to replacing clear felling with strip harvesting in pine stands. Projected reduction of GHG emissions for these measures is related to the increase of groundwater level as an alternative – clear felling scenario. In case of strip harvesting the increase of groundwater levels should be smaller thus also the increase of GHG emissions is smaller. Below is the chart of estimated cumulative reduction of GHG emissions for these measures compared to application of clear felling.



In general, all sets of forestry measures require investments and financial availability as the financial return is expected in a longer time period due to harvesting taking place decades after regeneration of the forest stand. For example, return of investment for mentioned sets of measures varies from 33 to 62 years depending on the investments required and the applied specific set of measures. Timber prices and amount of harvested timber provides less frequent, but considerable income which is significantly bigger than initial investments. The chart below shows approximate cash flow for the mentioned examples of sets of measures, where LVC307 stands for ash application measures, LVC308 – continuous cover forestry measures, LVC312 – regeneration of coniferous stands with high quality planting material and mounding, LVC313 – strip harvesting of pine stands.



AGRICULTURAL SECTOR CCM MITIGATION MEASURES

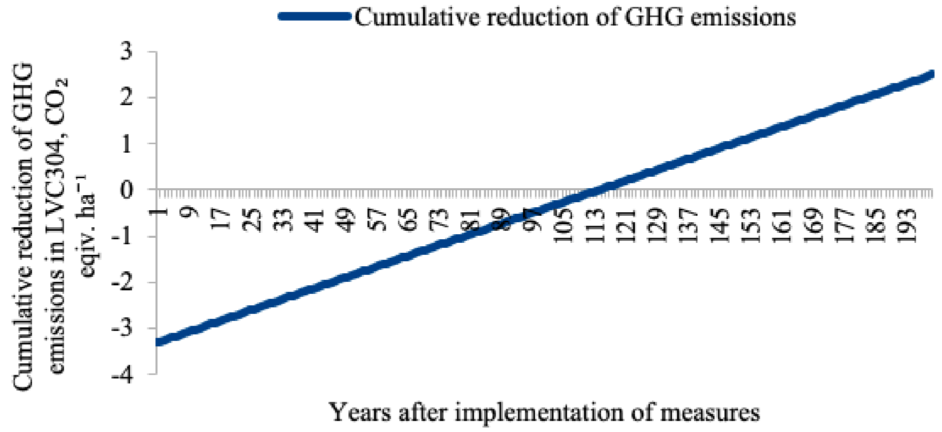
Measures involving change of crop type

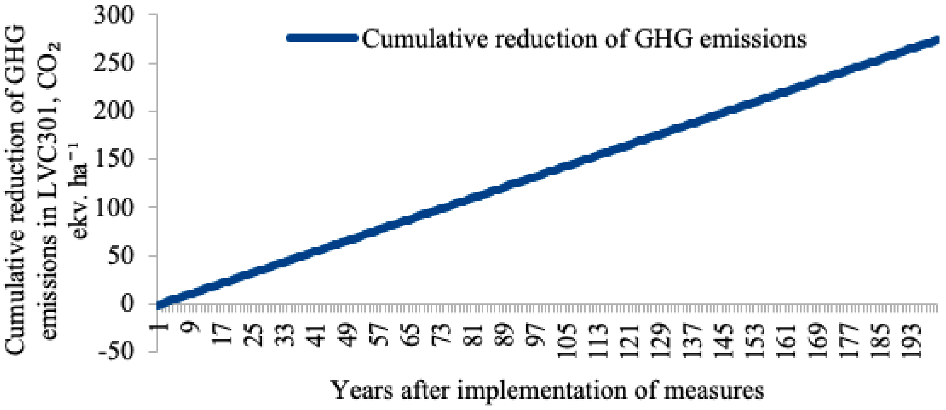
There are two sets of measures within this group. Both sets of measures as well as the reference site have the following characteristics:

- nutrient-rich organic soil (low bog peat soil according to Latvian classification)
- peat layer thickness at least 30 cm
- water table level at least 30 cm deep during the vegetation season
- the area is managed as cropland

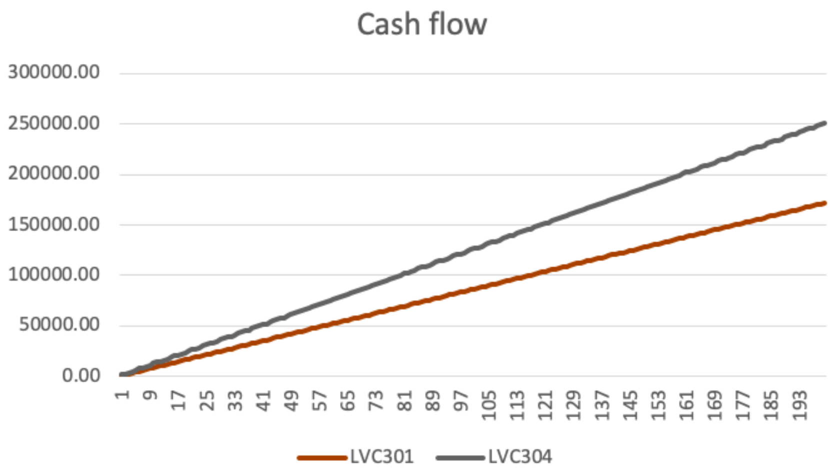
For both sets of measures the research task is to demonstrate the expected reduction of GHG emissions. One set of measures (LVC301) includes transformation of cropland to grassland. But the other set of measures (LVC304) includes introduction of legumes (biomass and nitrogen attraction) to crop rotation. In both sets of measures projected reduction of GHG emissions is related to the decrease of N2O and CO2 emissions from soil.

These sets of measures are included in one group because both of those involve crop change. In the charts below the estimated reductions of GHG emissions is shown. Considerable differences in the scale of GHG reduction can be observed between the two sets of measures. Introduction of legumes to crop rotation is estimated to produce significantly less reductions of GHG emissions and those require a very long period of time before being significant.





Although reductions of GHG emissions for both sets of measures are significantly different, their financial return is much more alike and approximately 3 to 4 times bigger than forestry measures. Additionally, these sets of measures provide annual income but on the other hand, compared to forestry measures, risks related to weather conditions (Droughts, frosts, snowless winters, flooding, hail, etc.) may be comparatively higher for the harvest.



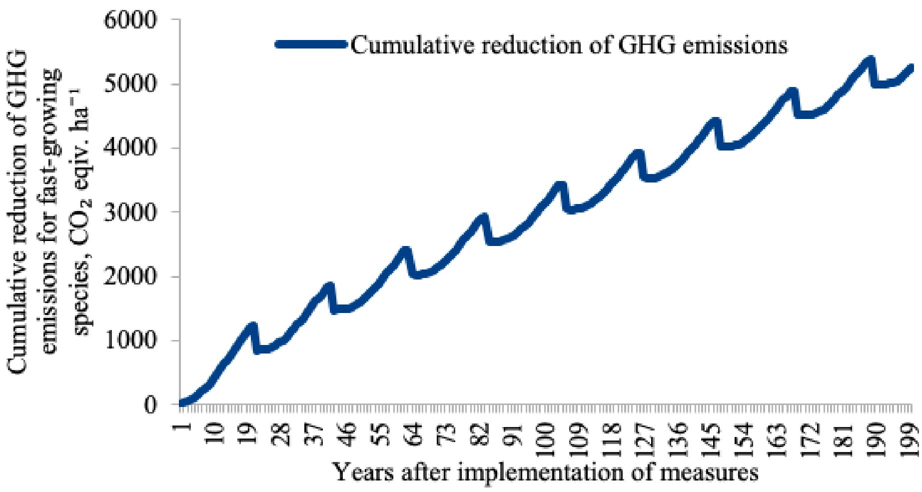
Measures involving complete or partial afforestation

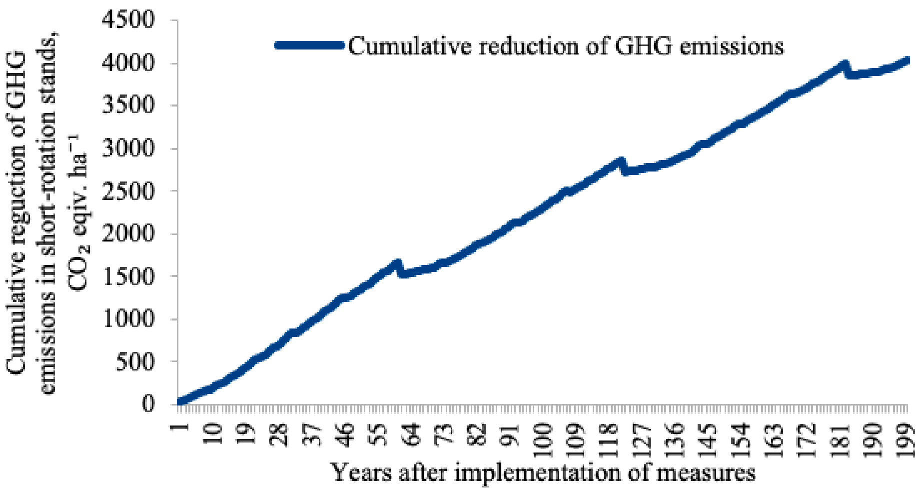
The benefits of afforestation can help protect bare ground from soil erosion, flooding and enhance carbon dioxide sequestrations from the atmosphere. Well managed afforestation can provide jobs, income from the sale of high-value timber products, social benefits, and carbon emissions reductions.

Reference sites for all these measures are characterized by nutrient-rich organic soils (low bog peat soil according to Latvian classification). Peat layer is at least 30 cm thick and the water table level is more than 30 cm deep during the vegetation season. Reference sites for measures related to afforestation of grassland are drained grasslands. One of these measures (LVC302) includes maintenance of the drainage system. Norway spruce is planted there and managed in shorter rotation periods. The other set of measures (LVC303) exclude maintenance of the drainage system (water table level is raised) and therefore selection of planted tree species is different – black alder (and birch).

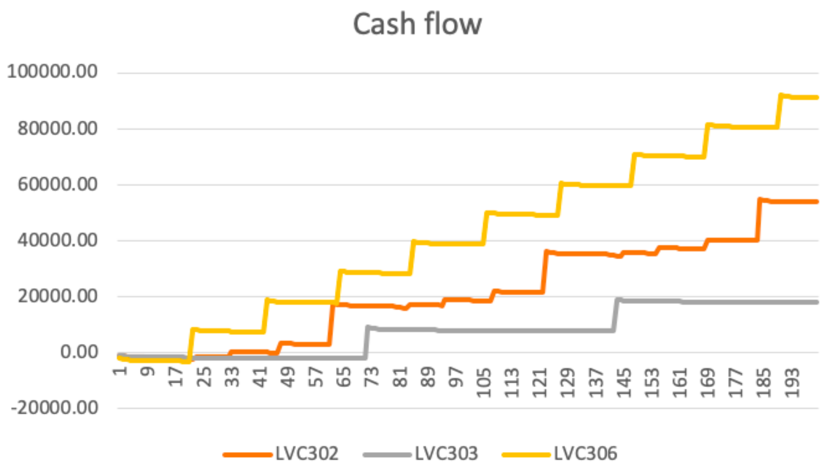
Measures related to complete or partial afforestation with fast-growing species were previously managed as cropland, therefore reference sites are available and provide a comparative analysis between inaction and action scenarios. Projected reduction of GHG emissions in this case is related to the decrease of N2O and CO2 emissions from soil as well as to the increase of CO2 removals in living biomass and other carbon pools. Additionally, partial afforestation is applied in strips along drainage ditches in cropland to avoid nutrient leaching to ditches and other water bodies.

As expected, all afforestation measures are related to significantly bigger cumulative reductions of GHG emissions than other sets of measures because of much more significant changes in land use. Below are two charts for cumulative reduction of GHG emissions in afforestation measures compared to their reference sites. The absolute numbers are significantly (more than 10 times) bigger than any forestry sector measures or those related to crop change in agricultural lands.





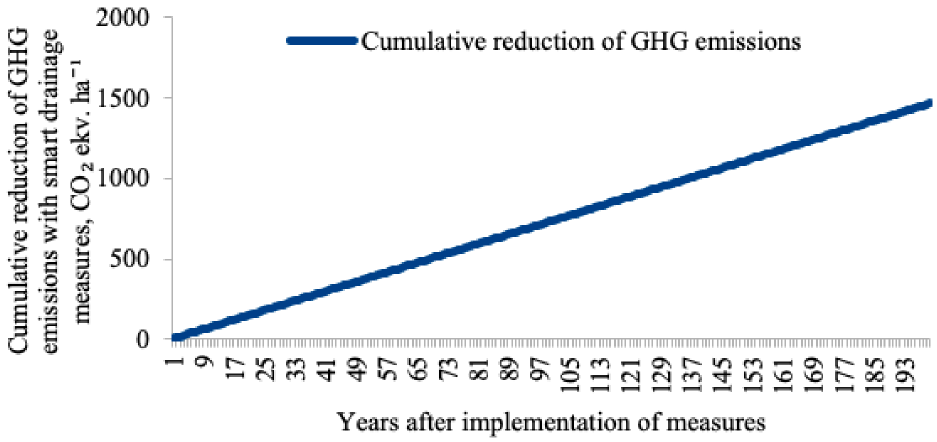
Although the reduction of GHG emissions in all these sets of indicators is estimated to be high, financial returns differ significantly due to growth rate of selected species and lengths of rotation periods respectively. Measures related to planting fast growing tree plantations are the most profitable within the group of afforestation measures taken into consideration, while the least profitable is the set of measures related with planting of black alder and excluding the maintenance of drainage systems.



Measures involving Climate smart drainage activities

Similar to the sites for the previously described sets of measures, also the site for implementation of smart drainage measures and its reference site is characterized by nutrient-rich organic soil (low bog peat soil according to Latvian classification) with at least 30 cm thick peat layer. Water table level is at least 30 cm from the ground surface during the vegetation season in the reference site and the area is managed as grassland.

Implementation of smart drainage measures includes raising the water table level in the field and increasing retention and storage of water in soil during and outside the vegetation season. These measures also reduce nutrient leakage to surface water bodies due to storing of drainage water in the field.



The chart indicates a significant estimated potential for reduction of GHG emissions in the implementation of climate smart drainage measures in grasslands.

METHODOLOGICAL ISSUES

Before analyzing the methodological issues encountered and that should be taken into account in similar analyses on a general basis, let's go back to a definition of socio-economic analyses. "We use socio-economic analyses to calculate the value of advantages and disadvantages for society of different climate change adaptation measures. In this way we can find the measures that will be of greatest use for society or which are the most cost-effective."[14]

The assessment of the socio-economic impacts of the CCM measures implemented in the LIFE OrgBalt project is important to identify and value their results and their contribution in terms of GHG emissions reduction. It is also important to identify the expected impacts at social and economic level for landowners and stakeholders. Finally, this assessment provides important feedback for partners whose research on these topics will continue beyond the scope of the project, but also for policy makers who will be able to make better oriented and data-based decisions on future actions and policies.

It is important to also highlight that the CCM measures' real impacts will be observable only in decades. The results of the implemented measures are therefore calculated as modeled impacts based both on the project data and on reference data where similar

[14] https://en.klimatilpasning.dk/knowledge/socio-economy/

conditions have been in place for a considerable amount of time to consider the available data as reference results rather than expected impacts.

The present analysis has been done by dividing the applied CCM measures within the LIFE OrgBalt project in four main groups, two falling under the Forest sector and three under the Agricultural sector. A cost-benefit analysis (CBA) has been carried out taking into consideration the effects of the measure. The cost of inaction has been compared to the cost of action, to understand which are the measures' costs. A budgetary economic analysis has also been done by taking into account the measures' financial return, so as to understand if those could be profitable or not for owners. A broader analysis should be undergone to assess whether these measures, although not profitable for landowners in the short term, could represent a win strategy for the remaining stakeholders such as policy makers within central and local governments.

The conducted macro-analysis took into consideration specifically two main indicators, the reduction of GHG emissions on one hand and the financial return on the other. The assessment of socially efficient response strategies to climate change problems involves the careful consideration of both costs and benefits of mitigation and adaptation measures. [15] The "cost of inaction" needs to be compared with the climate change mitigation costs. This assessment is difficult due to several main reasons which could be grouped as follows:

- Uncertainty - the lack of knowledge about when and with how big of an effect the different climate change impacts will occur. When referring to CCM measures calculations are made for very long-time horizons (up to 200 years in the LIFE OrgBalt PPC model), with a consequent uncertainty and variability linked to the future effects of the implemented measures and to their related costs. Moreover, socio-economic analyses in the field of climate change adaptation are actively new and methods are still under debate and development.[16]
- Availability of data - while there is an abundance of natural science-based research on the impact of climate change, the amount of social and economic analysis is far more limited. [17] Given the long-time horizon of these measures, changes in the value of the considered economic parameters should also be taken into consideration since these often occur before the project reaches break-even, the point where the costs correspond to the benefits.
- The time perspective for benefits and costs - "The time perspective becomes a challenge in socio-economic analyses where the time gap between the costs and the resulting benefits is too big. This is also the case where measures have a long investment horizon". These challenges can be clearly observed in the project's implemented measures where management cycles need to be respected

[15] https://www.oecd.org/env/cc/37117487.pdf
[16] https://en.klimatilpasning.dk/knowledge/socio-economy/
[17] https://www.oecd.org/env/cc/37117487.pdf

and owners can benefit from profits only after decades, making the return on investment so far away on time to not be sustainable in the absence of state financial programs and / or subsidies.

- Data and conditions variability across countries and regions: soil characteristics vary so significantly among regions and countries that specific analyses should be made at regional level. To this aspect the different market trends which affect prices and consequent costs in extremely different ways should be added. In order to build a more general analysis that could serve both landowners and policy makers in estimating the impact of inaction versus the impact of the selected CCM measures implementation, the PPC model has taken into consideration a set of indicators whose values are mainly referred to the Latvian context. For the Baltic Countries it has been considered that similar conditions could be applied as an approximation. Specific values for the CCM measures implemented in Finland will be applied instead. Data on GHG emissions from Finnish demo sites are not currently available and therefore these data have not been included in the present analyses. The data evaluation should be completed by the end of the year and the obtained values will be included in the PPC model, so as to be able to provide a country-specific analysis for these scenarios. As discussed in the report "Methodology for socio-economic analysis of the proposed measures", the model is structured for users to act also as administrators which means that they are potentially able to change the values set for each indicator. This allows any potential users with sufficient training to adapt the model input data to the specific country-reality taken into consideration, or to a specific land plot. Training sessions to train direct and indirect users will be organized in February/April 2024.

CONCLUSION

Climate change mitigation measures were divided into four groups. The biggest impact in terms of reduction of GHG emissions is expected to be in measures related to afforestation. That is mainly due to significant changes, in particular – land use. Reference sites for these types of measures are croplands and grasslands but the outcome of their implementation is the development of a forest (through plantation practices). Such changes provide not only decreased emissions from soil but also increase of carbon removals in living biomass and other carbon pools.

Socio-economic impact though differs significantly among afforestation measures. That is mainly related to growth rate of selected species and length of rotation periods as explained in the CBA of the proposed measures. Similar to forestry measures, length of rotation periods determine timescale for return of investment which is considerably shorter for fast-growing tree plantations. Those also are estimated to be the most profitable among forestry and afforestation measures. It should be considered that not all sites are suitable for creating tree plantations and providing the highest benefits through afforestation.

Food production is an essential issue and is becoming more crucial for the growing world population. There are multiple scientific articles also on potential for reduction of GHG emissions in agricultural lands as well as negative albedo effects of afforestation in high latitudes. Therefore, further research of clear benefits and adverse effects of afforestation is necessary.

Among all measures implemented, the fastest return of investment and biggest financial returns was for agricultural measures related to crop change, in particular, introduction of legumes that in turn provided the least reductions of GHG emissions compared to any other set of measures. Turning cropland into grassland provided significant amounts of reductions of GHG emissions that were comparable to some forestry measures. Such measures also provided financial returns that were approximately twice as high as the highest returns from afforestation measures or trice as high as the highest forestry measures.

Besides afforestation measures, the biggest reduction of GHG emissions is estimated in measures related to increased water table level in perennial grasslands. Though further research is expected to clarify climate and weather impacts as well as impacts of increased water table lever on harvesting volumes and financial outcomes.

Set of measures related to continuous forestry provides the biggest reductions of GHG emissions among forestry measures. Measures related to regeneration with high quality coniferous planting material and mounding method provide comparatively high reductions of GHG emissions among forestry measures as well. But those are not as stable as for wood ash application measures in forestry. Though types and characteristics of reference sites should be considered thoroughly which is much more obvious in forestry measures and those related with crop change in agricultural lands as conditions of reference sites also differ significantly and have specific processes that determine GHG emissions. Meaning that there are considerable benefits in all those sets of measures as well as reference sites and further research is needed to reach justified conclusions by practical measurements of GHG emissions to adjust the estimated GHG emissions.

A final and more complete socio-economic analysis will be provided in the document "Final monitoring of the socio-economic impacts of the project actions" which will be developed toward the end of the project.