Vegetable Production on Lowland Peat:

Delivering food security, climate change mitigation and biodiversity

NIAB

UK Centre for Ecology & Hydrology

Authors
Jennifer Rhymes, UKCEH
Christopher Evans, UKCEH
Elizabeth Stockdale, NIAB
Bruce Napier, NIAB

Acknowledgements
Produced by UK Centre for Hydrology and Ecology (UKCEH) and NIAB, on behalf of the WWF/Tesco Partnership Sustainable Agriculture workstream.

Working together

Background
Globally we are facing a triple challenge, to deliver food security, maintain/restore biodiversity and mitigate climate change. Vegetable production on drained lowland peat has resulted in highly productive but deeply unsustainable agricultural systems. For example, vegetable crop production on lowland peat in the UK produces approximately 40% of all UK grown vegetables, yet it also has the highest carbon emissions per unit area of any land-use in the UK.

To tackle these issues requires a combined, landscape-scale approach that supports continued vegetable production based on regenerative farming practices, together with the release of some land for restoration or wetter farming practices such as biomass production or carbon farming. This may require some expansion of vegetable production elsewhere, on mineral soils or as part of indoor farming systems.

This booklet is for UK farmers and growers who are producing crops on lowland peat and may be looking at ways to reduce their greenhouse gas emissions through water table management and alternative production methods.

About this booklet
This booklet highlights the barriers to and opportunities for moving towards sustainable lowland peat landscapes that can deliver food security, restore biodiversity and mitigate climate change (what we call the "Triple Challenge").

It explores what regenerative vegetable production looks like on lowland peat soils alongside other opportunities for farming on wetter soils to reduce greenhouse gas emissions and improve biodiversity.

It also examines what farmers and growers are already doing to address the Triple Challenge on lowland peat soils.

For more information contact Dr Jennifer Rhymes at jenrhy@ceh.ac.uk

1. What is regenerative vegetable production? What does this look like on peat?

Regenerative vegetable production can be defined as the profitable production of vegetables, which at the same time improves soil and biodiversity and reduces greenhouse gas emissions. Generally, regenerative practices are associated with reduced soil disturbance, targeted nutrient and pest management, and diversified cropping systems (with cover crops and companion crops integrated into the rotation alongside harvested crops). However, because drained peat soils have much higher background CO_2 emissions compared to mineral soils (this is because peat decomposes rapidly when exposed to oxygen) CO_2 emissions are still higher despite regenerative practices being implemented (e.g. reduced till) when the peat continues to be drained.

To address this, ***regenerative practices need to be combined with wetter soil management*** (Figure 1).The wetter the peat can be managed, whilst still allowing access for machinery and successful crop growth, the less CO_2 is emitted. A small increase in the water table may reduce rooting depth, but should not affect existing yields and may reduce irrigation requirements. However it may increase the risk of crop failure due to sudden flooding events at certain times of year.

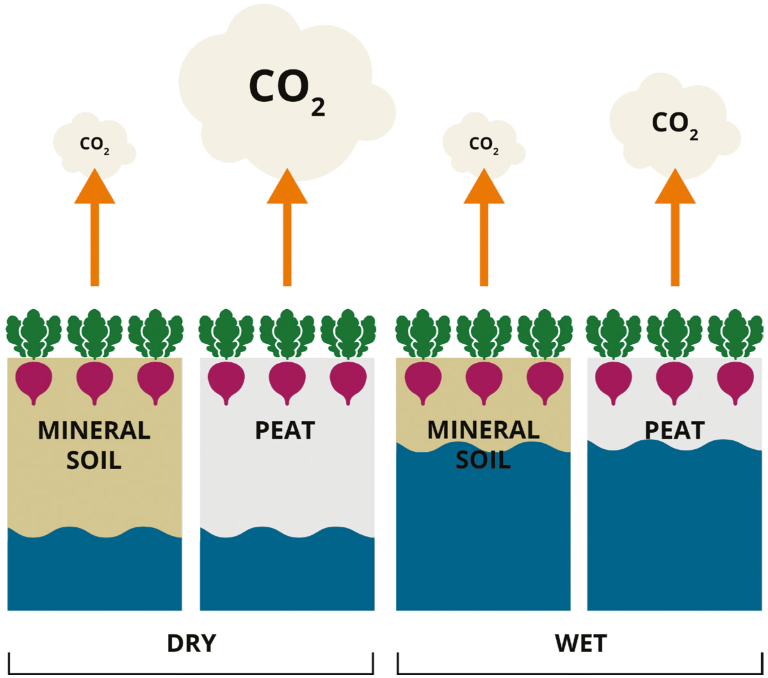

Figure 1 – Differences in CO_2 emissions under different soil moisture conditions that still allow for crop production on mineral and peat soils that practice the same regenerative practices (e.g. reduced tillage).

2. What other things work on wetter lowland peats?

Shifting towards wetter methods of vegetable production on peat will reduce the amount of CO2 emitted. However, any continued drainage is likely to lead to some unavoidable CO2 emissions. This means it will be difficult or impossible for farming systems reliant on peat drainage to be truly carbon-neutral. To achieve 'Net Zero' greenhouse gas emissions across lowland peat landscapes may therefore require some land to be taken out of vegetable production, to enable management that protects or even sequesters carbon. This does not necessarily mean that land must be taken out of production entirely – opportunities for wetter cropping systems, often termed paludiculture, and currently being developed and tested in the UK;

Paludiculture - wetter cropping systems could include plants used for bioenergy and/or construction material, or food crops such as celery and watercress management). It is important to be wet, but not too wet.

Paludiculture is intended to maintain the productive use of the land alongside carbon sequestration through peat formation. However, careful water management is needed; too dry will result in continued CO2 emissions, but too wet and soils will start to emit methane (CH4), another greenhouse gas that is 27x more potent than CO2 (Figure 2). Water management needs to be carried out with some precision. This is likely to require more farm reservoirs and water distribution systems such as subsurface drains to store and manage water locally. Additional benefits from optimised water management will see reduced N2O emissions under wetter conditions, another potent gas that is 273x more powerful than CO2. Reduced fertiliser use can also reduce N2O emissions.

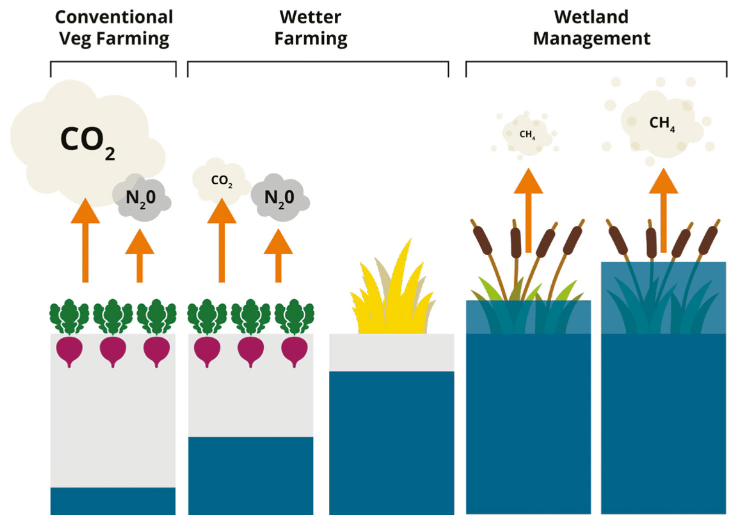

Figure 2 – Greenhouse gas emissions under different water management and land uses (conventional, wetter farming and wetland). Wetter farming involves continued productive use of the land, whereas wetland management is more focused on other objectives such as carbon sequestration or enhancing biodiversity.

Other options for land use with wetter soils include:

Solar farming – installing a large collection of solar panels over wet peat to sell electricity to the grid, reduce existing power costs on farm or to power other innovations on the farm (e.g. vertical farm). Solar farming is not necessarily incompatible with continued productive use of the land, although it is unlikely to support intensive cropping systems. Most solar farms on peat are currently drained, but there is no reason why this needs to remain the case.

Carbon farming – agricultural practices that are specifically intended to remove CO2 from the atmosphere and convert it into plant material and soil organic matter. This has traditionally involved wetland restoration, typically with biodiversity benefits as the primary objective, but with the growth of the carbon finance sector there is growing potential to apply agronomic practices to land-management with the specific aim of capturing and storing carbon.
Carbon farming could occur in conjunction with other wetter farming opportunities such as paludiculture, or alongside areas of more conventional crop production.

3. Where will the vegetables come from?

Given that lowland peat areas plays an integral role in supplying the UK's food production, large-scale changes in the use of agricultural peatlands could negatively affect overall food supply, especially for vegetables. To meet this shortfall without increasing reliance on imports, we would need to either grow more food on less land, or to relocate some vegetable production away from peaty soils to areas with relatively high fertility and water availability. Increasing vegetable production on mineral soils elsewhere in the UK may mean higher costs of production and would need to be accompanied by investments in infrastructure and supportive policy.

Across the UK, there is a higher proportion of cereal crops grown on lowland peat (Fig3; 41% in 2021) than vegetables (Fig 3; 21% in 2021), but more of the vegetable production occurs on remaining areas of thicker peat, with cereals more commonly grown on thinner peat soils. Displacing lower-value crops such as cereals and beet crops to mineral soils, prioritising fodder crops for displacement over crops grown for human consumption,whilst retaining (but minimising the impact of) high-value vegetable production on lowland peat soils might deliver the same level of emissions reduction, with fewer impacts on the economy, overall food supply or other aspects of the environment. The cultivation of maize for biofuel production on drained peats generates high CO2 emissions whilst making no contribution to food supply, and would be better undertaken on mineral soils where emissions will be far lower.

Another option is for some production to move indoors;

Indoor vertical farming – Vertical farming facilities powered by on-farm renewables extending vegetable growing seasons and add a multidimensionality to production, which can see yields increase by 20% per unit area of land footprint grown conventionally. Herbs and leafy greens are the typical crops grown in these facilities. Indoor farming could operate alongside some of the approaches described above, for example if on-farm solar, wind or wetland-based bioenergy production is used to power an indoor farming system. However the production of lower-value, higher-volume crops such as root vegetables remains uneconomic at present.

Proportion of crops grown on UK lowland peat in 2021

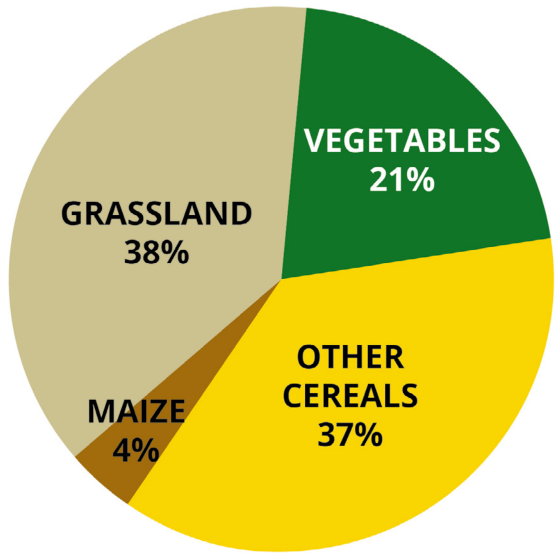

Figure 3 – Proportion of crop types grown on UK lowland peat in 2021. Maize separated from other cereals as it is often grown for fodder and bioenergy.

4. What might meeting the triple challenge look like at farm and landscape scale?

Each of the farming options discussed are associated with their own set of trade-offs. Typically, the practices associated with very productive land result in lower biodiversity benefits and higher environmental impacts, whilst farming practices on less productive land have fewer disbenefits. These triple challenge trade-offs are summarised in figure 4.

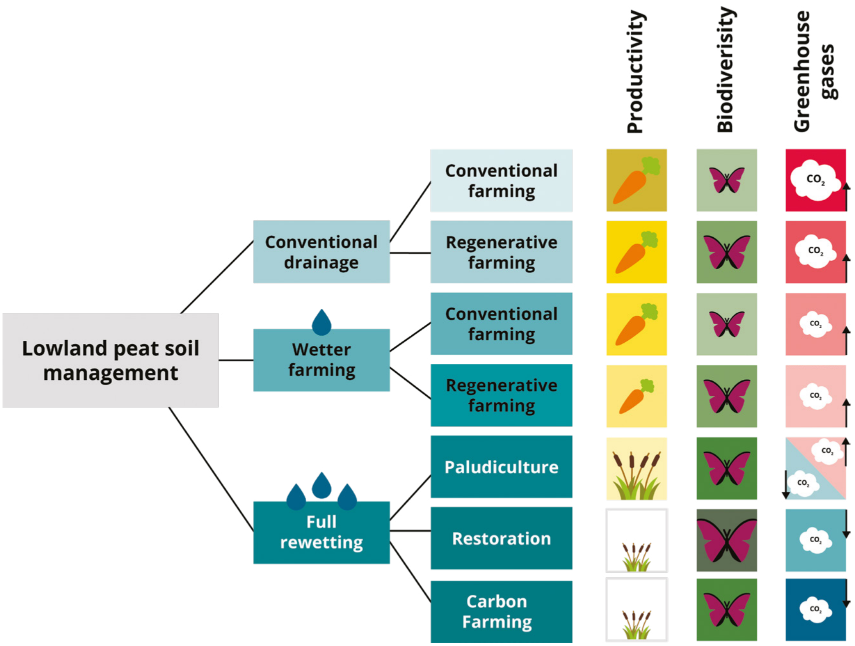

Figure 4 -The triple challenge trade-offs on lowland peat - How lowland peat soil management can impact vegetable productivity, biodiversity and greenhouse gas emissions.

Lowland peat landscapes that deliver healthy food, biodiversity, low or net-zero carbon emissions and enhance natural capital are likely to have a mosaic of **continued high value cropping systems under wetter conditions** (arable and vegetable crops) integrated with **alternative wetter land use opportunities** (e.g. paludiculture or carbon farming) **or wetland management,** together with an integrated system of water management (Figure 5). Water availability is key in deciding which areas are suitable for different land uses and water management. Often changes in soil moisture management in one field can also alter the soil moisture of surrounding land (depending on the water management approach), so in many cases it will be essential that neighbouring landowners work collaboratively. An integrated farming landscape will need to take account of the existing character of the land – for example land adjacent to river channels could be converted to wetland management, providing flood storage in winter and a supply of water for irrigation in summer (similar to the existing role of areas such as the Ouse Washes in the Fens).

Harder-to-drain land might be converted to paludiculture or carbon farming, while the highest value, most drainable land might be retained for crop production, but kept wetter than before using improved irrigation systems and water stored elsewhere in the landscape. Renewable energy production and indoor farming could enable yields to be maintained on a smaller land footprint.

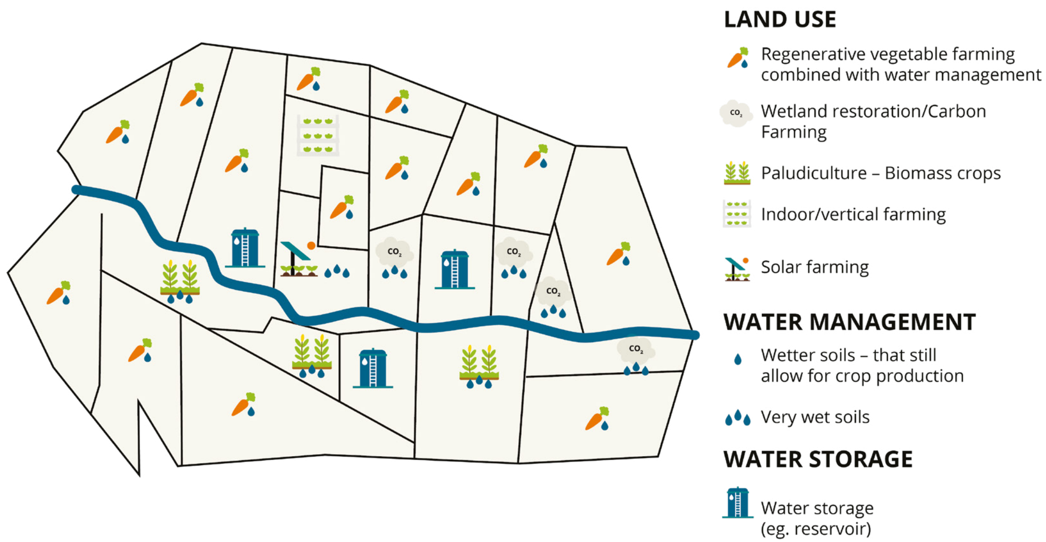

Figure 5 – What regenerative farming on lowland peat might look like across a landscape.

5. What are farmers doing in response?

'I've increased the size of my farm reservoir so I can keep my peat soils wetter through surface irrigation.'

'I have some fields on deep peat where we can laser level them and then use the drainage system to provide sub-surface irrigation for veg crops. We have good water level control and so can raise summer water tables to about 40cm'

'This year I have tried raising the water table in the field by keeping the ditches full. The field is hydrologically isolated so there haven't been any problems for neighbours. But the drought meant that we have really struggled to keep the water table in the middle of the field above 60 cm'

'On our mineral (sandy loam) soils including a grass ley in the rotation really made a difference to the soil structure making the soil hold together in crumbs, as well as darker in colour (more organic matter). When we put a ley in on the peat soils, it made no visible difference.'

'We are actively reducing tillage intensity wherever we can by reducing the number of operations and also reducing the depth we disturb soil, if at all.'

'We have a solar farm. But that land is now able to be maintained wetter which is better for the peat and we've also introduced some low-growing herbs and flowers which is great for biodiversity'

'Hedges aren't really a thing locally. Not sure if they would grow? Our fields are divided by ditches, but by managing the ditch banks to create diverse vegetation, we've increased the number of water voles.'

'We have focussed on using a range of different species mixtures alongside the tracks and in field margins. Some of the plants are there to support pollinators and others are there to support the insects that support the birds. I've been really pleased to see the difference it has made and it's created a real 'buzz' in the local community too.'

'We have taken some peat out of veg production and are working with the local conservation group on a restoration project. We have increased veg production on our mineral soils to maintain output, but they need more fertiliser and irrigation.'

'We use cover crops on the peat soil to slow down wind speed and bind the dry particles together so the soil doesn't blow away. We use cover crops on the mineral soils to reduce the impact of rainfall on the soil surface which leads to slumping and capping. Different species and mixture s do different things and we are also learning how best to use the cover crops to control soil-borne pests.'