



INTRODUCTION

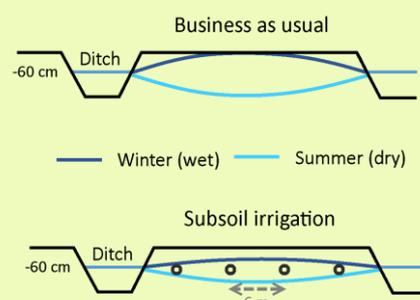
The **Paris Agreement**, that was unanimously adopted by all countries of the world in 2015 (confirmed in Katowice 2018) as well as the **IPCC (2018) Special Report on Global Warming of 1.5°C**, increase the pressure for sustainable peatland use in Northern Europe and other parts of the world. For some countries, complying with the set targets implies that all drained peatlands must be rewetted by 2050, with 50% by 2030. In contrast, the ongoing shift to bio-based economies may encourage the intensified use of terrestrial resources, including peatlands. Therefore, finding climate-friendly peatland-uses for food, fodder and energy production is of utmost urgency. **The PEATWISE project** set out to explore the potential of various peatland management practices to sustain production while mitigating greenhouse gas emissions across Northern Europe. *This policy brief outlines the mitigation measures in testing phases, presents the PEATWISE case studies, and provides recommendations based on the results from PEATWISE study sites in 2018, a year of extreme heat and drought.*

MITIGATION MEASURES

Waterlogged ecosystems preserve soil carbon stocks due to low oxygen availability and consequent decline of rates of decomposition processes producing carbon dioxide (CO₂) in the soil profile. Therefore, **peatland restoration** (rewetting) is considered the most promising way for reducing greenhouse gas emissions from drained peatlands. Based on the same principle, partial **water level rise in drained organic soils** potentially mitigates organic matter decomposition and consequent carbon dioxide emissions. Complete rewetting resulting in lower oxygen content in the topsoil, however, also increases methane (CH₄) (30 times more powerful greenhouse gas than carbon dioxide) emissions thus reducing the mitigation potential. Spikes of nitrous oxide (N₂O), a greenhouse gas 300 times more powerful than carbon dioxide, is produced under fluctuating water level regimes with high soil nitrogen availability and therefore nitrous oxide emissions are closely linked to fertilization. The scientific community lacks clear consensus on the effects of water level rise on overall greenhouse gas emissions under agricultural peatland use. Rewetting

Infobox 1: Subsoil irrigation

Subsoil irrigation is a technique used in the Netherlands and Germany to raise the water level during summer. Drainage pipes are installed below ditch water level, so that the pipes can infiltrate water during dry periods.



The increase in water level during summer from about -100 cm to -70 cm, was expected to reduce CO₂ emission. An experiment in the Netherlands showed that the yield can improve slightly due to improved drainage during wet periods, so that the land is manageable earlier in spring. Reductions in CO₂ emissions, however, were not found. The costs for this technique are €9000,- per hectare (installation + maintenance).

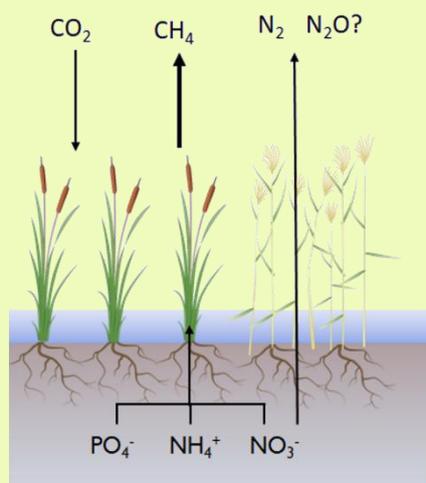
resulting in establishment of peat forming vegetation effectively mitigates greenhouse gas emissions but limits the value of harvestable biomass.

Infobox 2: Paludiculture

With paludiculture it is possible to rewet a peatland, with a water level close to surface, while still using the land for production (food, fiber or energy), with crops that are able to grow in waterlogged conditions. Typical species are *Sphagnum* (peatmos), *Typha* (cattail), *Phragmites* (reed) and *Phalaris* (reed canary grass). Paludiculture is expected to reduce greenhouse gas emissions and soil subsidence, increase biodiversity, and increase water and nutrient retention.

Some crops sequester carbon dioxide with low methane emissions (*Sphagnum*) with water levels 10 cm below the surface (*Phragmites*). Other crops require flooded soil (*Typha*) that increases methane (CH₄) emission due to the anoxic conditions. Establishing the optimal water level and avoiding input of carbon and nutrient into the system is to be therefore essential if paludiculture is used as a climate mitigation measure.

An important aspect of paludiculture is the development of the market for products, which is still in an experimental stage.



Methods are tested for greenhouse gas mitigation with water level rise at cultivated peatlands in the Nordic countries, the Netherlands, Germany and Denmark include, such as **subsoil irrigation** (infobox 1), higher ditch water level, reducing drainage and **paludiculture** (infobox 2).

Soil amendments are carried out mainly to improve trafficability and fertility of peat soils. These amendments affect soil physicochemical characteristics, such as moisture, pH and nutrient availability and can therefore change peat decomposition processes and greenhouse gas production. The impacts of **foundry sand addition** (infobox 3) on trafficability, yield and greenhouse gas mitigation potential are currently being tested e.g. in Sweden, Finland and Germany. Similarly to subsoil irrigation, results from this method are contradictory.

Ash, biochar and lime additions are being tested for their greenhouse gas reduction potential in field and laboratory experiments e.g. Finland. Management practices targeted to improve drainage and trafficability, e.g. **deep ploughing, peat inversion and grading**, are used at some regions in Northern Europe and have been lobbied for their climate mitigation potential. These methods are highly invasive, irreversible and estimated to be quite costly. To date, the climate and environmental impacts of these methods remain largely unknown. Caution is warranted when investing in extreme measures to improve trafficability of wet soils, especially since projected future increased temperature and precipitation extremes may affect the need for and the suitability of these methods.

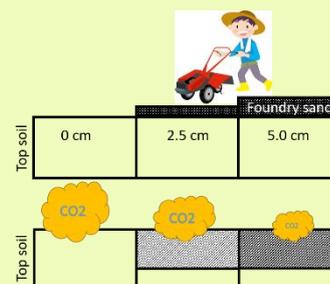
PEATWISE CASES

PEATWISE has eight case studies on drained peatlands used as grasslands or paludiculture spanning 20 degrees of latitude and covering a climate range from temperate to subarctic and from coastal to continental in Northern Europe with an additional case in New Zealand. Forest soils are tested within laboratory studies in Finland. Tested mitigation measures include **paludiculture** (three cases altogether in Denmark, the Netherlands, Germany), **subsoil irrigation** (one large pilot study in the Netherlands), impact of partial **water level rise** (four cases altogether in Finland, Norway, New Zealand), **foundry sand addition** (one case, Sweden) and **ash addition**

Infobox 3: Foundry sand addition

Due to subsidence, the risk for flooding is increased on cultivated peat soils. To improve the trafficability, 2.5 cm and 5 cm foundry sand was added and mixed into the top 10 cm of the soil.

Penetration resistance, carbon dioxide emission and yield was compared with a control without sand addition. The first results indicate 30% higher yields, 30% better trafficability and lower CO₂ emissions from plots treated with 5 cm foundry sand. The field trial was established 2014 and is still running.



(one laboratory study, Finland). The cases where partial water level rise is monitored were initiated in 2018, and therefore results are not yet available.

Subsoil irrigation has been estimated to reduce carbon dioxide emissions by up to 50%. In 2017 and 2018, **subsoil irrigation failed to reduce the greenhouse gas emissions** in the PEATWISE case study carried out as a large pilot on four dairy farms in the north of the Netherlands. Furthermore, subsoil irrigation improved the yield by less than 10%. Given the extreme dry and warm weather of 2018, the method's long-term mitigation potential cannot be reliably predicted based on these results. The lacking greenhouse gas reduction could, however, be taken as a warning, a reminder of that

the future warmer climate with expected frequent extremes may render some of today's proposed mitigation measures less efficient or harder to maintain.

The results from the PEATWISE **paludiculture** trials in the Netherlands (cattail and common reed) and Denmark (reed canary grass) highlight the generally high summer yields, that are lower (up to 50%) under nutrient limitation and after establishment. The costs of crop and land-use change depend on the land-use intensity and warrant further investigation. The first greenhouse gas data from both Denmark and the Netherlands emphasize the importance of water level in greenhouse gas mitigation at paludiculture sites. With high water level, the large methane emissions resulted in an offset in carbon dioxide emission reduction. **Paludiculture practices with high water levels (above 10 cm below surface) did not mitigate greenhouse gas emissions, but the annual greenhouse gas emissions (accounting for all three greenhouse gases) were reduced by 90%, when water level was slightly below soil surface (below 10 cm below surface).**

Foundry sand addition is mostly done for improving trafficability, but at the Swedish PEATWISE study site,

this method also **reduced soil respiration by 30%** at bare soil plots. Peat soil amendments with mineral materials need to be carefully considered on a case-by-case basis for their mitigation potential and cost-benefits. **Ash addition reduced nitrous oxide production up to 50%** in the PEATWISE laboratory experiments carried out with forestry drained peatlands.

SUMMARY

- In 2017-2018, subsoil irrigation did not mitigate greenhouse gas emissions. More research is needed to reliably assess the greenhouse gas mitigation potential of the method. Impacts of water level and soil water content on carbon dioxide production remain unclear
- Paludiculture can reduce annual greenhouse gas emissions by 90%. Water level should stay below the soil surface (below 10 cm below surface) in order to avoid large methane emissions
- Market for paludiculture products should be investigated
- Sand and ash additions give promising results and will be further tested



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