The economic case for rewetting England's patchy lowland peat

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Abstract

Peatland provides significant value to English food production and economy, with their drainage and use leading to extensive degradation and GHG emissions. Although some agri-environmental policies support paludiculture, there remains significant uncertainty as to the private and public benefit of adopting paludiculture by landholders, especially in landscapes where lowland peats are patchy. Using a case study approach, we define the private and social benefits of six landholders in the West Midlands of England adopting paludiculture or peatland restoration for biodiversity markets to minimise or reverse further lowland peat degradation. A stochastic bioeconomic modelling approach is applied which integrates land use alternatives, payments from agri-environmental policies, and monetisation of biodiversity net gains when lowland peats are restored for habitat gain.

In addition to the substantial capital costs of rewetting a catchment, land use opportunity costs, and regulatory and compliance costs affects the minimum feasible scale of rewetting lowland peat. These present significant barriers to the adoption of paludiculture, and current agri-environmental policies and payments are unlikely to be conducive to the adoption of paludiculture in small scale non-contiguous lowland peat. This puts at risk extensive areas of fragmented lowland peat and may result in continued lowland peat degradation, agriculture's contribution to GHG emissions and catchments not benefiting from the flood mitigation and biodiversity gain opportunities rewetting lowland peat provides. Monetisation of biodiversity net gains when restoring lowland peat habitats potentially offers the most economically beneficial pathway to protecting England's patchy lowland peats.

Keywords: Paludiculture, Biodiversity Net Gain, stochastic bioeconomic modelling

JEL code: Agricultural Economics, Q1

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1. Introduction

Peatlands provide significant value to food production and the English economy. A large proportion of peatlands in England have been drained for agricultural production and its continued use has led to extensive degradation and GHG emissions (Defra, 2023). In the UK, it is estimated that 80% of peatlands are in a degraded condition (JNCC, 2011; IUCN, 2024). The capacity of these degraded peatlands to store carbon is limited, resulting in them being a carbon source rather than a carbon sink and threatening other important ecosystems services they provide (Glenk and Martin-Ortega, 2018).

Strategies currently being pursued to avoid continued GHG emissions from the ongoing degradation of peatland is through the rewetting of peatland (Defra, 2023). The increase in the water table to within 10-30cm of the surface is theoretically believed to minimise total GHG emissions (including methane and nitrous oxide emissions) (Evans, Peacock et al., 2021). This requires a shift in land use into either peatland restoration or paludiculture. There are several options for paludiculture on peatland, but each with their challenges and expected differences in their net effect on GHG emissions, biodiversity and other externalities within a catchment.

There are several regulatory and consultative requirements for water impoundment and abstraction within a catchment that need to be met, as well as the capital and operational costs of adopting paludiculture practices or for peatland restoration (Moxey and Moran, 2014). Although there are some agri-environmental policies that support paludiculture (e.g. the Sustainable Farming Incentive (SFI) scheme, and actions CSW17 and CSW18 as part of England’s Countryside Stewardship Higher Tier), there remains significant uncertainty as to the private and public benefit of adopting paludiculture or peatland restoration (Moxey and Moran, 2014). This uncertainty is further exacerbated in landscapes where peatlands are patchy, being both smaller in scale and non-contiguous. The aim of this study is to investigate the private benefits and risks for landholders adopting paludiculture practices on patchy lowland peats or rewetting patchy lowland peat for creating monetizable biodiversity habitats.

2. Materials & methods

A stochastic economic modelling approach is applied which integrates land use alternatives, and monetisation of any biodiversity net gains (Figure 1). The framework utilises assessments of the effects of land use change on biodiversity net gain (BNG) and identified farmer/landholder preferences for alternative lowland peat rewetting options. Any capital and operational costs of establishing and managing rewetted lowland peat, as well as any regulatory and compliance costs, are also integrated. Four scenarios are modelled:

1) **Business as usual**: The baseline situation which represents business as usual for the existing farming system and use of lowland peat.
2) **No support**: The rewetting of lowland peat with a change in land use but no subsidy payments or support is received.

3) **CSHT supported**: The rewetting of lowland peat and change in land use supported by agri-environmental policies and payments.[*]
4) **BNG market**: Rewetting of the lowland peat and through habitat creation and management, monetise any BNG uplift (excludes any agri-environmental policies or payments available).

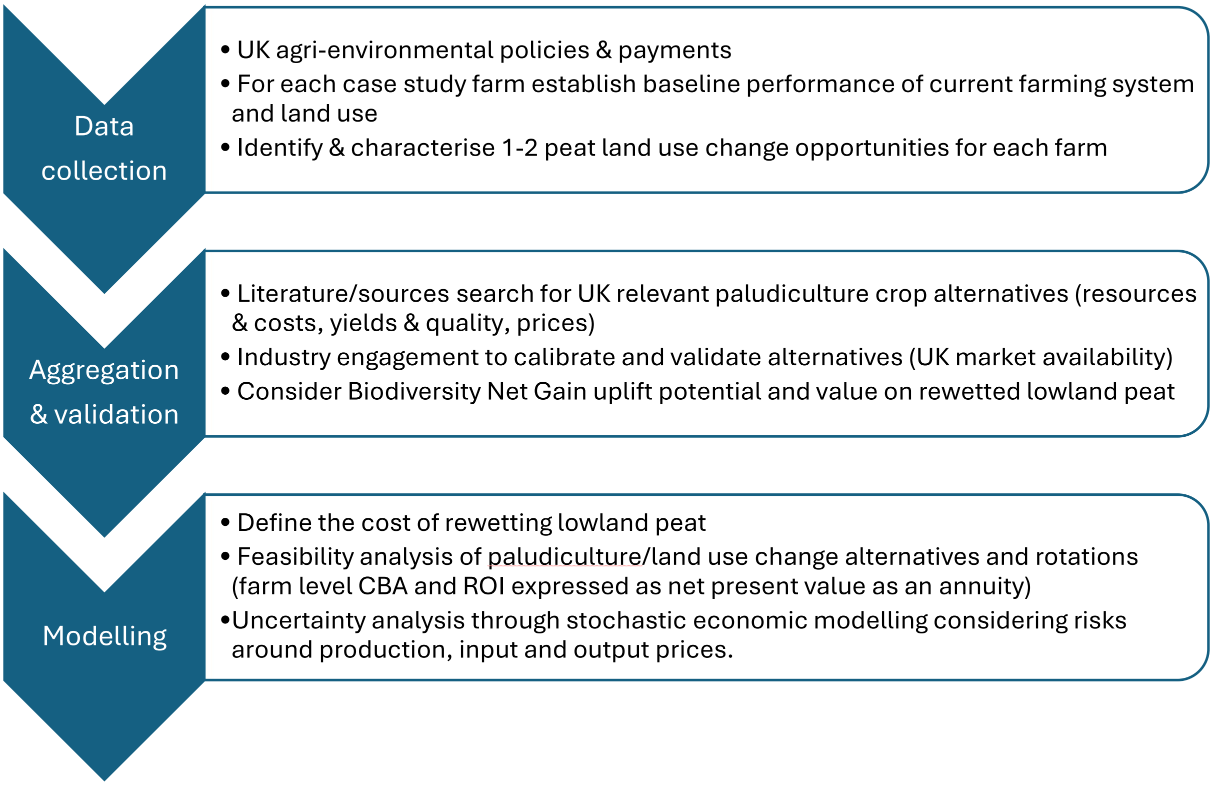

Figure 1: Methodology applied to undertake lowland peat rewetting feasibility study.

Farm level economic feasibility

The economic assessment of land use change on specifically identified areas of lowland peat at the farm level uses an *ex ante* private Cost-Benefit Analysis (CBA) approach with Monte Carlo simulation (Rae, 1994; Boardman, Greenberg et al., 2017). The model operates at an annual time-step and provides an aggregated outcome for alternative land use options with different planning horizons (e.g. annual arable crop vs Miscanthus). The aggregated outcome is the Net Present Value (NPV) of a land use option expressed as an annuity, NPV_a (Nuthall, 2016), such that:

$$NPV_a = NPV\left[\frac{i(1+i)^n}{(1+i)^n - 1}\right]$$

[*] Policies, actions and payments are based on the 2024 offer of the SFI scheme (https://www.gov.uk/government/publications/sustainable-farming-incentive-scheme-expanded-offer-for-2024/sfi-scheme-information-expanded-offer-for-2024) and Countryside Stewardship Higher Tier actions (https://www.gov.uk/government/publications/countryside-stewardship-higher-tier-get-ready-to-apply/countryside-stewardship-higher-tier-actions#csp2-rewetting-supplement). As of the 12th March the SFI scheme closed to new applications.

where *NPV* is the net present value (£ ha^{-1}), *i* is the real discount rate (*i* = 3.5%, HMT (2022)), and *n* is the total number of years of the defined land use option. This approach is significantly more accurate than just considering overall 30-year net returns or annualised gross margins. The NPV method considers the time-value of money and accounts for the distribution of costs and benefits throughout the life of a project (Boardman, Greenberg et al., 2017). Transforming a project's total NPV into an annuity value allows the comparison of projects with differing planning horizons. For a project to be considered viable it must have a positive NPV, and those projects with the highest NPV using a set of resources (in this case peatland), and with the least variation, would be considered the best choice for land managers.

The process utilises identified enterprise income, cash costs and subsequent gross margins to derive annual returns. Cash inflows and outflows are then extracted (including the value of initial capital invested by farmers and its salvage value if applicable) to undertake the economic analysis of the alternative land use options. Monte Carlo simulation procedures[†] are then used to determine the impact of risk or variable uncertainty on economic outcomes (Hardaker, Lien et al., 2015; Boardman, Greenberg et al., 2017). Alternative land use options that involve rewetting lowland peat are evaluated based on expected returns and risk (the variability of returns). In this case, the risk (production and output price risk[‡], and uncertainty around rewetting costs) is non-embedded in the decision-making process, as such the results of the simulations describe the risky consequences of the decisions applied before any risky states occur or tactical decisions can be made (Behrendt, Cacho et al., 2013; Hardaker, Lien et al., 2015).

Enterprise variable costs and production, and its variability, are derived from Farm Business interviews and published sources (NNFCC, 2011; Keating, Pettit et al., 2015; Wichmann, Krebs et al., 2020; Winkler, Mangold et al., 2020; NAAC, 2024; Redman, 2024; Terravesta, n.d.). Where available output prices and their variability are based on long-run means (NNFCC, 2011; Wichmann, Krebs et al., 2020; AHDB, 2024; AHDB, 2024; Redman, 2024). All input and output prices sourced are transformed into 2024 currency terms.

Monetisation of the biodiversity net gain

The biodiversity uplift potential from restoring lowland peat habitats (i.e., reversion from arable or grassland to wetland habitats) was assessed through a desk-based aerial survey conducted by Shropshire Wildlife Trust and Middlemarch and supplemented by the UK Habitat Classification (UK Hab) methodology[§]. Using Defra's Statutory Biodiversity Metric[**] mandated by Natural England the potential

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[†] 1000 iterations are used to generate populations of possible outcomes with assumed input cost uncertainties shown in Table 2.

[‡] Variability is based on grains, oilseed and beef prices reported over the period of 2014-2024 in real terms (2024 as base year) (https://ahdb.org.uk/cereals-oilseeds/uk-delivered-prices, https://ahdb.org.uk/beef/gb-deadweight-cattle-prices)

[§] Legacy Habitat Banks Ltd (2024) *Bridging Ecology and Economy: Commercial Opportunities in Biodiversity Net Gain from The Patchy Peat Solutions Project*, pp42.

[**] Department for Environment, Food & Rural Affairs and Natural England, Statutory Biodiversity Metric

quantity of BNG unit uplift was estimated for lowland peat that would be rewetted. The estimates factored in different habitats' distinctiveness, condition, and strategic significance, and provided expected BNG uplift for both Habitat Units and Watercourse Units. The value of the biodiversity net gain uplift for Habitat Units is included in the project cash flow, as well as the estimated costs of selling BNG units, habitat creation and maintenance. No other ecosystem services were considered in this feasibility study.

In alignment with Statutory biodiversity credit pricing (Defra, 2024) and the Legacy Habitat report[††], it is assumed 40% of the price received is required for creating and maintaining the habitats, with half of the costs used for legals, transaction costs, and creating the habitat (20% of price), with the other half used for maintaining the habitat and distributed on a per annum basis (20% over the life of a 30-year agreement). It is also assumed that revenue received from any BNG unit sales occurs on a staged per annum payment basis over the period of a 30-year agreement.

Given the uncertainty around the current market value of BNG units, the value of BNG Habitat units were based on the range of prices reported by Biodiversity Units UK[‡‡]. For lowland peat restoration it was assumed that purple moor-grass and rush pastures habitat based BNG units would be created with a normal distribution around £27,200 per unit (with a standard deviation of £2,500).

Case Study sites

Six case study farms in the West Midlands of England were engaged as part of the Environment Agency funded Patchy Peat Solutions (PPS) project. Lowland non-contiguous peatland in this area is known to be degrading through drainage, cultivation and groundwater abstraction, low summer flow rates and winter flooding along the River Severn. The aim of the PPS project was to explore the direct and indirect opportunities available to farmers on rewetted lowland peat soils.

Through farmer focused planning workshops, thematically coded semi-structured farmer interviews and individual consultation with collaborating farmers, a wide range of natural capital opportunities on each land holding were identified. From these the highest priority opportunities for rewetting small areas of lowland peat were identified and analysed for their feasibility (Table 1). This included defining the change in land use once rewetted and the infrastructure and regulatory requirements for rewetting the targeted lowland peat. Additionally, the potential for CSHT support was assessed and included in the CSHT Supported scenario.

Tools and Guides
https://www.gov.uk/government/publications/statutory-biodiversity-metric-tools-and-guides

[††] Legacy Habitat Banks Ltd (2024) *Bridging Ecology and Economy: Commercial Opportunities in Biodiversity Net Gain from The Patchy Peat Solutions Project*, pp42.

[‡‡] Biodiversity Units UK (2024). October 2024 Pricing Report from Biodiversity Units UK. https://biodiversity-units.uk/bng-news/key-insights-from-biodiversity-units-uks-october-2024-pricing-report

Table 1: Area of peatland rewetted, change in land use, associated agri-environmental actions and requirements for rewetting peatland.[§§]

Farm	Area (ha)	Current Land Use	Proposed Land Use	Requirements
A	13.0	Rough grazing for cattle/sheep (low stocking density)	Rewet for BNG (39.7 units) Reduced livestock grazing (50%) (PA2, CSW18)	Set-up & regulatory permissions 15 dams to control water table All-terrain vehicle for future maintenance. Environmental works (dredging & sediment storage – nutrient load)
B	12.4	Permanent grassland for suckler cows	Rewet for BNG (Fen habitats) (51.8 units) (or PA2, WN10, GRH6)	Set-up & regulatory permissions 15 dams to control water table
C	0.5	Low intensity multi-paddock grazing with suckler cows	Rewet for BNG (2.77 units) Wildflower meadows (PA2, WN10, GRH6)	Set-up & regulatory permissions
D	8.0	High intensity multi-paddock grazing with suckler cows	Constructed wetland for nutrient mitigation from agricultural land or the road. (37.8 BNG Units) (or PA2, WN10, GRH6)	Set-up & regulatory permissions Environmental works (2 dams, tilting weir)
E	10.2	High intensity multi-paddock grazing with suckler cows	Rewet for wetlands & BNG (36.4 units) (or PA2, WN10, GRH6)	Set-up & regulatory permissions Environmental works (tilting weir)
F	22.5	Miscanthus	Nutrient mitigation using constructed wetlands for BNG (169.5 units) Continued Miscanthus harvesting for bedding (PA2, CSW17)	Set-up & regulatory permissions Environmental works (tilting weir, pumping)

Costings for rewetting peatland

Table 2 indicates the assumed costs of rewetting peatland considered for each case study. All costs indicated either relate to only rewetting for paludiculture and CSHT scheme payments, or exclusively for creation and maintenance of BNG habitat. As

[§§] Assumed Countryside Stewardship Higher Tier capital and actions noted in parenthesis under Proposed Land Use are only part of the CSHT Supported scenario and are not part of the analysed BNG Market scenario. Actions defined as PA2: Feasibility study; WN10: Construction of water penning structures; CSW17: Raise water levels in cropped or arable peat soils to near the land surface; CSW18: Raise water levels in permanent grassland peat soils to near the land surface.

part of the Monte Carlo simulations, an uncertainty level expressed as coefficient of variation of 10% is assumed around the expected average cost for all establishment and annual operating costs. In addition to these costs are enterprise costs that are specific to alternative land uses on the rewetted lowland peat.

Table 2: Assumed total costs of rewetting peatland for case study sites.

<table>
<tr><th rowspan="2">Costs</th><th colspan="6">Farm</th></tr>
<tr><th>A</th><th>B</th><th>C</th><th>D</th><th>E</th><th>F</th></tr>
<tr><td>Establishment Costs</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Permit application</td><td colspan="6">£8,844</td></tr>
<tr><td>Technical feasibility (design, works, supporting information)***</td><td colspan="2">£12,000</td><td></td><td colspan="3">£12,000</td></tr>
<tr><td>Private Water supplies (FOI)</td><td colspan="6">£225</td></tr>
<tr><td>Landowner Consultation</td><td colspan="6">£200</td></tr>
<tr><td>Administrative labour</td><td colspan="2">£6,300</td><td></td><td colspan="3">£6,300</td></tr>
<tr><td>Capital: Site works (bunding, weir, reservoirs/dams) †††</td><td>£74,084</td><td>£69,084</td><td></td><td>£52,106</td><td colspan="2">£42,895</td></tr>
<tr><td>Capital: Equipment (water management, soil water monitoring)</td><td>£11,120</td><td>£3,450</td><td></td><td colspan="2">£3,450</td><td>£15,837</td></tr>
<tr><td>Habitat Creation‡‡‡</td><td>£216,172</td><td>£281,807</td><td>£23,935§§§</td><td>£205,345</td><td>£197,774</td><td>£992,189</td></tr>
<tr><td>Annual Operating Costs</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Water table monitoring</td><td colspan="2">£1,615</td><td></td><td colspan="3">£1,615</td></tr>
<tr><td>Repairs & Maintenance</td><td>£222</td><td>£230</td><td></td><td>£1,318</td><td>£858</td><td>£2,100</td></tr>
<tr><td>Habitat maintenance****</td><td>£7,206</td><td>£9,394</td><td>£503</td><td>£6,845</td><td>£6,591</td><td>£43,980</td></tr>
</table>

*** Cost in economic analysis is assumed to be covered by Countryside Stewardship Higher Tier payment PA2 Feasibility Study in CSHT supported scenario.
††† Cost reduced in CSHT supported scenario due to payments provided under WN10 Construction of water penning structures.
‡‡‡ BNG market scenario only: Represents 20% of the BNG uplift value reported by Legacy Habitat.
§§§ Includes permit application costs due to small scale.
**** BNG market scenario only: Represents 20% of the BNG uplift value reported by Legacy Habitat and prorated on annual basis for the period of a 30 year agreement.

3. Results and Discussion

The results of the economic analysis indicate the expected private benefits from the adoption of rewetting peatland for each case studies farm’s highest priority option (Table 3). For four of the six farms the highest priority options involved converting their lowland peat from agricultural production to management focused on the construction of wetlands or for biodiversity net gain.

For five of the six farms the conversion of lowland peat to a focus on biodiversity net gain led to an increase in profitability with reduced risk (indicated by a lower standard deviation of returns). If conversions of lowland peat from agricultural production were only supported through the current Countryside Stewardship Higher Teir (CSHT) scheme, the results are more mixed. Without any support (e.g. CSHT scheme) or monetisation of BNG, there is no financial incentive to rewet lowland peat. This is especially the case given the regulatory and capital costs (for most farm case studies) of rewetting lowland peat.

Table 3: Case study economic outcomes for business as usual, unsupported rewetting of lowland peat, CSHT supported rewetting, and rewetting for the BNG market. Mean net present value as an annuity (£ ha-1 year-1) with standard deviation shown in parentheses.

Farm	Business as usual	Rewetting, Land Use & Policy Scenario		
		No Support	CSHT supported	BNG market
A	£431 (£15)	-£315 (£31)	£922 (£46)	£1,387 (£126)
B	£163 (£12)	-£506 (£30)	£170 (£37)	£1,896 (£172)
C	£143 (£5)	-£1,112 (£100)	-£1,261 (£114)	£1,564 (£252)
D	£315 (£10)	-£831 (£49)	£182 (£37)	£2,140 (£188)
E	£314 (£11)	-£573 (£33)	£370 (£21)	£1,624 (£156)
F	£4,198 (£797)	£4,031 (£686)	£5,312 (£791)	£3,440 (£325)

Farms A and F maintained some agricultural production on their rewetted lowland peat. For Farm A the 50% reduction in livestock grazing activity was compensated through either payments received under the CSHT scheme or through the sale of BNG credits. Both implementation pathways led to an expected increase in profitability, albeit with increased variability of returns under the CSHT scheme than for BNG or business-as-usual. For Farm F that is currently growing Miscanthus for a niche and lucrative bedding market on their lowland peat, converting their lowland peat to a wetland for BNG based revenue would lead to a reduction in profitability. However, if Farm F aimed to actively manage the water table and participate in the CSHT scheme while still growing Miscanthus, it would lead to higher profitability than business-as-usual.

Farm C which engaged in a small-scale project would only benefit by looking to monetise any uplift in biodiversity. It is not viable for Farm C to undertake the proposed land use change of rewetting and establishing a wildflower meadow under the current CSHT scheme. Similarly, Farm D does not benefit from rewetting peat and converting pasture land to purple-moor grass and rush pasture under the CSHT scheme. It does benefit significantly from monetising any BNG. For both Farms B and E there are small gains to be made from rewetting lowland peat under the current CSHT scheme, albeit with increased variability of returns, and large gains to be made from monetising BNG.

The substantial capital costs of rewetting a catchment, as well as the regulatory and compliance costs of establishing a sub-catchment capable of being sufficiently rewetted and monitored (to meet the requirements of the Environment Agency or the aims of a Countryside Stewardship Higher Tier action), are key determinants of minimum scale for feasibility. Due to these costs, there remains a significant barrier to the adoption of paludiculture or rewetting lowland peat for environmental purposes. This is clearly highlighted by the No Support scenario which is without any agri-environmental payments or rewetting being undertaken as part of BNG habitat creation. When these are included, agri-environmental payments make up over 70%-80% of the revenue for the majority of case study farms. The exception to this is Farm F which has the potential of converting conventional Miscanthus production to Miscanthus production on rewetted lowland peat. In this paludiculture example, the majority of revenue comes from paludiculture not agri-environmental payments. However, this represents an exceptional case as Miscanthus for bedding is a limited lucrative market, as the majority of Miscanthus grown in the UK is used for lower valued (around 25% of bedding price) biomass production for combustion and bioenergy supply.

There is a need for policy to support market mechanisms and aggregation for cost–effective small scale lowland peat protection and development. There is a significant risk for landholders in adopting rewetting of lowland peat and paludiculture due to economies of scale constraints as well as uncertainty around markets for paludiculture outputs and the continuation of agri-environmental policies. Small scale and valuable pockets of lowland peat will continue to be degraded or lost without private or social investment.

There are several limitations of this exploratory analysis. Consistent with the recommendations of Moxey and Moran (2014), the aim of future research should expand the availability of commercially validated data around the biophysical and economic interactions of rewetting lowland peat, especially in regard to potentially high valued paludiculture alternatives which offer the potential of maintaining agricultural and environmental objectives. This should also be extended to better defining the costs of supplying and selling biodiversity habitat units by landholders (including scale of restoration interactions), especially given its potential to sustainably fund the rewetting and restoration of lowland peat.

As the feasibility of rewetting patchy lowland peats is very context specific, there is a need to achieve better alignment between rewetting options analysed by the various collaborators through an iterative co-development process with landholders, regulatory bodies and potential third parties that may contribute to establishing markets for ecosystem services beyond BNG. Additionally, investments in lowland peat rewetting and restoration (including habitat restoration for BNG uplift) can have long-run impacts on the capital value of land with additional risks around not meeting contractual obligations, and further research is required into the willingness to accept by landholders or willingness to pay by land buyers for any investments and long-term agreements that might be put in place.

Further consideration and analysis of options for developing productive, natural and social capital need to be incorporated to better understand the net social benefits of rewetting peatland (Glenk and Martin-Ortega, 2018). This requires improved valuations of ecosystem services from paludiculture, as this significantly limits defining the net social benefits from landholders adopting paludiculture and developing better agri-environmental policies (Glenk and Martin-Ortega, 2018).

4. Conclusion

Due to the costs of establishing paludiculture and meeting regulatory requirements for water impoundment and abstraction within a catchment, there will remain a significant barrier to the adoption of paludiculture or rewetting for environmental objectives. Additionally, the current agri-environmental policies and payments available through the SFI and Higher Tier Countryside Stewardship schemes will not always be conducive to the adoption of paludiculture in small scale non-contiguous lowland peats. This may put at risk extensive areas of fragmented lowland peat where private economic returns, due to the opportunity costs of changing land use, cannot justify investment into preserving smaller areas of lowland peats. This will result in continued lowland peat degradation and its contribution to GHG emissions from conventional agricultural production, as well as catchments not benefiting from the flood mitigation opportunities rewetting lowland peat provides. If biodiversity markets sufficiently develop and the value of BNG uplift remains competitive, this may provide the most conducive pathway to protecting small non-contiguous lowland peats in England, especially where the lowland peats are not currently used for high valued farming.

A significant limitation to this study is the availability of commercially validated data around the biophysical and economic interactions of rewetting lowland peat. The uncertainty analysis revealed the risk-reward proposition to landholders will remain a substantial barrier. In addition, limitations in the valuation of ecosystem services from paludiculture significantly limits defining the net social benefits from landholders adopting paludiculture and developing better agri-environmental policies.

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Conflict of interest statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability statement

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

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