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Carbon Reduction Guidance for Farmers and Landowners

REPORT

Carbon Reduction Guidance for Farmers and Landowners

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Introduction

Over thousands of years peatlands have stored carbon from the atmosphere. Despite only covering between 3 and 5 % of land area they have accumulated more than 30% of the world's soil carbon weighing in at roughly 500 billion tons. When drained, this organic carbon returns to the atmosphere through decomposition and makes peatlands responsible for almost 6% of global total anthropogenic CO_2 emissions - twice that of aviation. "Globally the EU is the second largest emitter of greenhouse gases (GHG) from drained peatlands (220 Mt CO_2-eq./ year = 15% of total global peatland emissions)[2,3,] "These emissions can be significantly reduced by raising water levels near to the surface (e.g. by drain blocking, stop pumping in polders), which reduces emissions and protects the remaining peat carbon store."[2]

Drained peatlands lead to a substantial amount of greenhouse gas (GHG) emissions from EU Countries[1], as well as other negative effects on water quality, biodiversity and soil quality. Rewetting degraded peatlands decreases CO_2 emissions, and potentially restores the capability of peatlands as carbon sinks.

Lowland farming on peatland is also a large employer in several regions across Europe and makes significant contributions to the rural economy as well as being important in terms of food production. However, by relying heavily on the drainage of lowland peat for farming, the landscape becomes a large emitter of greenhouse gasses and will have a long-term negative effect on both climate change and flood risk management. The farmland itself will also become prone to subsidence.

Projects that focus on rewetting of degraded peatlands can have various aims including rehabilitating of degraded bogs or fens to a near-natural state, or rewetting of agricultural fields on peaty soils to carbon farms or paludiculture fields. The aim of the rewetting project determines which ecosystem services are positively affected, for example the amount of carbon stored or sequestrated, or improvement of water quality.

[1] Data compiled by Greifswald Mire Centre based on National Inventory Reports 2019. (Sectors Agriculture, LULUCF - Cropland and Grassland)

[2] Joosten (2009) The Global Peatland CO_2 Picture https://unfccc.int/sites/default/files/draftpeatlandco2report.pdf

[3] O'Brolchain, Niall & Peters, Jan & Tanneberger, Franziska. (2020). CAP Policy Brief Peatlands in the new European Union Version 4.8.

When drainage of peatlands has led to a degradation of peat soils (and thus loss of carbon), there are **two possible actions** for halting the loss of carbon from the soil :

1) Acting on preserving the carbon stock of the soil. These activities aim at halting further loss of carbon from degraded peat soils by decreasing carbon exchanges. These types of activities include:

- paludiculture with harvest (*Sphagnum/Typha* and other food/product use crops)
- rehabilitating degraded peatlands to a near-natural state via rewetting

2) Acting on increasing the carbon stock of the soil by creating a new sinks of carbon. These types of activities include:

- paludiculture with no harvest (*Sphagnum*/Carbon farming)
- rehabilitating degraded peatlands to a near-natural state via rewetting

Possibilities for Rewetting and Paludiculture

Researchers in projects such as Interreg NW Europe funded Care-Peat have demonstrated that carbon finance from restoration and emissions reductions is a potentially viable alternative source of income for some types of farming that already rely on subsidies, for example grazed pasture, or in areas of farms that are too wet for traditional agriculture.

However, the income and employment across supply chains gained from arable farming need high-value crops that can support the large farm networks and their associated communities. This is where paludiculture steps in. Paludiculture - is the term for wet agriculture on peatlands. It is a sustainable alternative to conventional farming that combines the reduction of greenhouse gas emissions from drained peatlands but still supports continued agricultural land use and the production of an income-generating crop.

Following successful plot and field scale trials a variety of crops are currently being assessed for viability at a commercial field scale. The work is examining income generation, product development and production of business cases, alongside farming methods including planting and harvesting techniques, machinery requirements and weed and pathogen control. Promising crops include *Sphagnum* farming as a replacement for peat in growing media, Reed and *Typha* as bioenergy crops, Reeds as traditional thatch, *Typha* as replacement down for textiles and also a building materials including fibreboard and insulation. Research has also examined the use of *Sphagnum* moss in a Carbon Farm – where carbon is the crop, and also wetter farming where conventional crops such as Celery or Blueberry are grown above a partially raised water table.

As the world moves towards sustainable products, the market opportunities are huge. The goose down and insulation market is worth over € 4 billion per year and if *Sphagnum* were used to replace peat in growing media the demand is 30 million m^3 in the EU. Trials of both products have proven that high quality, market-ready products can be produced.

The effect of rewetting on GHG emissions can be measured in the field, but such measurements are very expensive. It is therefore not feasible to measure GHG effects of all rewetting projects for several years. Different modelling tools to assess the effects of rewetting projects on GHG emissions are available, which are cost-effective and user-friendly. The models provide the opportunity for a farmer or land manager considering a change in practice to understand the potential GHG benefits from making a change. Ongoing research will address the knowledge gaps identified by farmers, the lack of information around the financial impact from transitioning to new crops including uncertainties in joint financing streams such as those from carbon credits, subsidies and biodiversity net gain, to understanding of effects on local and regional water management.

Understanding target groups for rewetting and use of models

In 2023, Manchester Metropolitan University and the University of Galway conducted surveys of farmer attitudes toward rewetting/wetland farming (paludiculture) in England and Ireland.
In both cases, the majority (~68%) of farmers interviewed had not heard of paludiculture, but were interested in learning more about it. Most farmers are concerned about land degradation and want to increase biodiversity to 'do the right thing' but are often most limited to market uncertainties.
Our results clearly indicated a lack of existing business case studies and an unwillingness to enter uncertain markets were the main barriers preventing uptake of paludiculture.

3.1 UK Survey

Out of the 19 participants, 15 were currently farming on peat, with 12 of them specifically operating on lowland peat. The survey primarily focused on assessing the knowledge base of land managers regarding paludiculture. Participants were asked to rate their current level of knowledge on paludiculture practices with 21% stated that they had no previous knowledge, while 26% claimed to possess a high level of knowledge. These findings suggest the existence of knowledge gaps that need to be addressed through further outreach and education.

Regarding familiarity with paludiculture products, only 10% of land managers had never heard of any of them, whilst most had some level of awareness. Food crops, Reeds and *Sphagnum* moss has a similar degree of knowledge, ahead of emerging crops such as those for medicinal purposes, building materials and biochar. In terms of barriers to uptake, 55% agreed that both unwanted effects on neighbouring land causing conflict and increased water use were issues, while 72% agreed that lack of knowledge and machinery availability were concerns (Figure 1). This indicates a need for further education around paludiculture products and on how farm businesses can incorporate them as a viable option, alongside addressing concerns around barriers to uptake through provision of evidence around flooding and support around machinery adaptions from policy makers.

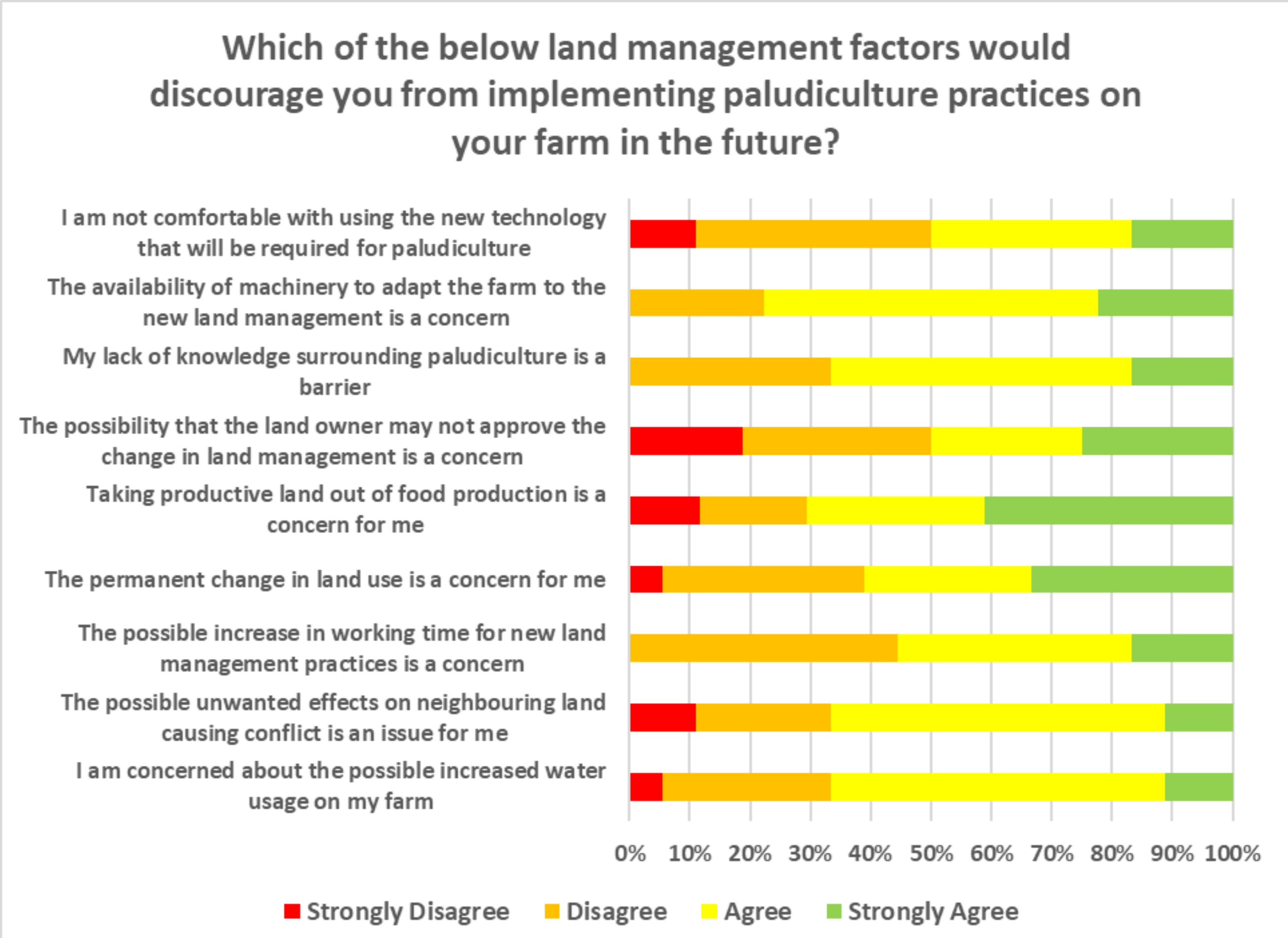

Figure 1: UK farmer survey responses for inhibiting factors to enter into paludiculture.

Inhibitors to uptake of paludiculture were dominated by financial concerns. 55% strongly agreed that paludiculture crops' profit margins posed a barrier, and 35% strongly agreed while 50% agreed that the lack of business cases for paludiculture was also a barrier. These findings suggest the presence of knowledge gaps that ongoing trials can address by providing more information on business cases and viability.

When considering the motivations that would support a farmer uptake of paludiculture (Figure 2), 72% agreed and 22% strongly agreed that the positive effect of paludiculture on climate change would be a motivating factor for adopting these practices. Additionally, 66% agreed that diversifying their farm was a good reason to consider paludiculture. However, most participants disagreed that it would reduce the overall amount of working hours on the farm, despite agreeing that it would require fewer inputs, which they considered a favourable aspect for adoption.

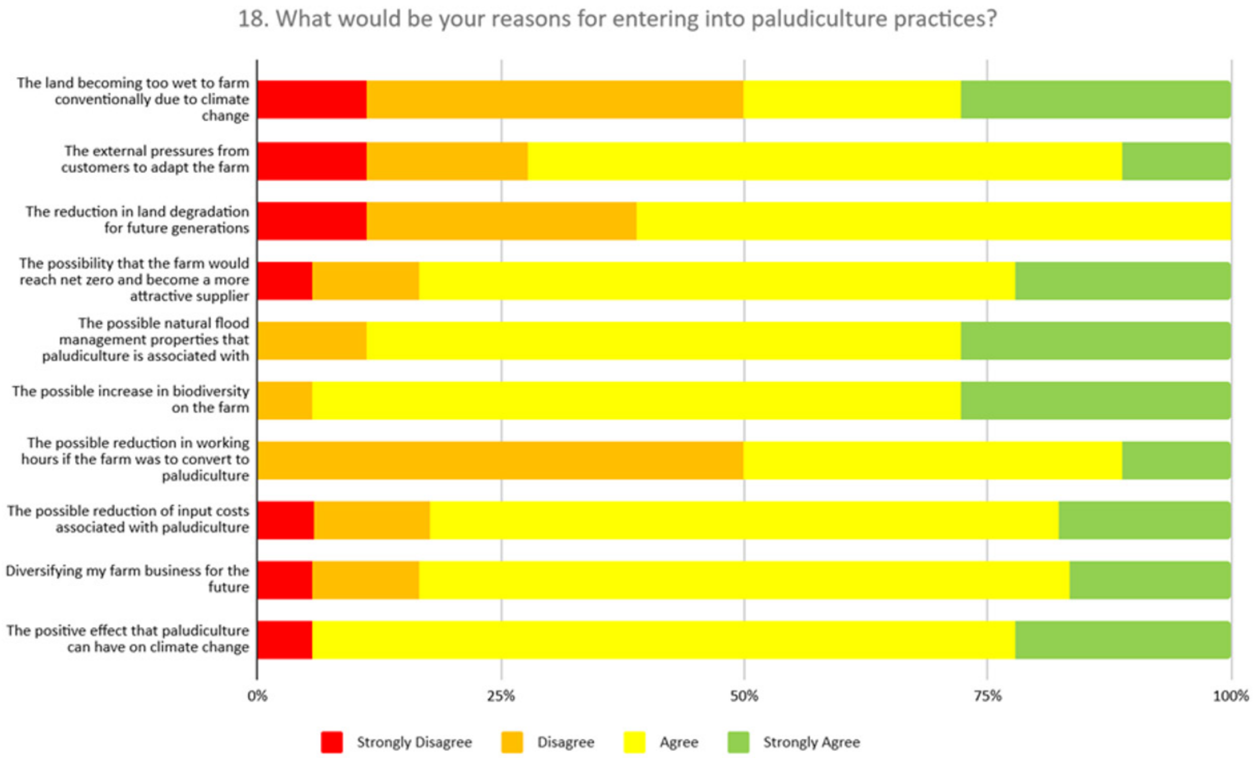

Figure 2: UK farmer survey responses for reasons to enter into paludiculture.

3.2 Irish Farmer Survey

The Irish survey was designed similar to the UK and took responses from April - July 2023. Dissemination of the survey was through contacts of the Care-Peat collaborative team, social media (Facebook, farming forums, boards.ie) and relevant media groups and government bodies. In addition, we prepared posters and attended three agricultural shows to promote uptake of the survey. At the end of the survey period, we received 48 responses. From these we interviewed five respondents for one-on-one semi-structured interviews.

The majority of responses came from those identifying at part-time farmers (57%) in the age bracket of 45-54 years old. While 67% of respondents had not heard of paludiculture, a similar percentage were interested in learning more about the practice.

Farmers were also asked to agree with different reasons for taking up paludiculture practices. Overall, Irish farmers showed their interest in long-term stewardship of their lands through choices like: 'land degradation concerns', 'increasing biodiversity', and 'diversifying farming practices' as the most important reasons. While not surprising, this indicates a need to demonstrate that maintaining water levels closer to the surface on organic rich soils will allow farmers longer term benefit.

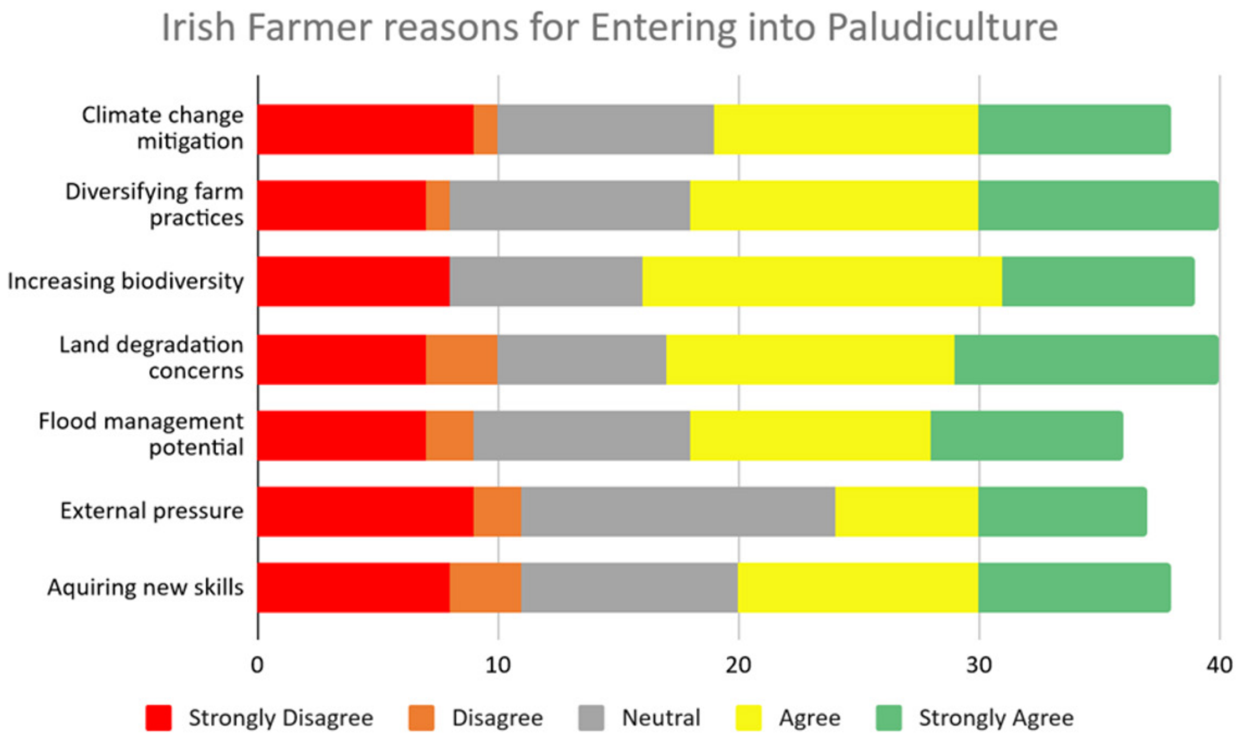

Figure 3: Irish farmer survey responses for reasons to enter into paludiculture

Perceived inhibitors toward entering paludiculture were mainly due to a lack of demonstration sites and worked examples with financial returns clearly outlined (Figure 4). Follow up interviews indicated that many are wary of the short-term schemes that encourage land practice change because of the uncertainty of financial benefit after the scheme had closed, and how it might interfere with existing payment schemes. Most environmental schemes such as those currently ongoing in Ireland (FarmPEAT, Farm Carbon) are short-term (3-4 year) projects. Longer term investments by government that add security to long-term payments are needed in order for uptake of these practices throughout the island.

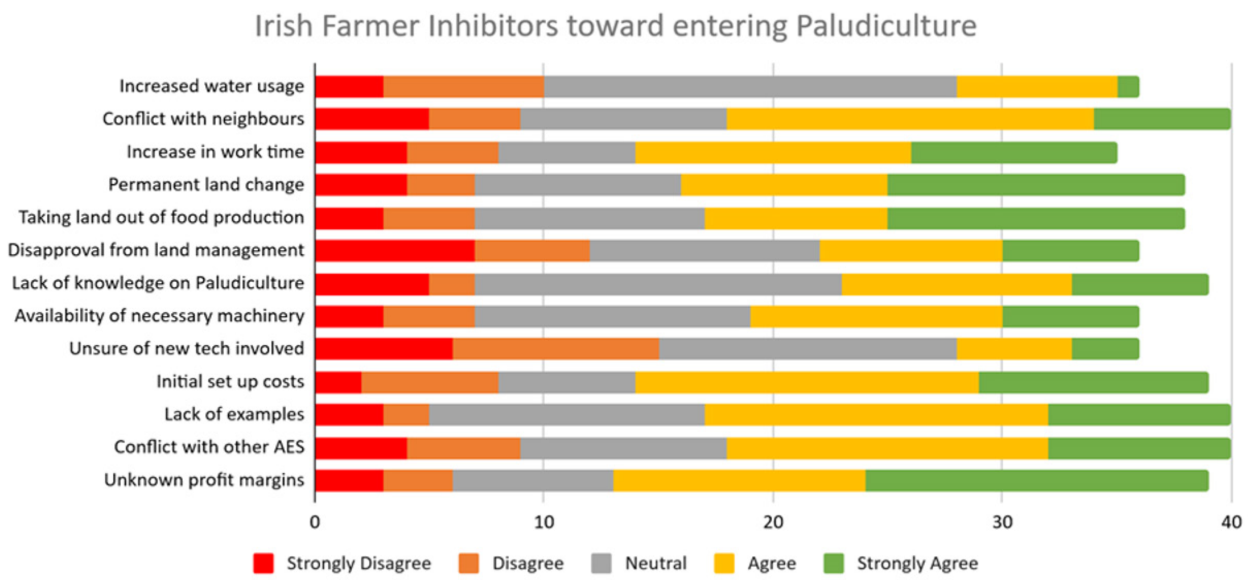

Figure 4: Irish farmer reasons against entering into paludiculture.

Interviews

Financing a project such as peatland rewetting requires significant capital. This was voiced as a serious concern by the interviewees. When asked about the potential for paludiculture in Ireland, with *Sphagnum* farming being the key topic of focus, the interviewees had concerns over the financial feasibility. Thus any large-scale rewetting programme must contain a long-term funding mechanism specifically within the farming schemes (i.e., CAP) so farmers can avail of these with risk.

With the sale of turf being banned in Ireland as of 2022, many farmers across the country have been left with degraded peatlands that are no longer providing any financial benefits to the farm. If a paludiculture system, such as *Sphagnum* moss, was to be implemented on these areas, it could benefit both the farmer and the land.

If there was to be a new legislative framework involving the introduction of paludiculture to Irish farmers, it would require significant stakeholder engagement. Of these stakeholders, the responses from both survey and interviews highlighted the need for there to be a clear differentiation between large, medium, and small-scale farmers. As one interviewee succinctly put it, “the same service pays the guy that is keeping 500 cows in Cork as the guy that's keeping 30 ewes in northern Donegal”. In order for a payment system to work, it would have to be adaptive to each stakeholder’s needs and capabilities.

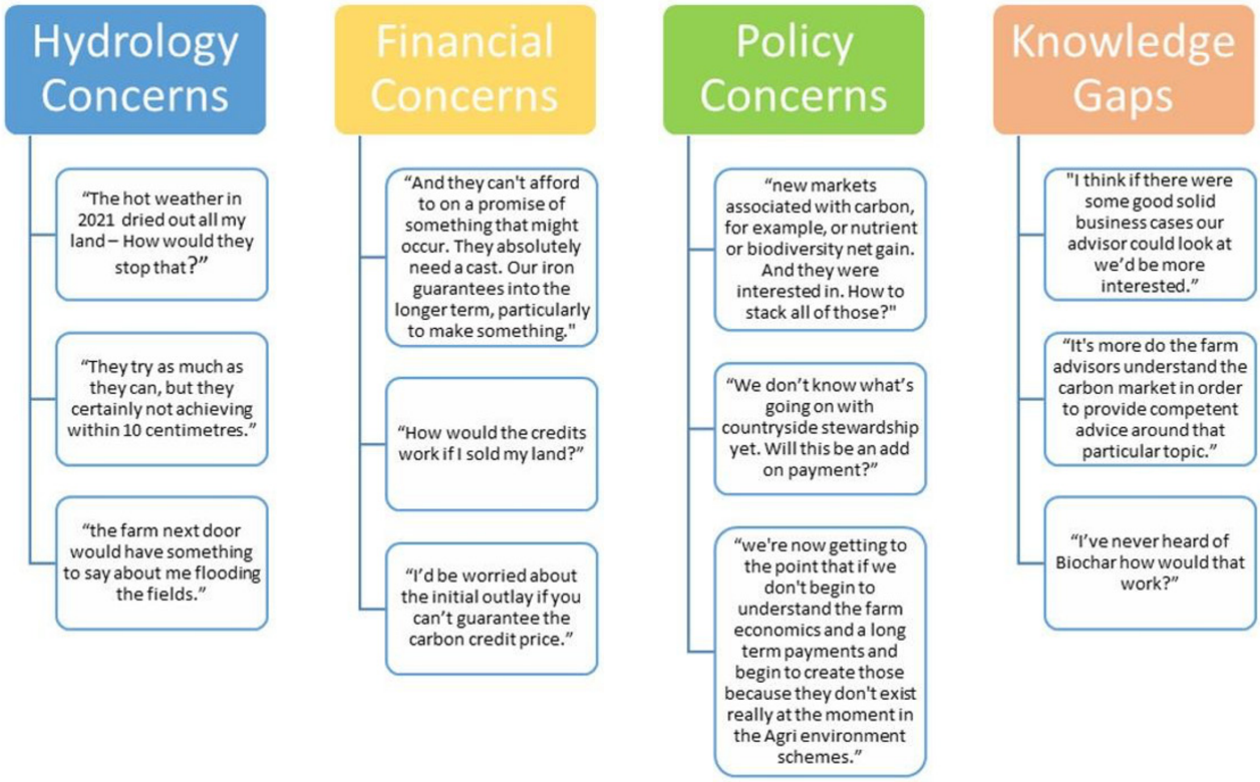

Figure 5: Quotes from land manager interviews highlighting themes of concerns.

Overview of three models

Drainage of peatlands releases large amounts of greenhouse gases (GHG), mostly CO_2. Rewetting restores ecological functioning of degraded bogs and mires, at least in part, which reduces GHG emissions. The effect of rewetting on GHG emissions can be measured in the field, but such measurements are very expensive. It is therefore not feasible to measure the GHG responses of all rewetting projects. There are several modeling tools to assess effects of rewetting projects on GHG emissions, which are much less demanding in terms of time and capital expenditure.. The models provide the opportunity for a farmer or land manager considering a change in practice to understand the potential GHG benefits from making a change. When coupled with the Pricing and Feasibility tool produced by Care-Peat, the potential income from the carbon savings can be considered.

Three modeling tools (or calculators) are demonstrated: the UK Peatland Code methodology, the Decision Support Tool developed in the main project of Care-Peat, and the Site Emission Tool (SET) developed in Interreg NWE Carbon Connects. Ease of use is estimated by the number of input parameters and the effort required to acquire these.

5.1 Care-Peat Model

The Care-Peat model was developed during the Interreg NWE Care-Peat project in order to provide a tool to peatland managers/owners to optimize the management/restoration of their sites. For that, the tool predicts their actual GreenHouse Gas (GHG) fluxes (i.e., if peatland behaves as a source/sink of carbon) but also simulates these same fluxes in case of different restoration scenarios.
The Care-Peat model is based on real time data and on the estimation of GHG emissions due both to ecosystem respiration and vegetation uptake. The ecosystem respiration mainly corresponds to the respiration of CO_2 from the soil by microbes. To keep the model as simple as possible, the water table depth was assumed to be the only parameter affecting respiration CO_2 fluxes. The estimation of the Gross Primary Production is directly related to air temperature, solar energy and vegetation types.
The tool is an EXCEL file in which two ways of calculations are possible: a general estimate based on limited information about the site (1), or a more accurate estimate based on site-specific data (2)

1. The user only knows global values corresponding either to a point measurement or a mean values based on several measurements (i.e., time series measured on one or several plots or field campaigns performed on several plots, for instance) of the investigated field. The three parameters needed are: the mean water table depth (cm depth from surface), the mean air temperature (°C) and the mean PPFD (Photosynthetic Photon Flux Density). The user fills in the boxes of the file with the 3 input data and after selecting the type of vegetation present on the studied site, the model calculates the GHG fluxes including Net Ecosystem Respiration, Gross Primary Production and Net Ecosystem Exchange.

2. The users knows the mean daily water table (m), the mean daily temperature (°C) and the mean daily PPFD (μmol/m²/s) thanks to sensors installed in the field. The user then fills in the boxes of the EXCEL file for each day of a year. Then, the user only needs to select the vegetation type in the drop-down list. The model calculates the GHG fluxes in relation with respiration, Gross Primary Production and Net Ecosystem Exchange.

Large input data are needed to apply the model, no land-management based processes are included. However, the model can help in estimating the impact of restoration work on carbon fluxes.
The rewetting and/or the modification of the vegetation are factors that can be modified in the model in order to analyse restoration scenarios and thus extrapolate the impact on GHG emissions to a future scenario.

The tool can be found here

5.2 Site Emissions Tool

The Site Emissions Tool[4] bases CO_2 and CH_4 emissions from peat soil with vegetation classes (based on an extended version of the Greenhouse Gas Site Types-database (GEST)[5] and combines this with standard IPCC Tier 1 calculations for N_2O emissions from soil and CO_2 emissions from fossil fuel use[6]. Therefore, CO_2 emissions from land management practices and N_2O emissions from fertilizer use can be estimated . Furthermore, potential production of specific crops that replace conventional fossil fuel products (e.g. for building material or substrate for horticulture) are taken into account in the avoided emissions total (including avoided emissions from fertilizer use). The tool compares two scenarios – a business-as-usual scenario and the rewetted scenario. GHG fluxes per scenario are calculated and reported in GWP (i.e. tCO_2-eq./year). The difference of tonnes of CO_2 equivalents between the two scenarios results in carbon savings. These carbon savings set a maximum of potential carbon credits (1 credit per 1 ton of CO_2 equivalent) that a project scenario can validate. The SET calculates emissions based on principles of GEST with additional estimates on N_2O emissions from agricultural practices. The calculated emissions are shown for CO_2 and CH_4 (in tCO_2-eq./year).

The SET and toolbox can be found here

[4] (van Belle & Elferink, 2021)

[5] developed by J. Couwenberg et al. (Couwenberg, et al., 2011; Couwenberg, Reichelt, & Jurasinski, in prep.)

[6] Eggleston, Buendia, Miwa, Ngara, & Tanabe, 2006

5.3 Peatland Code

The Peatland Code (IUCN, 2023)[7] is a voluntary peatland certification standard used in the UK. It allows peatland restoration projects to market the bundled benefits of restoration with a focus placed on the carbon benefits. The Peatland Code provides assurances and an audit trail for investors that their investments have produced genuine reductions in carbon emissions and that these emissions are robustly quantifiable, guaranteed for the long term and additional to other reductions. Values for the reductions in carbon emissions are derived from the UK National Greenhouse Gas Inventory[8].

To estimate before- and after-intervention emissions for each pilot site, a baseline habitat type and condition is established. This is then associated with an Emissions Factor. The baseline emissions are then compared to the restoration scenario emissions factor and an annual CO_2-eq. benefit estimated. This CO_2-eq. benefit incorporates gaseous CO_2, CH_4 and N_2O emissions from land and water, alongside fluvial Dissolved and Particulate Organic Carbon (DOC and POC). Initially, the Peatland Code focussed on upland restoration only, however, the current Version 2 of the Peatland Code provides an option for fen peatlands which brings in agricultural areas. Lowland raised bogs are also incorporated. For fen peatlands, it is possible to vary the emissions factor with site conditions based on water table depth where this is known, with increasing CO_2 emissions as the water table draws down and increasing CH_4 emissions as the water table approaches the surface (Evans et al. 2021 and 2023). Currently, it is not possible to move between Fen and Bog, for example if a farm where initial peat is classified as a fen but as nutrients and pH reduce following cessation of fertilisers and lime additions the site may restore to bog. The Peatland Code incorporates at 15% risk buffer to allow for emissions related to restoration activities and uncertainties in Emissions Factors but for the example in this guidance the overall emissions factors are used. Similarly, a transition period following intervention is incorporated but this is not included in the case study.

[7] Peatland Code 2.0, March 2023, IUCN,

[8] Brown et al., 2021, see Annex A3.4.28

Case studies

6.1 Care-Peat model - Example of the Zwarte Beek Valley, a Care-Peat pilot site of 250 ha rewetted during the project

Valley of Zwarte Beek is the biggest and best-preserved peatland in Flanders. Whilst the upstream area has some pristineness left, the Midstream area was heavily drained for agriculture and the peat layer is degraded by now. The first carbon budgets calculated from GHG measurements performed with the closed chamber technique suggest that the site emits about 6 tCO_2-eq./ha/year. One of the main reasons of these emissions was the low water table, especially during the spring and summer seasons.

Figure 6 : photos of the Zwarte Beek Vallei site and graph of the variation of the water table depth in 2020 before restoration works

The Care-Peat model allowed calculating the carbon fluxes using water table measurements recorded in some piezometers placed on the site. This current situation constituted the baseline scenario. Because of the low levels recorded in 2020, the calculated carbon fluxes are close to 6 tCO_2-eq./ha/year, in consistency with local measurements made with the closed chamber technique.

In Care-Peat, 250 ha within this Midstream region was restored within the project. The rewetting works mainly consisted of closing of internal ditches (about 15 km) and re-levelling of larger creeks. Closing these ditches gives the rainwater the chance to infiltrate again within the peat layer. This way the sponge-function is reactivated.

Figure 7 : photos of the Zwarte Beek Vallei site (closed internal ditches) and graph of the variation of the water table depth in 2021 after restoration works

The consequence of the relevelling is an increase of the mean water table depth in the peatland kike in 2021. New numerical calculations allowed calculating the new carbon fluxes. In 2021, due to the raising of the water table, the estimated carbon fluxes are close to -13 tCO_2-eq./ha/year, indicating that the site is now storing carbon.

6.2 Site Emissions Tool (farmer) - Example of Dutch dairy farm of 60 ha, with 80 dairy cows. The farm will transition to a *Typha* farm for building material.

A dairy farmer of an average Dutch dairy farm of 60 ha with 80 cows in the north of the Netherlands, farming on peat pasture meadows, is looking into options for rewetting part of the 60 ha farm for *Typha* farming and carbon credits. In the current situation (the baseline scenario), the groundwater level of the dairy farm in summer is around -60 cm relative to the surface . Animal manure is applied to the fields (roughly 230 kg/N/ha), with an average number of grazing days of 150 days per year. The farmer wants to establish a 10 ha *Typha* farm with water levels above the surface, and use the *Typha* as building material. The estimated yield for the *Typha* is 5 tons of dry matter/ha (no use of fertilizer). By using the SET, the emissions for the baseline and project scenario (*Typha* farm), and potential carbon credits are estimated.

The emissions of the baseline scenario consisting of the vegetation class (GEST), fertilizer use (part of N_2O), and activity fuel costs amount up to a total Global Warming Potential (GWP) of 370.9 (tCO_2-eq./year) for the 10 ha site. The emissions of the project scenario consisting of the vegetation class (GEST), activity fuel costs, and product use amount up to a total GWP of -7.5 (tCO_2-eq./year) for the 10 ha site.

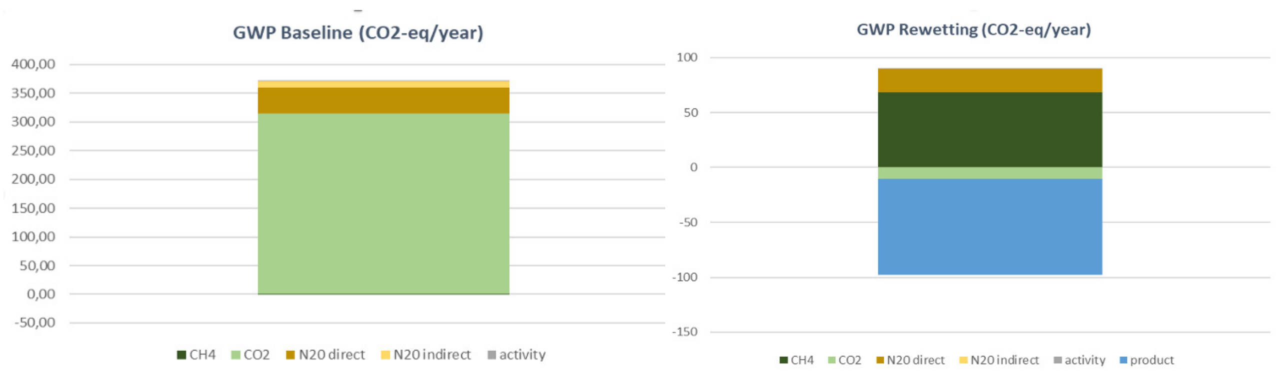

Figure 8: Example outputs from the Site Emission Tool covering baseline and rewetting emissions

Carbon savings

The difference between the total GWP of the baseline and project scenario is the "Savings total", which in this case is 378.3 tCO_2-eq./year. This means that potentially 378.3 carbon credits could be validated for this project per year. After 35 years, the carbon credit potential drops, since the peat layer in the baseline scenario would have been depleted (based on 50 cm of peat layer in 2022). Therefore, the savings stock part (257 tCO_2-eq./year) of the total savings is no longer available for crediting. The savings flow (34.2 tCO_2-eq./year) coming from the emissions avoided from fertilizer use, and emissions avoided from product use (87.1 tCO_2-eq./year) are still available for crediting after these 35 years.

6.3 Peatland Code – Example of the Carbon Farm, created from Grazed Pasture as part of Care-Peat

The baseline habitat of Winmarleigh Moss is drained and grazed pasture, it is dominated by grassland vegetation and is fertilised to promote growth of grass as food for sheep and cattle farming (Figure 9). The site sits on around 1.5 metres of peat. The upper layer is oxidised and decomposed but lower down the peat is well preserved. This peatland type sits best within the Fen Calculator and the specific 'Intensive Grassland' type. The Fen Calculator uses water table depth (WTD), in the first year the average depth was 45.9 cm, in the second year of the pilot the average depth was 42.1 cm below the surface, in both years the depth ranged from close to the surface to up to 100 cm below. The mean of the two years' data of 44 cm below is used here and produces original annual emissions of 18 tCO_2-eq./ha/yr.

Figure 9: The Winmarleigh Grazed Pasture (left) and Carbon Farm area (right).

During conversion to Carbon Farm the top 10 cm of nutrient rich topsoil was stripped, used to block ditches and create bunds around the site and a solar powered irrigation system was installed to maintain WTD. In the first year the mean WTD of the Carbon Farm was 16.6 cm and in year 2, 10.4 cm. These produce a mean WTD of 13.5 cm which produces annual emissions of 2.7 tCO_2-eq./ha/yr and a reduction of 15.3 tCO_2-eq./ha/yr.

It should be noted that topsoil stripping is not allowed in the Peatland Code, however, the topsoil removal had the effect of creating conditions (pH and nutrients) and vegetation (*Sphagnum* moss) more closely associated with lowland raised bog, if this peatland type was used then a post-restoration scenario of 1.6 tCO_2-eq./ha/yr is produced.

Financial feasibility & Pricing Tool: Examining the business case for carbon farming

Potential income from voluntary carbon offsetting has been explored (Table 1) using a financial feasibility and pricing tool specifically designed for carbon credits. This example explores the potential carbon income relative to establishment costs for transforming a 28 ha field currently growing feed Spring Barley to a restoration scenario.

The scenarios shown include the establishment costings of the Care-Peat Carbon Farm £74,700 of per ha, a more typical lowland peatland restoration figure of £15,000 per ha, and an indicative lower cost intervention of £6,000 per ha. They also consider if a loan is needed to undertake the works assuming a 50 year carbon offsetting agreement is in place. For each initial investment under each scenario the break- even carbon prices are shown; the break-even carbon price is the minimum each credit must be sold at to cover all costs over the investment period.

An assumed carbon emission reduction of 34 CO_2-eq. per hectare is used based on a hypothetical output from the models examined in the previous section in this report. Then, for each investment scenario, the profit or loss made per hectare per year by selling the available carbon credits at different market prices were demonstrated. The carbon credit prices used were £20 per CO_2-eq. (mid-point IUCN UK Peatland Code pending issuance unit prices) and £40, £80 and £120 per CO_2-eq. (low, central and high forecasted short-term trading prices in UK by 2030).

The break-even carbon prices are shown, these are the selling prices that cover all costs over the investment period. Whilst the break-even price for the carbon farm pilot is very high with a loan (£305.92/CO_2-eq.), the break-even prices for typical restoration and lower-cost intervention at more realistic prices of £62.40 and £25.70 CO_2-eq. In all cases the use of investment at 5% interest has a large impact on feasibility, highlighting that availability of low-rate capital will be important in achieving change for some landowners.

Table 1. Example outputs from the pricing and feasibility tool showing break even carbon prices and carbon 'profit' achieved at different carbon sales prices and under different cost scenarios. Figures are based on converting a 28 ha arable farm to carbon farm and a 50 year project length.

Project length 50 years, GHG reduction of 34 tonnes CO_2e per year per hectare; project size 28 ha	Carbon Farm cost		Typical peatland restoration cost		Low-cost intervention	
	£74,700 per ha		£15,000 per ha		£6,000 per ha	
	without loan	with loan @5%	without loan	with loan @5%	without loan	with loan @5%
Break even carbon price/t	£50.88	£305.92	£11.19	£62.40	£5.21	£25.70
Profit/ha/yr @ £20/t carbon	N/A	N/A	£265.29	N/A	£445.29	N/A
Profit/ha/yr @ £40/t carbon	N/A	N/A	£866.98	N/A	£1046.98	£430.67
Profit/ha/yr @ £80/t carbon	£876.36	N/A	£2,070.36	£529.60	£2,250.36	£1,032.37
Profit/ha/yr @ £120/t carbon	£2,079.75	N/A	£3,273.75	£1,732.98	£4,835.25	£3,972.42

In the Netherlands, CO_2-certificates (carbon credits) were sold for €70 per credit, while other sources mention €25-€50 per credit[9,10,11].

Audit costs also have an impact on feasibility, for example without the break-even prices (without loans) for the different cost scenarios on our 28 ha farm is £49.67/t, £9.98/t and £4/t. For small schemes these will have a larger impact, for larger schemes they represent a lower proportion of total costs highlighting opportunities for neighboring landowners to form 'Carbon Cooperatives' to share these costs,
or the development of techniques that can audit sites remotely and at lower cost. At carbon prices above
£40/t and particularly £80/t, feasibility increases dramatically for the typical restoration and lower cost intervention scenarios, and at higher carbon prices the income per hectare becomes highly favourable. The integration of carbon (restoration) farming practices such as rewetting the soil therefore has the potential to not only reduce carbon emissions but also offer economic advantages.

These practices can contribute to the enhancement of soil fertility, water retention, and biodiversity, which can lead to improved crop yields and overall farm productivity. Additionally, the market demand for sustainably produced agricultural products is growing, providing opportunities for farms that adopt environmentally friendly practices. Recognizing this potential, farmers could align environmental responsibility with financial sustainability and position themselves for a profitable future.

9 https://nationaleco2markt.nl/wp-content/uploads/2022/04/Marktverkenning-vrijwillige-koolstofmarkt-Nederland.pdf

10 https://platformco2neutraal.nl/

11 https://www.mnh.nl/project/valuta-voor-veen/#:~:text=00%3A00-,Koolstofbank,%E2%82%AC50%20euro%20per%20credit.

Summary and general recommendations

The models are mainly developed for peatlands from Western and Northern Europe.However, each peatland is unique due to the complexity of these ecosystems and many parameters can impact the gaseous carbon fluxes: peat composition, water chemical composition, nutrient input, weather conditions, etc. Only a devoted and integrated study on a site could give more accurate results. General findings from our scenarios using these tools across five countries, water levels greatly affect model outputs (i.e., emissions reductions), more so than reducing cattle or management options.

Table 2. Benefits and Limitations of models and tools including the Peatland Code, Site Emissions Tool (SET) and the Care-Peat model.

Models	Benefits	Limitations
All models	Less costly than continuous monitoring, based on proxies (vegetation, WTD etc)	Long-term monitoring data from empirical models mostly based on natural peatlands instead of rewetted/carbon farm/paludi
Peatland code, SET	Empirical models – emissions factors based on long-term monitoring data can be broadly applicable for different project scenarios to provide (rough) estimates. Simple to use.	Empirical models not applicable in all biogeographical regions in NW-Europe. Emissions Factor categories may not closely reflect the peatland type or crop.
Care-Peat model	Process based models for specific sites – calibrated per site and provide a more robust estimate	Inherent uncertainties regarding monitoring input data in models, model approach. Provides challenges for extrapolating their use to other sites and application of models for e.g. carbon crediting.

In conclusion, no one tool is "best", but they are complementary. We recommend using each tool and try different approaches to learn how site conditions change the GHGs at your site.

We could however propose some suggestions for Farmers/Landowners:

Contact your local agricultural advisor or peatland group to learn how.

For site managers, we propose to go a little bit further in the knowledge of their site by recommending:

1. Plan to measure groundwater and site information on a long-term period to define the baseline scenario.
2. Use the models to calculate the GHG fluxes and to compare with measurements in order to ensure the good response of the models.
3. Simulate restoration scenarios (like rewetting, vegetation changes…) with models and estimate the impact of these restoration on GHGs fluxes.

Links

Beadamoss - *Sphagnum* propagation company (https://beadamoss.com)

Interreg Carbon Connects
CCONNECTS - Carbon Connects | Interreg NWE (nweurope.eu/cconnects)

Interreg Care-Peat - Carbon loss reduction from peatlands: an integrated approach | Interreg NWE (nweurope.eu/care-peat)

Interreg CANAPE, Interreg North Sea Region Programme (northsearegion.eu/canape/)

IUCN Peatland Code Peatland Code | IUCN UK Peatland Programme (iucn-uk-peatlandprogramme.org)

Lancashire Wildlife Trust, The Wildlife Trust for Lancashire, Manchester and North Merseyside (lancswt.org.uk)
More information on Winmarleigh Carbon Farm: https://www.lancswt.org.uk/our-work/projects/peatland-restoration/winmarleigh-carbon-farm

Life Multi Peat Peatland Policy Hub including the SET Tool and the Pricing and Feasibility Tool http://multipeat.insight-centre.org/

Saltyco sustainable textiles from *Typha* saltyco® (https://www.ponda.bio)

United Kingdom Paludiculture Knowledge Hub (www.paludiculture.org.uk)

Veenweiden Innovatie Programma Nederland (https://vip-nl.nl/english)

Interreg North-West Europe

Care-Peat

European Regional Development Fund

EUROPEAN UNION

Eurosite

brgm — Geoscience for a sustainable Earth

Manchester Metropolitan University

natuurpunt

Ollscoil na Gaillimhe — University of Galway

Insight — Centre for Data Analytics

Université d'Orléans

cnrs

The Wildlife Trust for Lancashire Manchester & North Merseyside

Natuurmonumenten

Université de Rennes

North Wales Wildlife Trust — Ymddiriedolaeth Natur Gogledd Cymru

van hall larenstein — university of applied sciences