100,000 HECTARES OF UK WETLANDS

EXPLORING THE POTENTIAL

Technical guide

WWT
For wetlands. For life.

eftec
economics for the environment

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This publication and other resources described within are available at https://www.wwt.org.uk/using-data-to-put-wetlands-to-work/

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Executive summary

The challenge

Our natural world is in crisis: nearly 1 in 6 species in the UK are at risk of extinction, extreme winter rainfall is now seven times more likely, and every river in England is now polluted beyond legal limits. The burden of this neglect is staggering: financially, socially and environmentally.

The UK needs fast-acting, cost-effective solutions that can simultaneously address some of the greatest challenges we face: the escalating climate crisis, plummeting levels of biodiversity, the 'cocktail' of pollution in our rivers and seas, as well as the rapid decline in our own wellbeing.

WWT are calling for the creation of 100,000 hectares of new and restored wetlands in the UK by 2050

The solution

Wetlands are areas of land that are either permanently or seasonally inundated with water - salt, fresh or brackish - they include coastal habitats, rivers, lakes, ponds, marshes, bogs and wet woodland. They once covered vast areas of the UK, but over three quarters have been lost over the last 300 years, largely due to land reclamation for agriculture. Our remaining wetlands are highly fragmented and degraded.

Healthy, functioning wetlands provide critical ecosystem services: they sequester carbon, protect us from floods, purify our polluted waterways, enhance our wellbeing and boost the economy. Scaling up wetland protection and restoring converted or degraded wetlands is imperative to tackling these challenges.

WWT are calling for the creation of 100,000 hectares of new and restored wetlands in the UK by 2050, to make a real difference to nature recovery and to restore critical ecosystem services and functions. Economists have shown that there is a strong economic case for this scale of wetland expansion.

The potential

This study assesses both the spatial and economic potential for large-scale wetland restoration targeted at addressing multiple issues. It involves:

- Mapping, at a UK scale, both the spatial demand for wetlands that can store **carbon** (with a focus on blue carbon), improve **water quality**, increase **flood resilience**, or improve **urban wellbeing**; and suitable areas for wetlands designed to tackle these themes, for example, via natural flood management wetlands, constructed treatment wetlands, community urban wetlands, sustainable drainage systems or saltmarsh creation;
- Quantifying, through natural capital accounting, the scale of the potential benefits provided by large-scale, targeted wetland creation in the UK - benefits that are often underappreciated in considerations of wetland policy options; and
- Developing resources and engagement materials to demonstrate this potential.

WWT

The work enables users to:

- Identify areas of the UK where wetland restoration can deliver real impact for people and communities, by storing carbon, improving water quality, increasing flood resilience and improving wellbeing;
- Explore where wetlands offer maximum value through multiple benefits;
- Facilitate discussions with partners interested in increasing natural capital benefits through large-scale wetland creation; and
- To generate action by demonstrating to policymakers and the wider public the potential impact of wetland restoration.

Spatial potential

The mapping identified the potential for 673,000 hectares of 'wetlands for water quality', 174,100 hectares of 'wetlands for carbon storage' (saltmarsh potential), 587,600 hectares of 'wetlands for flood resilience' and 196,500 hectares of 'wetlands for urban wellbeing'. Accounting for overlaps, the **total area of mapped wetland potential is 1.2 million hectares** across Great Britain (Figure 1) of which 29% is made up of areas where wetlands could provide multiple key benefits.

The maps show ample space available for large-scale wetland creation in the UK, without compromising agricultural productivity: 100,000 hectares would amount to just 0.6% of the UK's farmland. While wetland opportunities may be limited in the most productive areas, wetlands and agriculture are not mutually exclusive: many wetland habitats can be grazed by livestock, and there is growing interest in paludiculture: systems that support crops suited to higher water tables. Wetlands can also be designed to manage flood risk, hold water or capture nutrient runoff may have positive impacts on food security.

Economic potential

Mapped areas of wetland potential were used to define natural capital assets included in the economic valuation. Each of the mapped themes was refined to 25,000 hectares of potential, to create an overall area for valuation of 100,000 hectares, aligning with

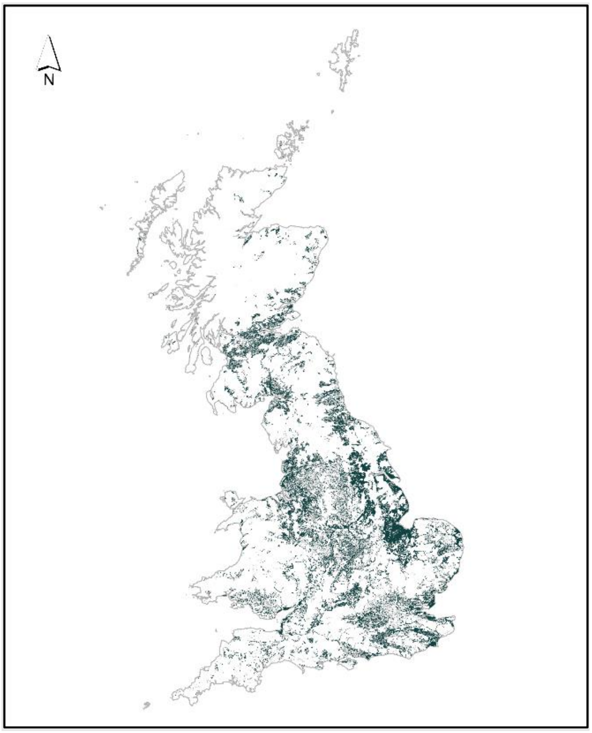

Figure 1. Combined (multi-benefit) wetland potential across Great Britain.

the ambition to restore or create 100,000 hectares of wetland.

The natural capital accounts highlight substantial economic benefits that far outweigh the costs of wetland creation: accounting for costs of wetland creation and loss of agricultural productivity, we estimate that wetlands could add **at least £8 billion to the UK economy** over a 60 year period.

Accessing the resources

The wetland potential maps can be accessed through the **Wetland Data Explorer** app, developed in collaboration with The Rivers Trust. Users of the app can visualise wetland potential on a regional and national scale, dive into the wetland potential in a region of interest and access a wide range of publicly available data layers to inform strategic wetland projects across the UK.

Comprehensive accounts of the natural capital analysis are provided as separate reports for each of the four wetland themes. A summary of the approach and outputs are provided in this report.

Notes on using the maps

The maps are designed to assess the strategic potential for wetland solutions on a national or regional scale. While they are designed for initial scoping of potential focus areas, users should note the following:

- The maps are not suitable for viewing at a local scale (e.g. individual farms or fields), being based on national datasets rather than detailed local data. Not all areas of identified potential will be feasible for wetland creation, which should be assessed through local studies.
- There may be potential for wetland creation outside the areas mapped here: areas that do not meet the criteria for 'demand'.
- The maps do not specifically target biodiversity, such that many of the potential wetlands may not form key components of ecological networks: a treatment wetland, for example, may have less biological diversity than an equivalent wetland with better water quality; an urban wetland may be relatively isolated from other wildlife sites. When sited appropriately and designed with biodiversity in mind wetlands can, however, deliver significant biodiversity gains in otherwise nature-depleted areas.
- While the 100,000 hectares ambition is UK-wide, all except the 'wetlands for carbon storage' maps were produced at the GB scale due to the limited data availability for Northern Ireland. It is hoped that comparable maps for Northern Ireland will be produced in due course.

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Introduction

1 Introduction

1.1 Background

The loss and degradation of wetlands through land-use change, pollution, invasive species, disrupted flow regimes and, in turn, the changing climate, means that the world's wetlands are under unprecedented pressure. Forty percent of the world's wildlife depends on wetlands, but a quarter of wetland-dependent species are at risk of extinction globally (IUCN, 2024; Ramsar, 2007). Since 1970, populations of freshwater species have declined by an average of 83%: a much greater decline than those of species depending on any other ecosystem (WWF, 2022). The UK has lost over 75% of its wetlands over the last 300 years (Fluet-Chouinard et. al., 2023).

Healthy, functioning wetlands provide critical ecosystem services (Brander, et al., 2024): protecting communities from the impacts of climate change by sequestering carbon and increasing resilience to flooding, drought and extreme heat (Fennessy & Lei, 2018). Wetlands have a vital role to play in cleaning up our rivers – important for public health and for restoring nature (Ferreira, et al., 2023). Research shows that access to nature brings health and wellbeing benefits - particularly to our most vulnerable communities - with wetlands being particularly effective at reducing stress, compared to other green spaces (White et. al., 2020).

Scaling up wetland protection and restoring lost or degraded wetlands in the UK is imperative to solving some of the greatest challenges we face: the escalating climate crisis, plummeting levels of biodiversity, the 'cocktail' of pollution in our rivers and seas, as well as the rapid decline in our own wellbeing.

1.1.1 What are wetlands?

Wetlands are areas where water is the primary factor controlling the environment and the associated plant and animal life: occurring where the water table is at or near the surface of the land, or where the land is covered by water (Ramsar, 2007). Wetlands may be fresh, brackish or saline, permanent or temporary, with five major wetland types generally recognised:

- **marine** (coastal wetlands including coastal lagoons, rocky shores, and coral reefs);
- **estuarine** (including deltas, tidal marshes, and mangrove swamps);
- **lacustrine** (wetlands associated with lakes);
- **riverine** (wetlands along rivers and streams); and
- **palustrine** (meaning "marshy" - marshes, swamps and bogs).

Additionally, there are wide range of artificial wetland types, such as farm ponds, reservoirs, canals and treatment wetlands.

In the context of this study, wetlands are referred to as including inland wetland types found in the UK, both natural (lacustrine, riverine and palustrine) and artificial, as well as saltmarshes in coastal areas and estuaries. This study has a limited focus on upland peat habitats (see Section 4). The study does not extend to the marine environment.

1.2 WWT's 100,000 hectares ambition

WWT has set ambitious targets of ensuring that the UK has a bigger, better and more connected network of wetlands. We are calling for the creation of 100,000 hectares of new and restored wetlands in the UK by 2050, through a combination of direct action, partnership working, capacity building and community engagement (WWT, 2023a; WWT, 2020). These wetlands need to be able to sustain healthy wetland nature and provide nature-based solutions, including those that help people to adapt to, and mitigate, the impacts of the climate emergency. To achieve this 'Blue Recovery', WWT have published proposals for wetland solutions focussed on four key themes:

1. Wetlands for water quality
2. Wetlands for carbon storage
3. Wetlands for urban wellbeing
4. Wetlands for flood resilience

Each proposal details the partnerships and policy frameworks required to reach the 100,000 hectares target. They lay out the steps needed to move from small-scale, ad-hoc wetland creation to a strategic network of larger, connected wetlands that maximise benefits to society and nature.

1.2.1 Why 100,000 hectares?

The Wetland Vision Partnership identified the total land area of England 'with potential for new wetland creation' as 1,583,500 hectares (including blanket bogs) (Wetland Vision Project, 2008).

The Natural Capital Committee (eftec, 2015) identified a good economic case for expanding the extent of inland freshwater wetland areas in England by 100,000 hectares, estimating a benefit cost ratio of between 3:1 and 9:1. In addition, the Committee set out the return on investment of a 54% increase in saltmarsh habitat (22,000 hectares), 140,000 hectares of restored peatland (estimated to provide net benefits of £570 million over 40 years in carbon values alone), and showed positive benefit cost ratios for investment in the coordination of catchment-based management of water regulating services.

While this presents a strong economic case for wetland expansion far in excess of 100,000 hectares, 100,000 hectares is, nevertheless, an achievable, ambitious and economically viable target, with the potential to make a real impact on UK society and nature recovery.

1.2.2 How does 100,000 hectares fit in with existing government commitments on wetlands?

The UK government has committed to protecting and restoring 30% of the land and of the sea for nature's recovery by 2030, in accordance with the Kunming-Montreal Global Biodiversity Framework (GBF) targets (Convention on Biological Diversity, 2022). This explicitly includes wetlands, with targets to restore degraded terrestrial, inland water, and marine and coastal ecosystems, and protection of areas of importance for biodiversity and ecosystem functions and services.

The 25 Year Environment Plan (25YEP; (Defra, 2018)) sets out the UK government's vision for nature recovery. The devolved nations are setting out various approaches to nature recovery in plans, strategies, and legally binding targets.

In England, the Environmental Improvement Plan (EIP; the first revision of the 25YEP) sets legally binding targets to restore or create more than 500,000 hectares of wildlife-rich habitats outside of protected sites by 2042 (140,000 hectares outside protected sites by 2028), as well as restoring precious water bodies to their natural state by cracking down on harmful pollution (Defra, 2023a). Local Nature Recovery Strategies (LNRS) are under development to identify where important habitats can be restored, enhanced, connected, and deliver environmental benefits (Defra, 2023b). These targets and actions will help to grow the Nature Recovery Network (NRN), a national ecological network that expands, buffers and connects our best terrestrial and freshwater wildlife sites, and allows wildlife populations to move and thrive. In addition to biodiversity, the NRN aims to provide greater public enjoyment, carbon capture, water quality improvements and flood management.

The new Labour Government have committed to meeting the statutory environmental targets set by the previous Conservative Government, alongside the EIP. The Government intends to conduct a full review of the EIP, which could set out further ambitions for wetlands and other habitats. Their manifesto commits to expanding nature-rich habitats such as wetlands and peat bogs for wildlife to thrive, and to lock carbon in our soils and landscapes; increasing climate resilience; building more sustainable homes and creating places that increase climate resilience and promote nature recovery (Labour, 2024). The King's Speech announced a 'Special Measures' bill to transform the water industry, and restore our rivers, lakes and seas to good health (Prime Minister's Office, 2024). The Bill will apply to both England and Wales.

The previous Government initiated a number of actions and targets: the Net Zero Strategy aims to restore approximately 280,000 hectares of peatland by 2050 (HM Government, 2021) ; the Plan for Water aims to transform the management of the water system to deliver a healthy water environment and a sustainable supply of water for people, businesses and nature (Defra, 2023c). The Plan includes a Water Restoration Fund for projects that improve the water environment and water management and restore protected sites (e.g. by re-meandering rivers, removing invasive non-native species, creating and restoring water-dependent habitats such as wetlands, removing barriers to enable fish and other species' natural movement in rivers, and supporting catchment partnership groups in local delivery).

In Scotland, the Scottish Biodiversity Strategy to 2045 aims to restore the ecological status of rivers, lochs and wetlands and their catchments, as well as to increase the extent of riparian woodland habitat, restore substantial areas of peatland, and significantly increase the extent, condition, connectivity and resilience of wetland habitats (Scottish Government, 2023a). The strategy will, following consultation, be supported by a Natural Environment Bill that sets out the framework for statutory targets for nature restoration. Scotland's River Basin Management Plan (2021-2027) aims for 81% of the water environment to be in 'Good' or 'High' condition by 2027 and 90% in the long-term, and the Government's climate change programme aims for 250,000 hectares of peatland to be restored by 2030 (SEPA, 2021; Scottish Government, 2020a).

The Welsh Labour Government have developed a set of collective actions that will help support the meaningful delivery of the '30 by 30' target, including: expanding and scaling up the Nature Networks Programme to improve the condition, connectivity and resilience of protected sites; increasing the delivery capacity of the National Peatland Action Programme to a scale capable of achieving the net zero 2050 target of 45,000 hectares of peatland restored; and establishing a targeted scheme to support restoration of seagrass and saltmarsh habitats. The Local Places for Nature Programme (Welsh Government, 2024a), established in 2020, is creating areas of nature within communities, encouraging a greater appreciation and value of nature, creating more greenspaces, and supporting wider biodiversity objectives. The Welsh Government has also committed to working with nature to improve flood management in all major river catchments, expanding wetland and woodland habitats in the process. Going forward there will be funding for more of these projects across Wales, working with Welsh farmers, landowners, and civil society (Welsh Labour, 2024).

The Government has committed to developing a nature recovery framework which will include statutory biodiversity targets. Proposals have been laid out in the Environmental principles, governance and biodiversity targets: White Paper (Welsh Government, 2024b). The Environment (Wales) Act 2016 and Well-being of Future Generations (Wales) Act 2015 are important frameworks for bringing about these proposals.

In Northern Ireland, the Department for Agriculture, Environment and Rural Affairs (DAERA) Ministers have publicly endorsed the '30 by 30' target (NEIL, 2021). Adoption of a new Environment Strategy is anticipated as Northern Ireland's Environmental Improvement Plan (EIP) under Schedule 2 of the Environment Act 2021. The current draft strategy is underpinned by six proposed Strategic Environmental Outcomes (SEOs) which are based around the DAERA core vision of sustainability at the heart of a living, working, active landscape valued by everyone. The proposed SEOs include 'Excellent air, water, land & neighbourhood quality'; 'Healthy & accessible environment & landscapes everyone can connect with & enjoy'; 'Thriving, resilient & connected nature and wildlife'; 'Sustainable production & consumption on land and at sea'; 'Zero waste & highly developed circular economy' and 'Net zero greenhouse gas emissions & improved climate resilience and adaptability' (DAERA, 2022a).

WWT's 100,000 hectares target can help support the delivery of all these policies, targets and actions.

1.2.3 Putting 100,000 hectares into context

Wetlands once covered vast areas of the UK, but their area has significantly reduced in size over the last few centuries: over three quarters (approximately 8 million hectares) have been lost since 1700, largely due to land reclamation for agriculture (Fluet-Chouinard et. al., 2023). The Wetland Vision project mapped the maximum former extent of wetlands in England (Figure 2), based on underlying soil characteristics (Hume, 2008). The map approximates wetland landscapes before significant drainage efforts began (likely the pre-roman period) and shows wetland coverage approximating 33% of the land area of England (4 million hectares). Great expanses of lowland wetlands, the fens in particular, have since been almost entirely drained, while only around 20% of UK peatlands remain in a near-natural state (Artz, et al., 2019).

The current extent of wetlands in the UK is estimated to be around 3 million hectares (WWT internal review of available data; (Office for National Statistics, 2015)), though the exact area is uncertain due to inconsistencies in wetland definition and classification and the limited coverage of existing datasets.

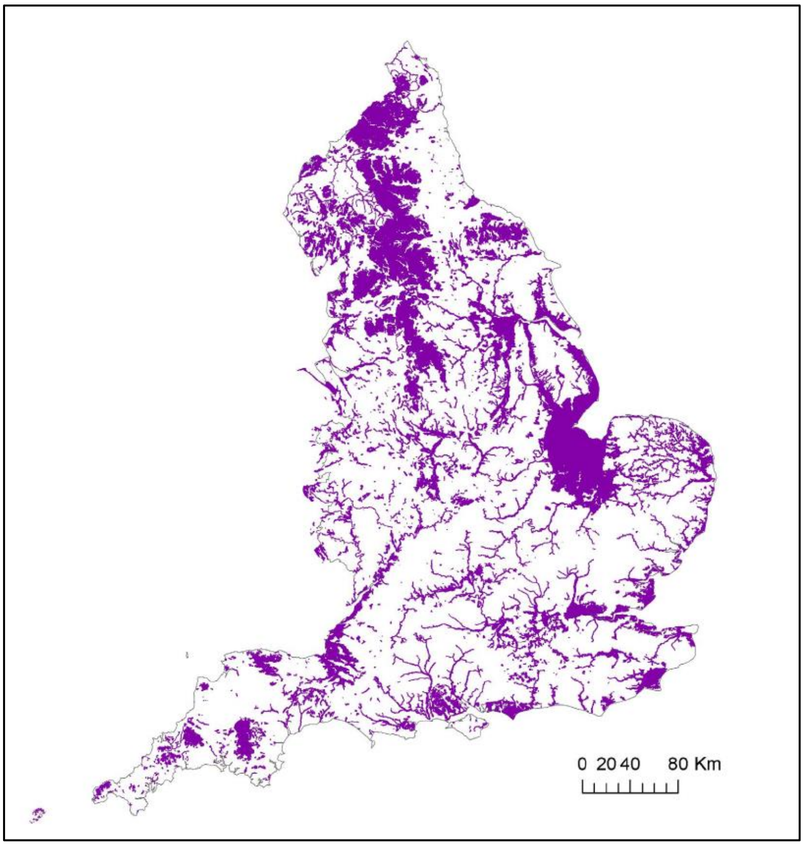


Figure 2. Theoretical historic extent of wetlands (indicative map)[1]. Reproduced from (Hume, 2008).

Figure 3 shows the approximate extent of existing UK wetlands. Non-priority vegetated wetlands such as reedbeds and wet grasslands, as well as many small wetlands such as ponds, are likely to be under-represented due to the limited availability of equivalent higher resolution data for all UK nations. Coastal wetlands below Mean High Water are excluded. Compared with the historical extent for England (Figure 2), our remaining wetlands are small and highly fragmented.

100,000 hectares, an area roughly 1.5 times the size of Anglesey, would increase the UK wetland extent by around 3%. This would amount to 0.6% of the total farmed area of the UK (Utilised Agricultural Area: 17 million hectares (Defra, 2023d)). Although, it is important to note that farming and wetlands are not mutually exclusive: many wetland types - wet grassland and saltmarsh, for example - would usually remain under farming. In addition, wetlands created in urban areas often do not require the conversion of agricultural land.

[1] ©Wetland Vision, a partnership between Environment Agency, English Heritage, Natural England, RSPB, and The Wildlife Trusts. Derived from data supplied by the Environment Agency © and Database Rights the Environment Agency 2008. Derived from data supplied by Natural England Natural England 2008. This map is based upon Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of Her Majesty's Stationery Office © Crown copyright. Unauthorised reproduction infringes Crown copyright and may lead to prosecution or civil proceedings. Natural England 100046223 2008.

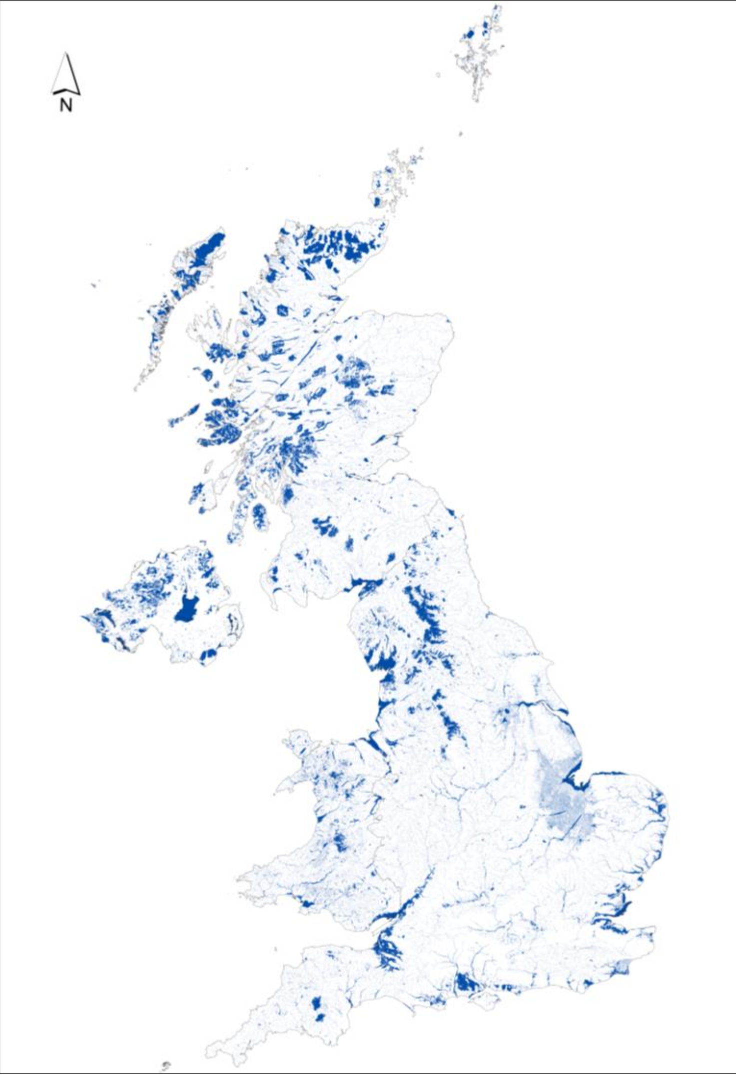


Figure 3. Indicative (minimum) current UK wetland extent (see Appendix I for datasets included).

1.3 A roadmap to 100,000 hectares: mapping and quantifying the potential

Many UK communities are already benefiting from nature-based solutions, many of which involve wetland interventions. Despite this progress, WWT believes there is potential to go bigger with wetlands, by moving from ad-hoc interventions to creating a strategic network of wetlands across the UK. To achieve this, we need to understand the potential for wetland expansion and restoration at a UK scale.

WWT's Roadmap to 100,000 hectares project aims to identify areas where wetlands would be best placed to deliver multiple key benefits to UK communities and to quantify the benefits provided by this scale of wetland creation and restoration.

This study specifically addresses the following questions:

1. Which areas of the UK are suitable for large-scale wetland creation/restoration?

2. What is the spatial demand for wetland creation/restoration to provide solutions to support flood resilience, water quality and urban wellbeing improvements?

3. What are the economic benefits of wetland creation at this scale?

We used a mapping approach to address questions 1-3, with data from the mapping feeding into natural capital accounts (NCA) designed to assess the economic benefits of 'wetlands for urban wellbeing', 'wetlands for flood resilience', 'wetlands for water quality' and 'wetlands for carbon storage'.

The resources developed through this work include a series of wetland potential and priority area maps hosted within an online, interactive data explorer, natural capital accounts, technical documentation and engagement materials.

1.3.1 How will the outputs be used?

These resources will form part of the evidence base for the potential of the UK landscape to support larger, healthier and better functioning wetlands that provide natural solutions to the flooding, water quality, wellbeing and climate crises we face. The resources will better enable WWT and other organisations championing wetland restoration to:

- Identify broad areas of the UK where wetland creation and restoration could deliver real impact, by storing carbon, improving water quality, increasing flood resilience, improving wellbeing, and highlighting areas where these benefits overlap i.e. where the benefit: cost ratio is likely to be the greatest. For WWT, this will allow the identification of new areas to focus on delivering the 100,000 hectares target;

- Enable discussions with stakeholder groups such as local government, business leaders and major landowners, to identify areas of potential for maximising natural capital benefits through large-scale wetland creation;

- Demonstrate the scale of the potential (both spatial and economic) to policy makers, for example, by highlighting parliamentary constituencies where there is particularly high potential for wetland solutions to address wellbeing issues; and

- Demonstrate the scale of the potential and illustrate the value of wetlands as nature-based solutions to the wider public, to generate action and advocate for wetland conservation.

1.3.2 How is this work different to other national/regional habitat restoration potential mapping?

The strategic planning of habitat restoration potential, which includes wetlands, is being addressed through a number of government initiatives. For example, the England LNRS are mapping where local habitat improvement and restoration could address national-scale environmental objectives, and the Natural Resources Wales (NRW) WINS project (Gwybodaeth am Gymru ar gyfer atebion sy'n seiliedig ar natur or Welsh Information for Nature-based Solutions), has mapped the best places to take action to enhance the environment using nature-based solutions (Natural Resources Wales, 2018a). WINS focussed on four key policy themes: green spaces (for wellbeing); water spaces (for natural flood management); blue spaces (for managing nutrient enrichment); and wood spaces (for woodland planting). A number of other organisations and partnerships have undertaken mapping of wetland restoration potential focussed on particular ecosystem services for devolved UK nations. For example, the Marine Management Organisation (MMO) and Marine Scotland have mapped saltmarsh restoration potential for England and Scotland, respectively (MMO, 2019; Smeaton et. al., 2022).

The maps presented by this project are not intended to replace these important resources, but to form part of a growing evidence base of the potential for restoration and of the vital services provided by wetlands. However, a few aspects of this work make it unique:

- UK (or GB) scale – The maps have been produced at a UK scale (or Great Britain, where data for Northern Ireland was unavailable) using equivalent datasets, where available, for each UK nation, in order to produce a comparable picture of the relative potential across the country as a whole. While environmental policy frameworks and targets are largely set by devolved governments, stakeholders operating *across the UK*, such as some large landowners and many eNGOs, would benefit from maps that offer a clear picture of the potential across all four nations.

- Wetland specific – This work is explicitly wetland-focussed, whereas the majority of studies either incorporate wetlands within a wider landscape approach to habitat improvement or include wetland aspects as part of a suite of interventions to address a specific issue. While both of these approaches are necessary, this work is designed to recognise the specific role that wetlands have to play in addressing the challenges we face in the UK – and addresses WWT's call for a 'Blue Recovery'.

- Multi-benefit approach – This work identifies the suitability of the landscape to support wetlands as well as the relative 'demand' for wetlands based on the key issues that wetlands can help to address. By combining maps of wetland potential focussed on specific individual benefits, we also highlight the potential for wetlands to deliver multiple benefits. A similar approach combining suitability and potential benefits of woodlands, was used to create the 'Woodland Opportunity Map' for Wales (Welsh Government, 2021).

- Quantified benefits - The wetland potential mapping has been used directly to estimate the feasible returns to society of the strategic ambition for 100,000 hectares of new or restored wetlands targeted in optimal areas for delivering flood resilience, urban wellbeing, carbon sequestration and water quality improvements.

Section 4 compares some of the key areas of overlap between the mapping presented here and other similar maps produced at the country-scale.

1.4 Purpose of this report

This technical guidance details the methods used to map the potential of the UK to support large-scale wetland creation and summarises the methods used to estimate the returns to society of a realistic wetland creation strategy. Full details of the natural capital accounting methods are provided separately for 'wetlands for urban wellbeing', 'wetlands for flood resilience', 'wetlands for water quality' and 'wetlands for carbon storage'. The results of both the mapping and natural capital accounting are summarised, together with a discussion around key outcomes, the uses of the outputs and important caveats. Interactive maps can be viewed individually in ArcGIS Online (Appendix II), together with other relevant open-source data in the Wetland Data Explorer.

1.5 Scope and limitations of the mapping

The following general principles were followed in defining the scope of the Roadmap to 100,000 hectares mapping:

Wetland creation versus restoration

Here, we define wetland **creation** as establishing wetland habitat where it is currently not present and has not previously been present, and **restoration** as the process of assisting the recovery of a wetland ecosystem that has been degraded, damaged, or destroyed (Gann, et al., 2019). This work does not distinguish between areas of potential for restoration or creation but is likely to include opportunities for both: for example, many areas of potential for intertidal wetlands and floodplain inundation will have been wetlands historically (prior to human modification), while many urban and constructed treatment wetlands are likely to involve creation of new wetland habitat.

Data sources and resolution

The outputs have been produced using entirely open-source data. Higher resolution, more detailed attribute data are available, however, given our aim of producing a strategic national overview of relative potential, and the costs and processing implications of including such data, they were deemed beyond the level of detail required. Incorporation of higher resolution datasets is recommended for detailed operational planning at a local scale.

Indicative outputs

For the reasons outlined above, the outputs of this work are indicative only and not intended to be used to identify preferred locations for wetland creation at very local scales. They are intended to give a national/regional scale overview of the relative potential for wetland creation targeted at maximising the carbon sequestration, flood resilience, urban wellbeing and water quality benefits. For many practical reasons, it is unlikely that all of the mapped areas of potential are suitable/feasible sites for wetlands.

Similarly, omission from our wetland potential maps does not suggest that an area is unsuitable for wetlands. The prioritisation steps followed have selected the optimal areas for delivering selected ecosystem services at national scale, whereas many other (often local) factors may render an area important for wetland creation/restoration. Areas where wetland restoration is of particular importance for biodiversity, for example, have not been considered here (see below).

Comparability between UK nations

The aim was to produce, as far as possible, comparable outputs for each UK nation. Many differences exist in equivalent datasets available for different nations and it was necessary to derive proxy data for some variables. Datasets available for England and Wales were very similar to each other in terms of their attributes and data collection methods.

Geographic extent

Given that the 100,000 hectares ambition is nationwide, we strived to produce outputs for the UK as a whole. However, due to the limited availability of equivalent open-source datasets for Northern Ireland, some maps have been produced at the GB scale. Further work to produce comparable maps for Northern Ireland is planned.

Inclusion of biodiversity

This work is designed to recognise the specific role that wetlands have to play in addressing the challenges we face in the UK and the creation and restoration of bigger, better, more connected wetland habitats will inevitably help the recovery of many declining wetland species and of UK nature more broadly. The mapping does not, however, specifically target the creation of ecological networks, as defined by (Lawton, et al., 2010): suites of high-quality wildlife sites containing biological diversity with connections between them enabling species, or their genes, to move.

It is also the case that many of the mapped wetland 'types' may not form key components of ecological networks: a treatment wetland, for example, may have less biological diversity than equivalent wetland with better water quality; and an urban sustainable drainage system (SuDS) may be relatively isolated from other wildlife sites.

However, when sited appropriately and designed with biodiversity in mind e.g. by incorporating diverse vegetation communities, wetlands can deliver significant biodiversity gains in otherwise nature-depleted areas.

The outputs of this analysis are compared with other wetland potential datasets focussed on enhancing ecological resilience in Section 4.

Outline methodology

2 Outline methodology

2.1 General approach to mapping wetland potential

Wetland restoration potential was mapped separately for WWT's four 'Blue Recovery' themes: water quality, carbon storage, flood resilience and urban wellbeing, before being combined and summarised into overall wetland potential maps.

We aimed for a consistent approach to mapping wetland potential across the four individual themes to ensure meaningful and comparable outputs. Some variation was inevitable due to differences in underlying data and the spatial units appropriate to each theme. The general process is summarised in Figure 4 and described in more detail below. Appendix III contains the detailed methods for each theme and Appendix II summarises the maps produced at each stage.

Caution should be taken when comparing wetland potential between UK nations due to differences in datasets used and data availability for each UK nation. Users are advised, for example, to consider a broader range of constraints/obstacles relevant to their area of interest when interpreting the maps. Appendix IV lists the datasets used for each nation.

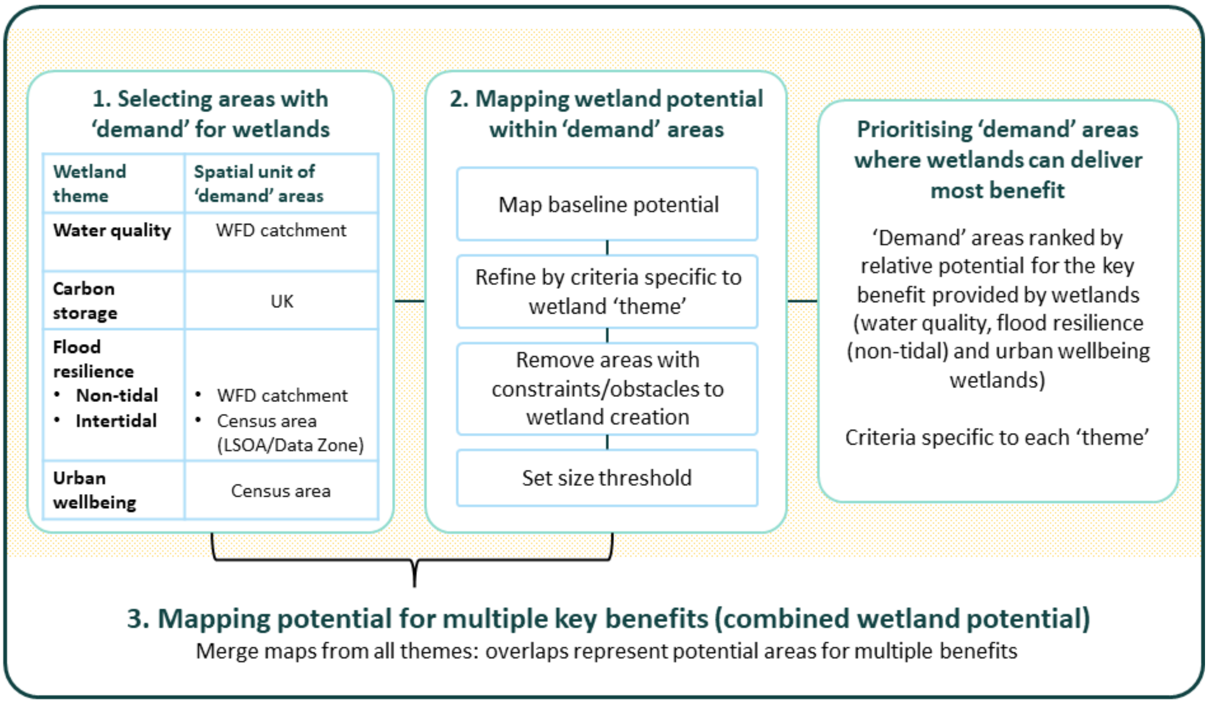


Figure 4. General stages used to map wetland potential for the four themes (boxes in shaded area): water quality, carbon storage, flood resilience and urban wellbeing; and for all themes combined.

1. Selection of areas with 'demand' for wetlands

This involved the selection of areas where wetlands could offer realistic solutions using a range of criteria specific to each theme (see sections 2.1.1 to 2.1.4). Only areas of particularly high 'demand' for wetlands were included in the priority 'demand' area maps.

The spatial units of 'demand' areas were specific to each theme (Figure 4): they included Water Framework Directive (WFD) waterbody catchments (hereinafter referred to as catchments) for 'wetlands for water quality' and 'wetlands for flood resilience', and 2011 census areas for 'wetlands for urban wellbeing'. Because climate change is a global issue it was not necessary to define a spatial unit of demand for carbon storage wetlands.

2. Mapping wetland potential within 'demand' areas

Within each 'demand' area, we mapped the potential of the landscape to support wetlands using topographic and hydrological indicators relevant to each wetland theme. We used Topographic Wetness Index (TWI) to indicate the tendency of an area to hold water, and hence its physical suitability for wetland restoration (Box 1). Areas of high topographic wetness formed the baseline wetland potential layer for the 'wetlands for water quality', 'wetlands for urban wellbeing' and some elements of the 'wetlands for flood resilience' mapping.

For 'wetlands for carbon storage' and some elements of the 'wetlands for flood resilience' mapping, wetland potential was derived from government flood risk data or other topographic and hydrological indicators (Sections 2.1.2 and 2.1.3).

Mapped areas of wetland potential were then refined based on a set of criteria specific to each wetland theme. This involved identifying and extracting areas of potential based on (i) geographic parameters, for example, proximity to existing access routes for 'wetlands for urban wellbeing'; proximity to potential pollution sources for 'wetlands for water treatment'; or (ii) additional landscape suitability parameters, such as limiting to 'wetland' soil types.

The resulting layers were further refined to exclude areas where wetland creation is unlikely to be possible due to constraints or obstacles. This included areas of built infrastructure, existing waterbodies, priority wetland habitat or other land-use types where wetland restoration would not be feasible or recommended. Figures 6 to 9 contain the full list of constraints and obstacles applied for each theme. These are not exhaustive due to limited data availability at the national scale – for example, the resulting maps likely include areas of existing non-priority wetlands. Restoration of these habitats may still be possible, however, if they are currently degraded.

3. Mapping potential for multiple key benefits (combined wetland potential map)

A 'multi-benefit wetland potential' layer was created by overlaying the four wetland potential maps created in Step 2 for individual themes: water quality, carbon storage, flood resilience and urban wellbeing. The greater the number of overlapping layers, the greater the opportunity for creating wetlands that deliver multiple benefits, i.e. relating to multiple themes. While all wetlands are likely to provide a range of ecosystem services, areas of overlap represent those where wetland creation could provide greatest return on investment.

Summarising wetland potential maps

The percentage cover of wetland potential identified for individual themes (excluding 'wetlands for carbon storage'; Step 2) was summarised for each of the 'demand' areas selected for the relevant theme (Step 1) and mapped to show the relative difference in coverage across 'demand' areas.

The percentage cover of 'multi-benefit wetland potential' (Step 3) was summarised and mapped for all catchments and, separately, Westminster parliamentary constituencies (Office for

National Statistics, 2024), in order to tailor the maps for a range of target audiences.

Prioritising 'demand' areas where wetlands can deliver most benefit

The 'demand' areas prioritised for each of the four 'themes' in Step 1 were ranked by the relative level of benefit that wetlands could provide to that theme. Datasets that best described the scale of demand were ranked individually, before being combined into an overall ranking from 'high' to 'low' 'demand' for each theme, which was subsequently mapped.

Due to a lack of spatially explicit data on carbon sequestration potential, it was not possible, at this stage, to map the relative carbon storage potential for individual sites/areas identified in the 'wetlands for carbon storage' map. While we have identified those of intertidal areas where restoration to saltmarsh is most likely, further work incorporating other factors likely to influence carbon sequestration is required to explore where saltmarsh restoration would be most effective for climate mitigation.

2.1.1 Wetlands for water quality

2.1.1.1 Background and scope

In England, only 14% of English rivers are in good health, while the UK is consistently ranked as one of the worst countries in Europe for bathing water quality (Harvey, 2021; Environmental Audit Committee, 2022). Pollution from a range of sectors, including agriculture, industry, mining, transport and domestic households, is having a devastating impact on people and wildlife. Pollutants such as heavy metals, sediment and nutrients like phosphorus and nitrogen are at dangerous levels in many of our watercourses.

Wetlands can play a vital role in helping us tackle our current water quality crisis. Treatment wetlands are engineered wetlands specifically designed to help clean polluted water. They do this by optimising the natural biological, chemical and physical treatment processes that occur in wetland habitats in order to transform and remove pollutants. Treatment wetlands have the potential to remove up to 60% of heavy metal loads, trap and retain up to 90% of sediment run-off and eliminate up to 90% of nitrogen input (Ellis et. al., 2003).

Not only are treatment wetlands efficient and cost-effective pollution removers, they also provide numerous co-benefits: boosting biodiversity, offering protection from flooding, and improving health and wellbeing (WWT, 2023b).

WWT's vision is for treatment wetlands to be used more widely across a range of sectors, to tackle the UK's poor water quality and bring multiple benefits to wildlife and people. The 'wetlands for water quality' route map lays out the proposals, partnerships and policy frameworks required to make this happen (WWT, 2023b). The wetlands for water quality potential mapping and natural capital accounting outlined below demonstrate the scale of the potential and quantifies the benefits, in monetary terms, of large-scale wetland creation targeted at improving water quality.

Box 1. Baseline wetland potential mapping using the Topographic Wetness Index (TWI).

The TWI, also referred to as the compound topographic index (CTI) calculates a relative wetness score for each pixel of a digital elevation model, based on a combination of slope and upstream contributing area. The larger the TWI, the greater potential for the landscape to hold water; in other words, high TWI indicates areas that were likely wetlands prior to human hydrological modification and would likely revert to wetland should human influence (on hydrology) reduce or be reversed. The index has, therefore, been used as a measure of the potential of an area to be receptive to wetland restoration (Higginbottom, et al., 2018). Values have been shown to be indicative of soil organic matter, erosion potential, and wetland extent (Beven, 1997; McKenzie & Ryan, 1999).

Processing was undertaken using the Raster Calculator tool in ESRI ArcGIS Pro, to derive a raster layer of the Topographic Wetness Index (TWI) from the FABDEM digital elevation model clipped to the UK coastline (Hawker & Neal, 2021).

The following steps were performed to derive TWI:

1. Calculate Flow Direction raster layer (Flow Direction tool)
2. Calculate Flow Accumulation raster layer (Flow Accumulation tool)
3. Create Slope raster layer (Slope tool: slope in Percent Rise)
4. Compute TWI (Raster Calculator) using formula:

$$Ln\frac{\big((Flow\ Accumulation + 1) * cell\ size\ of\ dem\big)}{(\frac{Slope}{100} + 0.0001)}$$

- A value of 1 is added to Flow Accumulation to account for the candidate pixel i.e. each cell is part of its own catchment area.
- A constant of 0.0001 was added to Slope to avoid issues of dividing by zero.

The resulting TWI layer was subject to post-processing using a Boundary Clean and Majority Filter, to generalise the layer and reduce the number of single pixels of a given value where the majority of surrounding pixels were of a different value. TWI values above a threshold 'wetness' value of fifteen (the lower value of the two 'wettest' TWI categories defined using the [Jenks Natural Breaks algorithm]; Figure 5) were extracted as the baseline 'wetland potential' areas.

Figure 5. TWI calculated for mainland UK. Note: areas of accumulation in upland peat-rich soils are under-represented by TWI (see Section 4).

This analysis has focused on areas where there is both the need and the potential for wetlands for water quality. Such wetlands could include constructed treatment wetlands (CTWs) or systems that promote water quality improvements through more natural, free-flowing wetlands. The mapping exercise focuses on identifying areas where wetland solutions could be implemented using natural flow paths and wetland-compatible (impermeable) soil-types. However, locations both within and outside of the identified areas of potential may indeed be suitable for CTWs targeted at specific pollution sources.

Other wetland types mapped in this study may have substantial water quality benefits. For example, wetlands for urban wellbeing may include Sustainable Drainage Systems (SuDS), such as rain gardens and swales, that help filter out pollutants entering watercourses; natural flood management interventions help to trap and retain nutrient-rich sediment; and, in saltmarshes, pollutants are buried within accreting sediment (Adnitt, et al., 2007).

2.1.1.2 Mapping steps

Figure 6 outlines the key steps and criteria used to map ‘demand’ areas for ‘wetlands for water quality’ and the potential of the landscape to support these wetlands. Detailed methods are provided in Appendix III. Appendix IV lists the data sources used.

Spatial units of ‘demand’ areas

WFD waterbody catchments were used as the spatial units for identifying areas of ‘demand’ for ‘wetlands for water quality’. The success of water quality improvements is widely reported at the catchment level, e.g. through WFD status assessments, and addressing water quality across whole catchments is acknowledged as an effective scale at which to deliver sustainable, cross-cutting improvements to the water environment.

2.1.2 Wetlands for carbon storage (saltmarsh potential)

2.1.2.1 Background and scope

Carbon stored in vegetated marine and coastal ecosystems, particularly saltmarshes, mangroves and seagrass beds, is referred to as Blue Carbon. The contribution of these habitats per unit area to long-term carbon sequestration is much greater than that of forests (Mcleod, et al., 2011). Recently restored saltmarshes in the UK are estimated to bury an average of 13.3 t CO2e ha^{-1} y^{-1}, compared to 8.2 t CO2e ha^{-1} y^{-1} in established saltmarsh (Mason et. al., 2022).

The UK has lost a considerable amount of saltmarsh since the mid-1800s, mostly due to land claim for agricultural use. Reduction in saltmarsh cover and habitat disturbance from land-use transition can cause significant emissions of carbon stored in sediment and associated vegetation (Lovelock et. al., 2017). Restoring and recreating these habitats could play an effective role in climate change mitigation by sequestering and storing atmospheric carbon, while at the same time delivering a wide range of other benefits.

Saltmarshes are important habitats for many migratory birds and fish, offer coastal flood protection through absorbing wave energy, help prevent coastal erosion, can improve water

Selection of areas with high 'demand' for water quality solutions

Spatial units: WFD waterbody catchments

Datasets representing 'need'

- Failing WFD coastal and inland catchments
- Household projections
- Numbers of new houses built 2021-2022

Mapping potential locations for *wetlands for water treatment* within 'demand' areas

Mapping wetland potential

Topographically 'wet' areas within or 300m downstream of:

- Agricultural land classes 3 and 4
- Forestry operations
- High surface runoff areas (non-urban)
- Urban runoff
- Factory and industry discharges to water
- Frequently polluting Combined Storm Overflows (CSOs)

Removal of areas with constraints/obstacles to wetland creation

Roads, surface and tidal water, buildings, railways, OS functional sites, ancient woodland, orchards, priority grassland habitats and priority wetland habitats.

Final processing

Clip to wetland soil types and 'demand' areas

Set size threshold

≥ 0.2 ha

Figure 6. Summary of methods used to map 'wetlands for water quality' potential. Detailed methods are provided in Appendix III. Appendix IV lists the data sources used.

quality by trapping polluted sediments, support many important tourism and industrial livelihoods, and provide an important nursery area for the juvenile stages of many fish species (including several commercial species) (WWT, 2023c).

WWT is calling for at least 22,000 hectares of new and restored saltmarsh habitat across the UK by 2050 (WWT, 2023c), alongside the protection of our existing saltmarshes. The 'wetlands for carbon storage' route map details the purpose, processes, partnerships and policy frameworks required to make this happen. The saltmarsh potential mapping and natural capital accounting outlined below demonstrate the scale of the potential and quantify the benefits, in monetary terms, of large-scale saltmarsh creation, to UK society (WWT, 2023c).

The maps presented are indicative and useful for initial searches of potential restoration sites.

The inclusion of an area in the map does not indicate whether the land is actually available for saltmarsh restoration. More detailed investigation and consultation of local data, opinion and knowledge would be required to confirm this for a given site.

2.1.2.2 Mapping steps

Figure 7 outlines the key steps used to map 'wetlands for carbon storage' potential. Appendix III shows the detailed methods. Appendix IV lists the data sources used.

It was not necessary to define a spatial unit of 'demand' for carbon storage wetlands, given that reduction in atmospheric CO_2 is a global challenge. While locations may differ in the quantity of carbon that can be sequestered, it was assumed, for this step, that all restored saltmarsh has potential carbon sequestration benefit.

2.1.3 Wetlands for flood resilience

2.1.3.1 Background and scope

The UK is experiencing more frequent and intense flooding due to the heavier rain and stronger storms caused by climate change. Around 5.2 million properties in England – one in six – are at risk of flooding. Compounding this is the fact that large swathes of wetland, our natural flood storage habitats, have been degraded or destroyed over the last three centuries. Fields have been drained, floodplains disconnected and rivers straightened and dredged, while soils have been compacted and eroded, increasing runoff and sediment loads entering our watercourses. This has drastically reduced the capacity of the UK landscape to accommodate increased flooding. By the 2050s the average annual economic losses from coastal and river flooding in England and Wales could amount to between £1.6 and £6.8 billion (Defra, 2012a).

The UK Government recognises that traditional flood defences such as concrete embankments and walls will no longer be enough to protect us from climate change impacts, and in some circumstances, they may exacerbate the problems, for example, by accelerating flows and diverting flooding. Natural Flood Management (NFM) offers a complementary or sometimes alternative, sustainable and cost-effective way of reducing flood risk. NFM works by using a mosaic of natural features to slow the flow of water entering watercourses, storing flood water

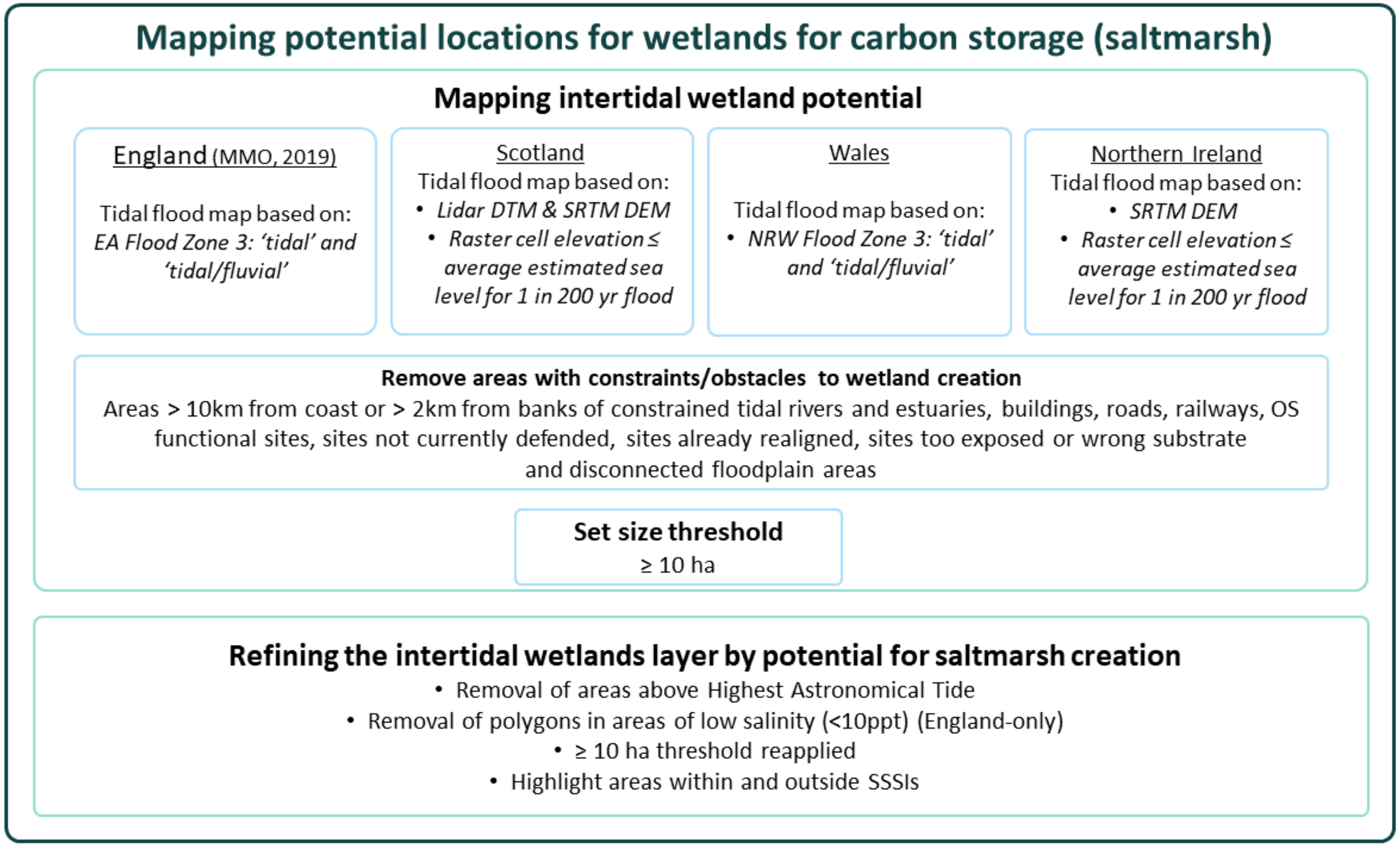


Figure 7. Summary of methods used to map 'wetlands for carbon storage' (saltmarsh) potential.

NB. Baseline potential mapping for England used the Marine Management Organisation Saltmarsh Potential (MMO) - Potential habitat creation sites within floodplain (MMO, 2019) dataset; equivalent methods were developed here for Scotland, Wales and Northern Ireland. Appendix III shows the detailed methods. Appendix IV lists the data sources used.

temporarily before releasing more slowly, increasing infiltration into the ground and evaporation back into the atmosphere, and de-synchronising peak flows across tributaries, which can significantly reduce flood peaks downstream (The Rivers Trust, 2024).

Creating more wetlands in the landscape when combined with other NFM techniques (such as cross-slope tree-planting, horizontal ploughing and peatland management) can increase flood resilience while delivering a wide range of co-benefits, such as improved biodiversity, increased wellbeing, enhanced water quality and strengthened community spirit (WWT, 2023d). Flood resilience wetlands can be created using a range of NFM techniques, including the re-connection of rivers to their floodplains by removing flood embankments, installing leaky woody dams across streams to slow flows and encourage peak flows to spill onto floodplains, or creating offline storage areas to temporarily or permanently store peak flows and increase infiltration.

WWT's vision is that NFM, especially where wetlands are used, is mainstreamed as part of the UK's approach to flood risk management in the UK. The 'wetlands for flood resilience' route map lays out the proposals, partnerships and policy frameworks required to make this happen (WWT, 2023e). The 'wetlands for flood resilience' potential mapping and natural capital accounting outlined below demonstrate the scale of the potential and quantifies the benefits to UK society of large-scale wetland creation focused on flood resilience.

A subset of NFM intervention types that can be designed to provide new wetland habitat have been the focus of this analysis (Table 1).

Table 1. Flood resilience techniques included in the analysis, and their flood resilience benefits.

NFM Technique	Flood resilience benefits
Runoff interception bunds	Usually formed of vegetated earth banks, bunds constructed across contours can intercept the flow of surface water, holding back and storing water, while reducing sediment transport downstream. Bunds can also divert water into storage areas.
Offline storage areas	Topographic depressions (natural or constructed), can store water outside watercourses, increasing the storage capacity of the floodplain and slowing the flow of surface water. Bunds may be used to increase the storage capacity.
Floodplain inundation	Involves reconnecting a river to its floodplain, allowing temporary flood water storage that is slowly released back into the watercourse.
Leaky dams and gully blocking	Barriers made of natural woody materials are placed across water channels. They obstruct high river flows, which slows the flow and allows infiltration into the soil. Barriers can be used to encourage banks to overspill, reducing or further delaying downstream peak flows. At normal river flows the barriers allow water to pass through.
Floodplain wet woodland	Tree-planting on existing floodplains can slow down flows as well as increasing sediment deposition and infiltration to the soil.

NFM Technique	Flood resilience benefits
Managed realignment	The planned breach or relocation of sea defences to allow previously defended land to flood. This can help to dissipate wave energy and protect against coastal erosion while creating intertidal wetland habitats such as salt marshes and other tidal marsh habitats.

2.1.3.2 Mapping steps

Figure 8 outlines the key steps used to map 'demand' areas for 'wetlands for flood resilience' and the potential of the landscape to support these wetlands. Detailed methods are provided in Appendix III. Appendix IV lists the data sources used.

Spatial units of 'demand' areas

WFD waterbody catchments were the spatial units used for identifying areas of 'demand' for 'wetlands for flood resilience': these wetlands are ideally delivered as part of a catchment-based approach to flood management.

2.1.4 Wetlands for urban wellbeing

2.1.4.1 Background and scope

In 2018, 40% of all GP appointments in England were attributed to mental health, with the NHS spending over £34 billion annually on mental health services (Mind, 2018; NHS, 2016). Research shows that access to nature brings health and wellbeing benefits and blue spaces, such as wetlands, are particularly effective in reducing stress compared to green spaces (White et. al., 2020). Within the UK's 200 most disadvantaged neighbourhoods, only 3% of residents have access to green space within a 15-minute walk (Natural England, 2021). The destruction and degradation of wetlands in urban areas exacerbates this disparity, leading to inequitable access to nature.

Urban wetlands come in all shapes and sizes. They include mini-wetlands at the individual property level, sustainable drainage systems (SuDS) and small ponds at the street level, restored streams and wildlife ponds at the neighbourhood level, and urban park wetlands including lakes, streams and ponds, that provide large natural spaces in our cities and towns.

WWT proposes that as part of its 100,000 hectares ambition, the location of created and restored wetlands should consider the potential to address the mental health and wellbeing crisis. To ensure that wetland interventions are as effective as possible at tackling this crisis, restoration should be focused on locations where current access to natural spaces is minimal, poor mental health is rife and where there are high levels of deprivation and vulnerability to flooding. The 'wetlands for urban wellbeing' route map lays out the proposals, partnerships and policy frameworks required to make this happen (WWT, 2022). The wetland for urban wellbeing potential mapping outlined below and the associated natural capital accounting, demonstrates the scale of the potential and quantifies the benefits to UK society of an ambitious wetland creation target focused on urban wellbeing.

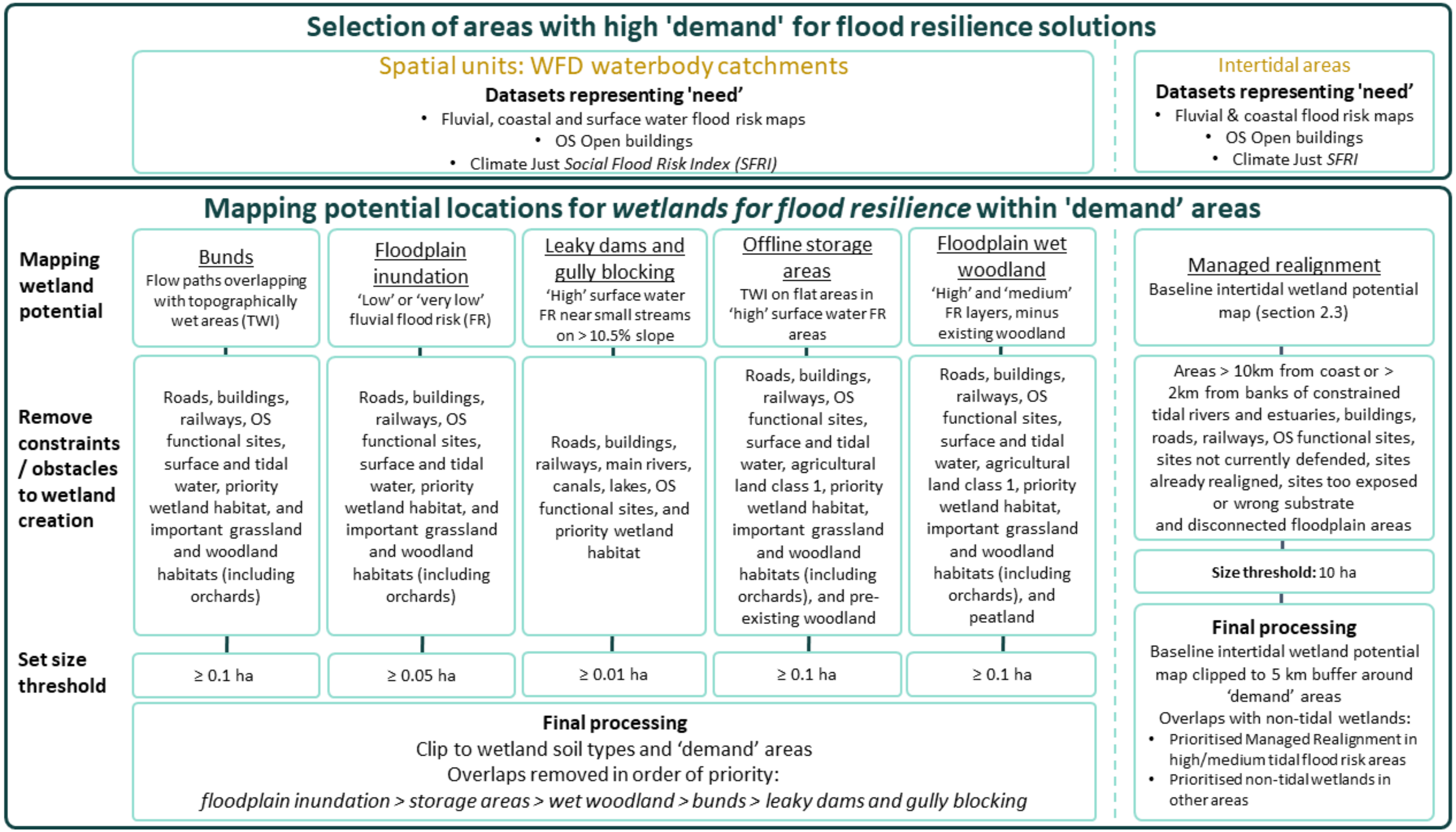


Figure 8. Summary of methods used to map 'wetlands for flood resilience' potential. Detailed methods are provided in Appendix III. Appendix IV lists the data sources used.

WWT

2.1.4.2 Mapping steps

Figure 9 outlines the key steps used to map 'wetlands for urban wellbeing' potential. Detailed methods are provided in Appendix III. Appendix IV lists the data sources used.

Spatial units of 'demand' areas

2011 Census areas were used as the spatial units of 'demand' areas for 'wetlands for urban wellbeing'. Census areas are the geographic hierarchy used for the standardised reporting of many local-level population statistics and comprise Lower layer Super Output Areas (LSOAs) in England and Wales (Office for National Statistics, 2016) and Data Zones in Scotland (Scottish Government, 2014a). Each has a similar population size or number of households, such that urban areas generally contain a large number of smaller census areas, and rural areas contain fewer, larger census areas.

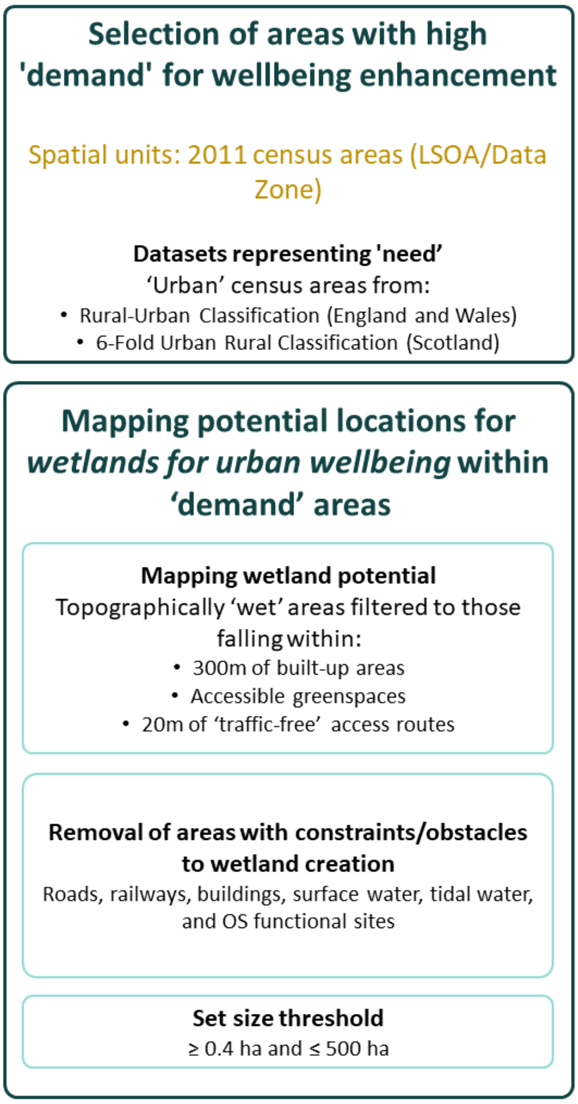


Figure 9. Summary of methods used to map 'wetlands for urban wellbeing' potential. Detailed methods are provided in Appendix III. Appendix IV lists the data sources used.

2.2 General approach to natural capital accounting

2.2.1 Background

The idea of natural capital (Box 2) is to define nature as an asset that society depends on, and that should be protected or maintained in order to continue providing benefits to people into the future.

Box 2. Commonly used terms relating to values provided by nature to society(1).

Natural Capital: all the elements of nature that provide benefits to people.

Ecosystem services: the benefits that nature provides: provisioning (food, fibre, energy etc), regulating (climate, water, nutrient cycles etc.) and supporting (biodiversity, soil etc.)

Natural capital accounting: the systematic process of identifying, measuring, recording and summarising information on the *stocks* of natural capital assets and the *flows* of benefits they provide.

Natural capital accounts produce information on our impacts on nature and on how we depend upon nature. They cover both the benefits provided by natural capital assets and the costs of maintaining them. Like financial accounts, these accounts are structured to ensure consistent and transparent reporting of all information (environmental, financial and socio-economic), assumptions and knowledge gaps, which supports comparisons across locations and over time. Expressing values in monetary terms allows the comparison of public goods to private (financial) costs and benefits, enabling a better case to be made for investing in the maintenance (or enhancement) of natural capital.

The natural capital accounting produced by this study focusses on identifying the scale of the potential benefits provided by large-scale, targeted wetland creation at a UK-scale – benefits that are often underappreciated in considering wetland policy options.

Comprehensive accounts of the natural capital benefits analysis, produced by eftec in close collaboration with WWT, are provided as separate reports – one for each of the four key wetland themes: 'wetlands for urban wellbeing', 'wetlands for flood resilience', 'wetlands for water quality' and 'wetlands for carbon storage'. These reports detail the approach taken, the key results, including key data gaps and uncertainties, and provides recommendations on the interpretation of, and future updates to the accounts.

2.2.2 Scope

Each account aims to evidence the value associated with creating wetlands targeted at improving wellbeing, water quality, storing carbon and increasing flood resilience. The benefits accounted for under each of the four themes are detailed in Table 2. The accounts utilise data on the mapped areas of potential wetlands, the services they support, the value of the benefits they provide to people, and the distribution of those benefits across businesses and society into the future. These benefits are compared to the costs (due to creation and maintenance) of wetland creation in a balance sheet. The analysis of these benefits has followed Defra's 'Enabling a Natural Capital Approach' (ENCA) guidance (where relevant) and aligns with HM Treasury green book appraisal principles (Defra, 2023e; HM Treasury, 2022).

The natural capital accounts estimated the economic benefits of creating 25,000 hectares of each wetland type between 2024 and 2050 (the target year for the 100,000 hectares ambition), located in the optimal places for provision of key benefits.

The ‘wetlands for flood resilience’ account focused specifically on non-tidal wetlands, i.e. excluding those that would be created by managed realignment. The methods and input data used to estimate the flood protection benefits of freshwater and intertidal wetlands are quite different. As such, flood protection from intertidal wetlands created by managed realignment has only been valued within the ‘wetlands for carbon storage’ account.

2.2.3 Identifying natural capital assets (target areas for wetland creation)

Mapped areas of wetland potential for the four themes (Section 2.1, Steps 1 and 2) were used to define the natural capital assets for each account. Each map was refined to a target area of approximately 25,000 hectares per theme to create an overall area for valuation of 100,000 hectares, which aligns with WWT’s ambitions (Section 1.2).

Target areas were distributed proportionally across the UK nations, in line with population sizes, such that quantified benefits are distributed across the UK rather than concentrated in a specific nation. The 'wetlands for carbon storage’ target areas were distributed based on relative area of potential rather than population size: the proportion of total saltmarsh potential mapped within each UK country, was applied to the 25,000 hectare target area. Table 2 outlines the geographic scope of each account, which varied according to data availability.

For each of the four wetland themes, we selected areas of mapped potential where wetlands are likely to deliver the greatest value for that theme, up to the 25,000 hectare target. Table 2 lists the criteria used to select wetlands for inclusion in the target area. The natural capital accounts (‘wetlands for urban wellbeing’, ‘wetlands for flood resilience’, ‘wetlands for water quality’ and ‘wetlands for carbon storage’) describe the full methods and data sources used to define the target areas.

Table 2. Criteria used to define the natural capital assets, the benefits considered, and the geographic scope, for natural capital accounting of 100,000 hectares of wetland creation targeted at the four wetland themes. Full details, including data sources for the criteria, are described in the natural capital accounts for each theme[2].

Theme	Criteria used to define 25,000 hectare target area	Benefits considered	Geographic scope
Wetlands for water quality	Wetlands in catchments with: • area of **wetland potential sufficient for water quality to improve to Good** WFD status; • **Reason for Not Achieving Good Status (RNAGS) = phosphate**; • Current **WFD status = Bad**; • Current **WFD status = Poor** and highest **% cover of wetland potential on low-grade agricultural land[3].**	Water quality; food provision; water supply; recreation	England, Scotland
Wetlands for carbon storage (saltmarsh)	**Proportion of total hectares of saltmarsh potential** mapped within each UK country, applied to target area.	Carbon sequestration; food provision; fishing (commercial); flood risk management; recreation and tourism; water quality	UK
Wetlands for flood resilience	Wetlands in catchments with: • highest **% cover of wetland potential on low-grade agricultural land**; • within or feeding into catchments with expected **high risk of future flooding**	Flood risk management; carbon sequestration; food provision; air quality regulation; recreation; physical health	GB
Wetlands for urban wellbeing	Wetlands in census areas with: • High '**Neighbourhood Flood Vulnerability**' (Sayers, Horritt, Penning Rowsell, & Fieth, 2017); • Low levels of **access to accessible greenspace**; • High incidence of **mental health conditions** in population.	Carbon sequestration; recreation; mental health; physical health; urban cooling	GB

[2] Data sources are also included in Appendix IV of this report, as these criteria were used to map relative demand for water quality, flood resilience and wellbeing benefits (Section 0;

Appendix III).

[3] Agricultural Land Classification (ALC) for Wales and England (Welsh Government, 2017; Defra, 1988) and Land Capability for Agriculture classification (LCA) for Scotland (James Hutton Institute, 1981) classify land from grades 1 – 5 and grades 1-7 respectively, where ALC/LCA grades 1 and 2 are the highest quality agricultural land (i.e. few limitations for agricultural land; higher yields) and ALC/LCA grades 3 and above represent lower quality agricultural land.

2.2.4 Aggregation of benefits

The approach taken in estimating the costs and benefits is consistent across the four accounts, allowing for aggregation across accounts. The accounts monetised costs and benefits based on a 2024 price year and projected costs and benefits over 60 years. All accounts assumed that an equal area of wetlands is created each year between 2024 and 2050 (i.e., the year in which the target area of wetland creation is achieved). The monetised benefits estimated in each account can be aggregated with a low risk of double counting, for the following reasons:

- **Little overlap in target wetland areas**. Target areas in each theme were defined by where wetlands would be most likely to fulfil the primary purpose of that theme (i.e. flood resilience, urban wellbeing or water quality improvement, and carbon sequestration). Although it is possible for an area to be suited to wetlands that are high priority under multiple themes, for example, wetlands providing both flood resilience and water quality improvements, in practice this study did not identify substantial areas of overlap in the target wetland areas identified for each account. This reduces concerns of double counting the benefits of wetland creation across the accounts.

- **Wider potential wetland area providing similar benefits**. Each account has identified a larger potential wetland area than the 25,000 hectare target area actually covered by the account. Although benefits have been estimated for defined target wetlands, the benefit values applied are general averages at a regional or national scale, rather than being spatially explicit at the site level. This means that the calculated benefits are not tied to specific locations within the target area, but rather represent a typical value that could be achieved at other wetland sites if the sites we have mapped to demonstrate the vision were not available. This includes if they were not available because they were used for a different wetland type. As a result, even if two accounts identify overlapping target wetlands, there are alternative locations that could be used, and these would benefit different communities, so there is no double-counting of the benefits. This is because the values used are not dependent on the exact site but reflect the typical benefits that could be realised in various potential locations. Therefore, if a wetland were moved from one location to another within the wider potential area, the values they generate would not be compromised. The account results do not prescribe specific locations for wetland creation; instead, they illustrate the potential societal returns from implementing a realistic wetland creation strategy across a broader landscape.

Results

3 Results

3.1 Wetlands for water quality

3.1.1 Catchments with 'demand' for wetlands

In total, 2,224 river and coastal waterbody catchments across the UK were identified as priority 'demand' areas for 'wetlands for water quality' (Figure 10a, Table 3), which equates to 26% of the total number of catchments in the UK (8,643). These catchments are largely concentrated in central and southeast England where water quality issues are linked to the higher population density and a more intensively managed landscape. In Scotland, priority catchments are concentrated around the Central Belt, particularly along the southern coast of the Firth of Forth, and in Dumfries. Most of the priority catchments in Northern Ireland are in County Down and County Armagh. In Wales, priority catchments are mostly located in the counties of South Wales.

3.1.2 Wetland potential within 'demand' catchments

The mapped potential for 'wetlands for water quality' across Great Britain is shown in Figure 10b. A total of 672,938 hectares of 'wetlands for water quality' potential were identified (Table 3). The relative area of potential across priority 'demand' catchments is summarised in Figure 10c relative to catchment size.

Table 3. Identified areal coverage (in hectares) of 'wetlands for water quality' potential and number of priority 'demand' catchments, per country.

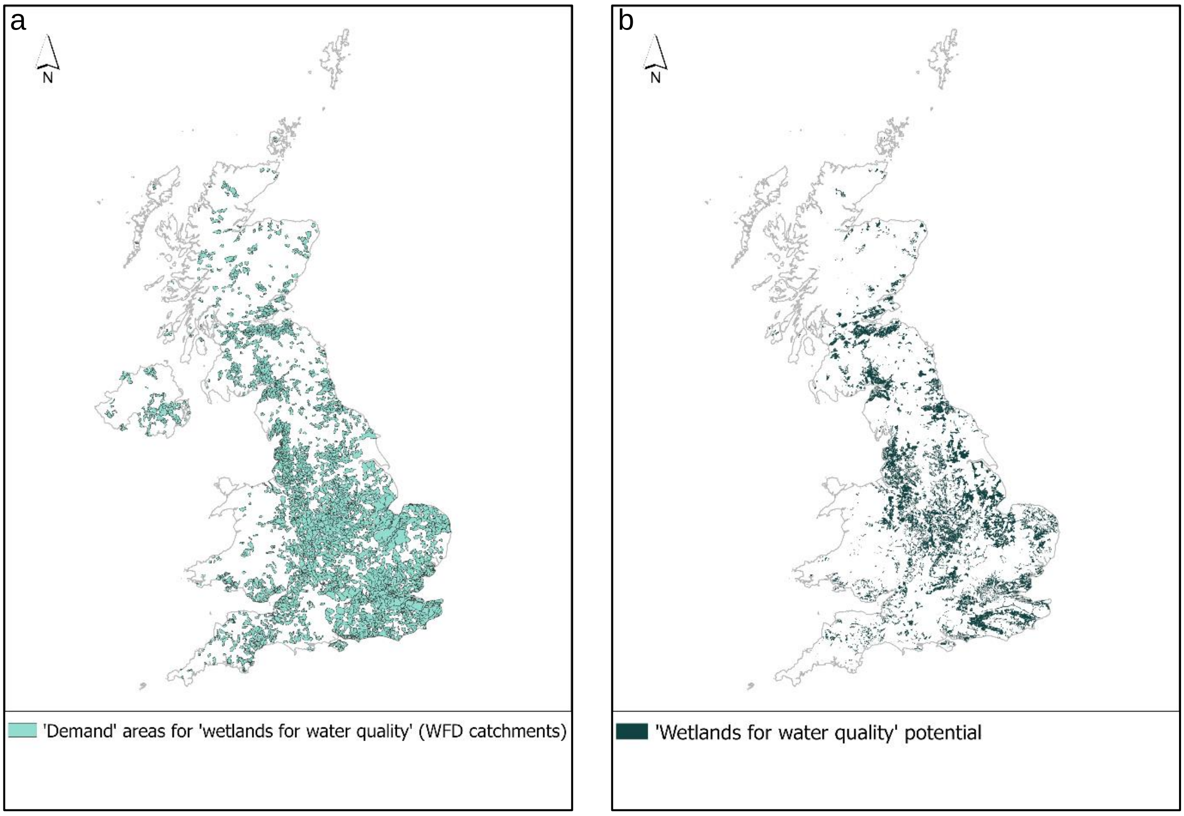
	Total area (ha)	Number of 'demand' catchments
England	578,041	1,633
Scotland	89,927	431
Wales	7,970	88
Northern Ireland	TBD	72
Total	**672,938**	**2,224**

While the distribution of wetland potential closely matches that of the 'demand' catchments, particularly high concentrations of potential are highlighted in the Fens; in Kent, south of Maidstone and Ashford; coastal Essex; Oxfordshire; Cheshire; Shropshire; around York and Doncaster; and around Southport and the Ribble Estuary. In Scotland, there are concentrations of wetland potential around Dumfries; between Glasgow and Edinburgh; and between Stirling, Dunfermline and Dundee. The majority of wetland potential in Wales is dispersed around the eastern counties and South Wales.

Out of the six criteria (defined zones around potential pollution sources; see Figure 6 and Appendix A3.2) used to indicate where wetlands could be used to address poor water quality, the most criteria met by a single wetland parcel was four (Figure 10d). Wetlands created in areas that met multiple criteria are likely to help alleviate water quality issues arising from multiple sources and may represent key areas to focus restoration efforts. Agricultural land classes 3 and 4[4], urban runoff, factory and industry discharges, and frequently polluting Combined Storm Overflows (CSOs) displayed the most overlap: these criteria tend to be concentrated in and around urban areas. The largest blocks of contiguous wetland potential (over 30 hectares in size) where four criteria overlap are located within England, e.g. around Coalville, Crewe, Great Yarmouth, Leominster, Matlock, Penrith, Sheffield, and Tenbury Wells.

3.1.3 'Demand' catchments where wetlands can deliver most benefit

Priority 'demand' catchments ranked as having 'high' demand for 'wetlands for water quality' (Section 2.1; Appendix A3.1) were located in the Midlands, central East Anglia, Sussex, County Durham, North Yorkshire, Stirling, Dumfriesshire and Ayrshire (Figure 10e).



[4] Moderate to poor quality land likely to require relatively high chemical input to achieve high yields, and hence where the highest degree of pollutant runoff is likely (see Appendix A3.2)

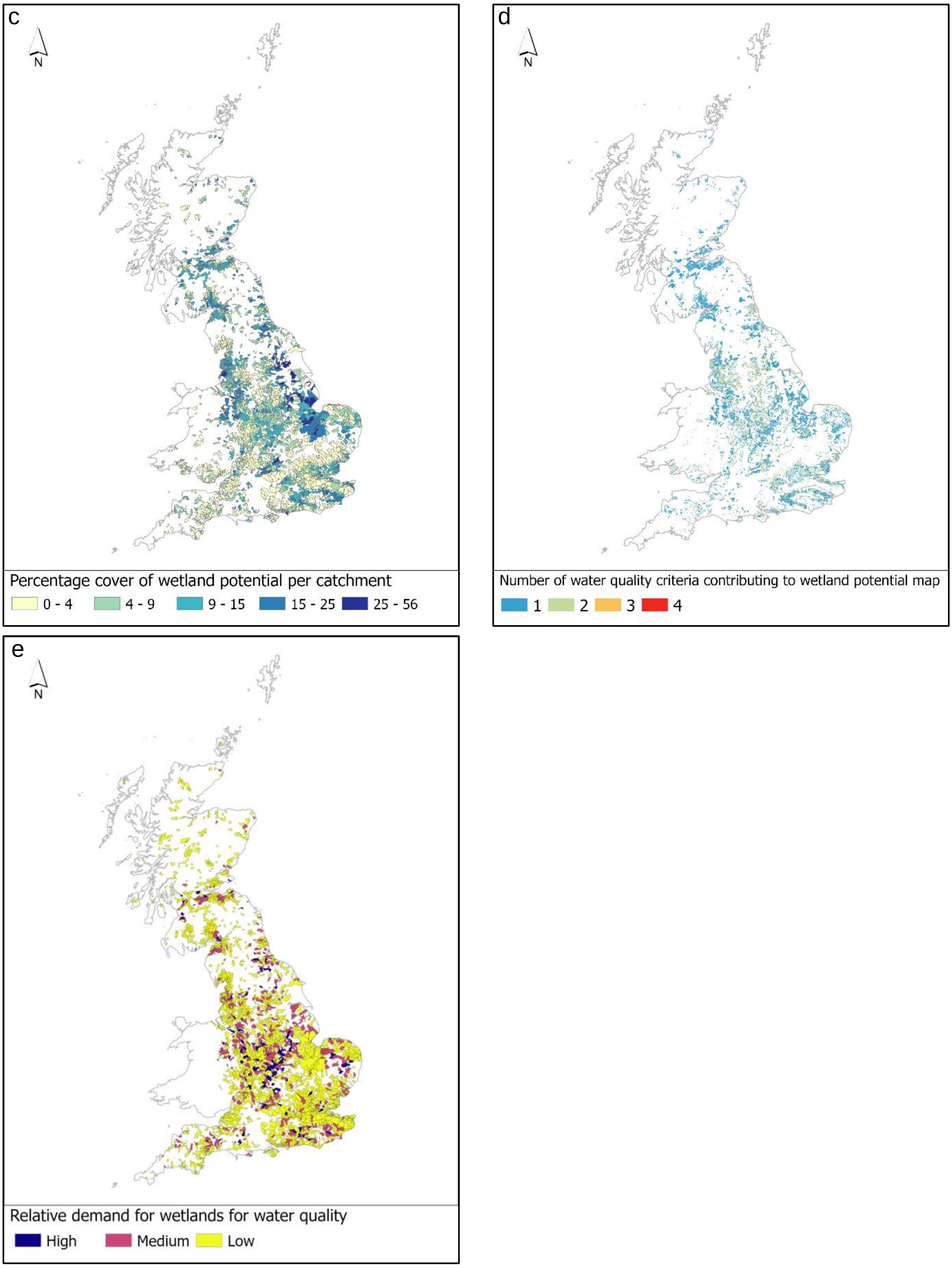


Figure 10. 'Wetlands for water quality' maps showing (a) Priority catchments with 'demand' for water quality wetlands; (b) Indicative 'wetlands for water quality' potential; (c) % cover of wetland potential per 'demand' catchment; (d) Number of criteria that contributed to the identification of wetland potential areas (see Appendix 3.2); and (e) Relative 'demand' for water quality benefits across 'demand' catchments.

3.2 Wetlands for carbon storage

3.2.1 Potential locations for saltmarsh creation

Figure 11 shows the indicative ‘wetlands for carbon storage’ (saltmarsh) potential mapped for the four UK nations. A total of 174,107 hectares of saltmarsh potential were identified by refining the intertidal wetland potential layers (Table 4; see Appendix A4.2).

Table 4. Identified areas (in hectares) of intertidal wetland potential and saltmarsh potential in the UK.

	Area of intertidal wetland potential (ha)	**Area of carbon storage (saltmarsh) potential (ha)**
England	258,074 (MMO, 2019)	150,638
Scotland	15,496	6,716
Wales	25,746	13,411
Northern Ireland	7,322	3,342
Total	306,639	**174,107**

Wetlands for carbon storage (saltmarsh) potential has been identified in all four UK nations. In England, large areas of potential are evident in the Wash, along the Suffolk, Essex and Kent coastlines, the Severn Estuary, outer areas of the Humber Estuary, the Ribble Estuary and Morecambe Bay; and in Wales, around Cardiff and Newport, Carmarthen Bay, Cardigan Bay, from Dyfi Estuary north to Porthmadog, and the Cefni Estuary. In Scotland, relatively small areas of saltmarsh potential are identified in the Firth of Forth, Dumfries and Galloway, Dornoch and Moray Firths and parts of the Outer Hebrides and the west coast. Loch Foyle is the largest area of potential in Northern Ireland, with smaller areas in Strangford Lough and north Dundrum Bay.

Nineteen percent (32,586 hectares) of the area of potential is currently under Site of Special Scientific Interest (SSSI) designation (Natural England, 2024a; Scottish Government, 2024a; Natural Resources Wales, 2024a) or Area of Special Scientific Interest (ASSI) (Northern Ireland Environment Agency, 2016), with these SSSIs widely scattered across the south, Kent and Essex coasts in England, and West Wales (Figure 11). The 4,700 hectare area of potential in the Gwent Levels SSSI on the Severn Estuary is the largest contiguous area of potential falling within a SSSI. This SSSI is largely dominated by coastal and floodplain grazing marsh.

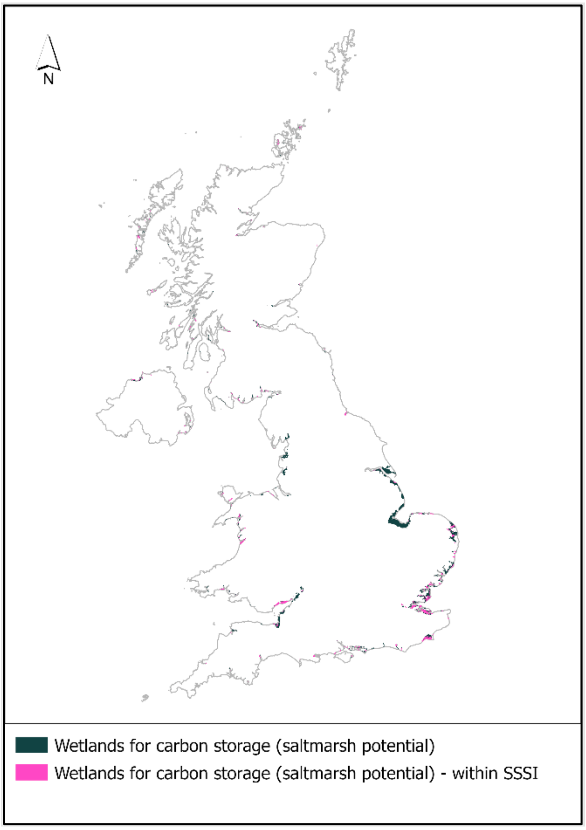


Figure 11. Indicative 'wetlands for carbon storage' (Saltmarsh) potential map, showing areas of potential within SSSIs.

3.3 Wetlands for flood resilience

3.3.1 Catchments with 'demand' for wetlands

In total, 1,867 WFD river waterbody catchments across Great Britain were identified as priority 'demand' catchments for 'wetlands for flood resilience' (Figure 12a, Table 5), which equates to 27% of the total number of catchments in GB (6,861). The vast majority (76%) of priority catchments are in England with 14% in Scotland and 10% in Wales. Concentrations of priority catchments are identified in Yorkshire and the Humber; the East and West Midlands; southern counties of Northwest England; Southeast England; Central Lowland regions of Scotland; and South and Northwest Wales.

3.3.2 Wetland potential within 'demand' catchments

Figure 12b shows the indicative locations for 'wetlands for flood resilience' in Great Britain, which is summarised by WFD catchment in Figure 12c. A total of 587,610 hectares of flood resilience wetland potential were identified, with offline storage areas, managed realignment and runoff interception bunds delivering 41%, 20% and 18% of this potential, respectively (Table 5).

Table 5. Total area (in hectares) of identified flood resilience wetland potential for each NFM technique assessed, and number of priority catchments per country.

	Area of wetland potential (ha)			
NFM intervention type	**England**	**Scotland**	**Wales**	**Total**
Runoff interception bunds	80,107	31,784	8,429	**120,320**
Flood inundation	53,758	906	869	**55,534**
Leaky dams / Gully Blocking	422	68	409	**899**
Offline storage areas	210,765	22,843	4,849	**238,457**
Floodplain wet woodland	58,536	8,149	1,523	**68,207**
Managed realignment	98,113	1,320	4,759	**104,192**
Total area	**501,701**	**65,070**	**20,839**	**587,610**
Number of priority catchments	1,417	261	189	1,867

Particularly high concentrations of potential non-tidal flood resilience wetlands are identified in Lincolnshire; the Cambridgeshire fens; South Yorkshire (around Doncaster); along the River Trent (between Lincoln and Nottingham); catchments of the Thames Basin, particularly in Oxfordshire, Berkshire and Surrey (Figure 12c); and across many catchments of the West Midlands (e.g. catchments of the River Severn in Shropshire). In Scotland, key areas include Dunbartonshire, North Lanarkshire, Ayrshire, the Lothians, Stirling and Falkirk, Clackmannan and Fife; and in Wales, non-tidal flood resilience wetland potential is clustered within South Wales, Clwyd and north Powys (Figure 12b).

The largest areas of wetland potential are identified in (i) low-lying regions where offline storage areas, floodplain wet woodland and floodplain inundation represent the key means of delivering flood resilience wetlands in non-tidal areas (Figure 12b), and (ii) coastal areas, where opportunities for managed realignment are prevalent. Runoff interception bunds are the key measure of wetland creation around upstream flow paths. Potential locations for wetland storage areas are clustered in the Midlands and the North of England, Lincolnshire, West of London and Oxfordshire, Dunbartonshire and around Wrexham, Denbigh and South Glamorgan. Much of the floodplain wet woodland potential is around Doncaster, the Lincolnshire and Cambridgeshire fens, between Burton upon Trent and Nottingham, and in the Scottish Borders. Large areas of flood inundation potential were identified around the Washes, West of Lincoln, Doncaster, East Riding of Yorkshire, around Southport and Formby, in South Wales and in Moray, Scotland. Leaky dams and gully blocking featured most heavily around the mid-Pennines, between the Yorkshire Dales and Peak District National Parks, Lancaster, Northwest Wales, Mid and West Glamorgan and Dunbartonshire.

3.3.3 'Demand' catchments where wetlands can deliver most benefit

High priority catchments for flood risk benefits were distributed in Central and Northeast England, North East Wales and southern parts of Northwest England, Kent and Southwest London. The majority of medium priority catchments were located in the Central Belt of Scotland. All other catchments scored 'low' priority for flood resilience benefit (Figure 12d, Appendix A5.3).

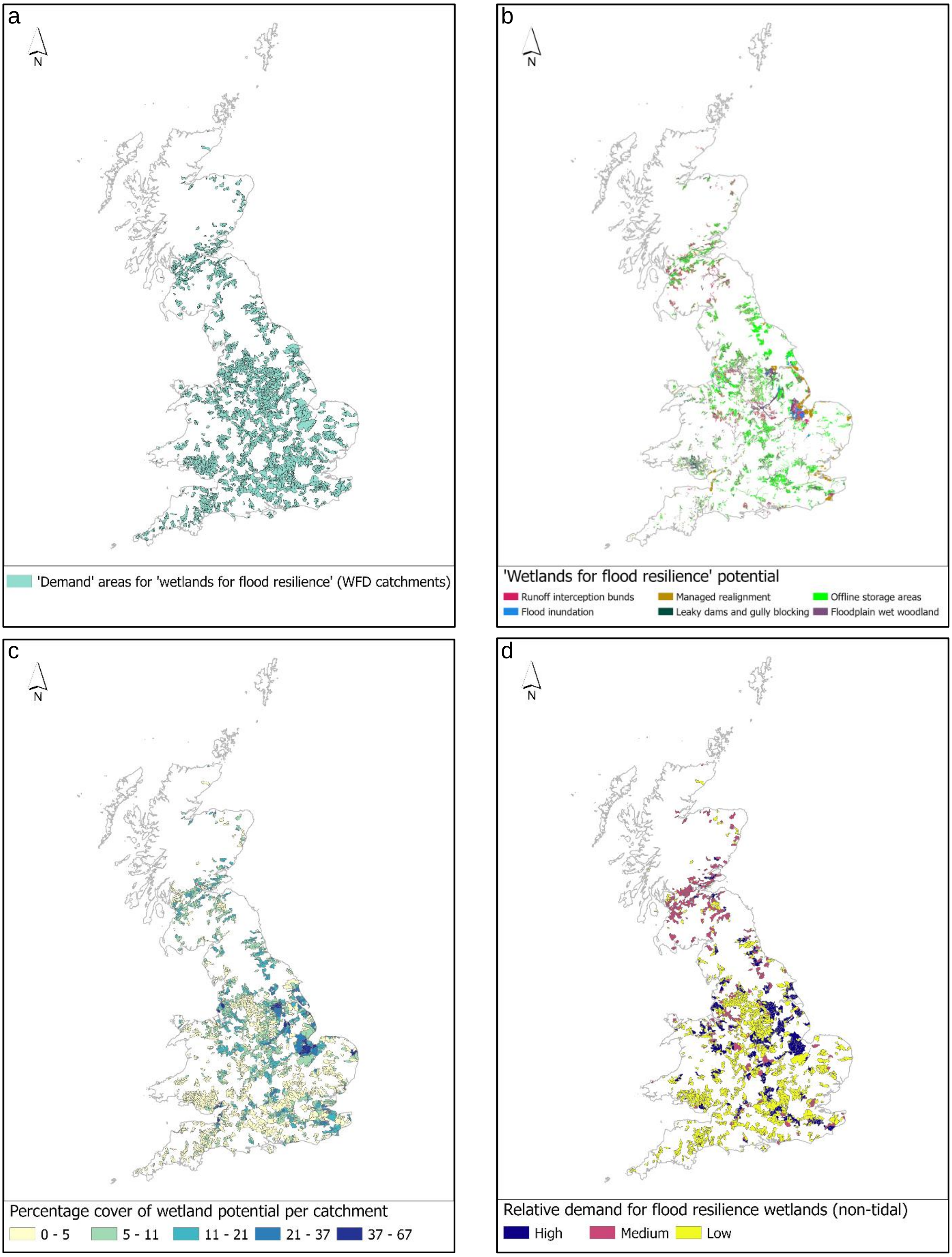


Figure 12. 'Wetlands for flood resilience' maps showing (a) Priority catchments with 'demand' for flood resilience wetlands; (b) Indicative 'wetlands for flood resilience' potential; (c) percentage cover of wetland potential per 'demand' catchment; and (d) Relative 'demand' for flood resilience benefits across 'demand' catchments (a).

3.4 Wetlands for urban wellbeing

3.4.1 Wetland potential within 'demand' census areas

The mapped potential locations for 'wetlands for urban wellbeing' across Great Britain is shown in Figure 13a, which is summarised by our priority 'demand' census areas (LSOAs and Data Zones) in Figure 13b. A total of 196,498 hectares of urban wellbeing wetland potential were identified (Table 6).

Table 6. Total area (in hectares) of identified urban wellbeing wetland potential per country.

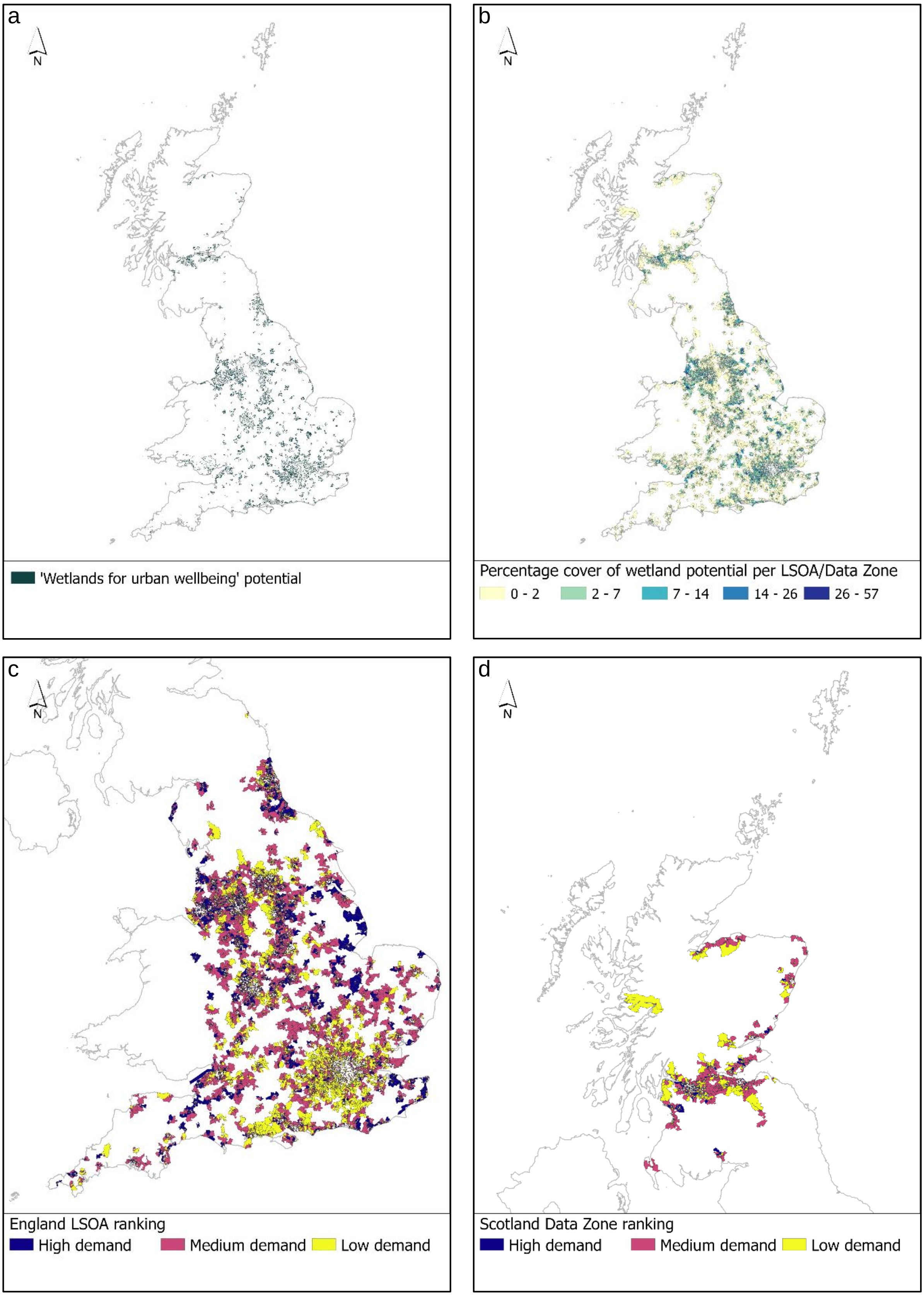
	Total area (ha)
England	172,630
Scotland	15,762
Wales	8,105
Total	**196,498**

Unsurprisingly, in line with the prioritisation of urban census areas as our 'demand' areas, concentrations of potential locations for urban wetlands correspond with the distribution of built-up areas across Great Britain, with large areas of potential occurring in suburban and rural fringe areas which tend to have more space available for habitat creation. Some key locations include Abergele, Bangor, Bristol, Cambridge, Cardiff, Chester, Doncaster, Edinburgh, Formby, Glasgow, Inverness, Lincoln, Newport, Wrexham, Oxford, Preston, Southport, Reading, Swansea, Weston-Super-Mare, and York.

3.4.2 Census areas of 'demand' where wetlands can deliver most benefit

LSOAs in England assigned a 'high' ranking for potential wellbeing benefits are scattered across the country, with clusters along the Northeast coastline, Merseyside and the Wirral, the Fens, around Sheffield, the Lincolnshire coast, and parts of Kent and Somerset (Figure 13c). LSOAs in Wales assigned a 'high' ranking can be found around Wrexham, towns along the Dee estuary along to Conwy, around Newtown, Swansea, Port Talbot and Llanelli and then in parts of Newport, Cardiff, Caerphilly, Merthyr Tydfil and Rhondda Cynon Taf (Figure 13e). Data Zones in Scotland ranked 'high' for potential wellbeing benefits are found around Dumfries, Kilmarnock, Glasgow, Inverness, Edinburgh and in parts of Fife and Clackmannanshire (Figure 13d).

Many of the indicative potential wetland locations overlap with census areas assigned a 'high' ranking for potential wellbeing benefits. In England, this included LSOAs and towns found around the Wash and Fens, e.g. Boston, March and Spalding, and north to Skegness; Nottinghamshire, East Derbyshire and South Yorkshire; St Helens, Liverpool, Southport, Blackpool, Middlesborough, Bognor Regis; towns around the Kent coast, Oswestry, Blyth and Carlisle. In Wales, around Gladlys, Queensferry, Newport and Cardiff, and in Scotland, Data Zones in Dumfries and Glasgow, and towns around the Firth of Clyde.


a
N
'Wetlands for urban wellbeing' potential
b
N
Percentage cover of wetland potential per LSOA/Data Zone
0 - 2
2 - 7
7 - 14
14 - 26
26 - 57
c
N
England LSOA ranking
High demand
Medium demand
Low demand
d
N
Scotland Data Zone ranking
High demand
Medium demand
Low demand

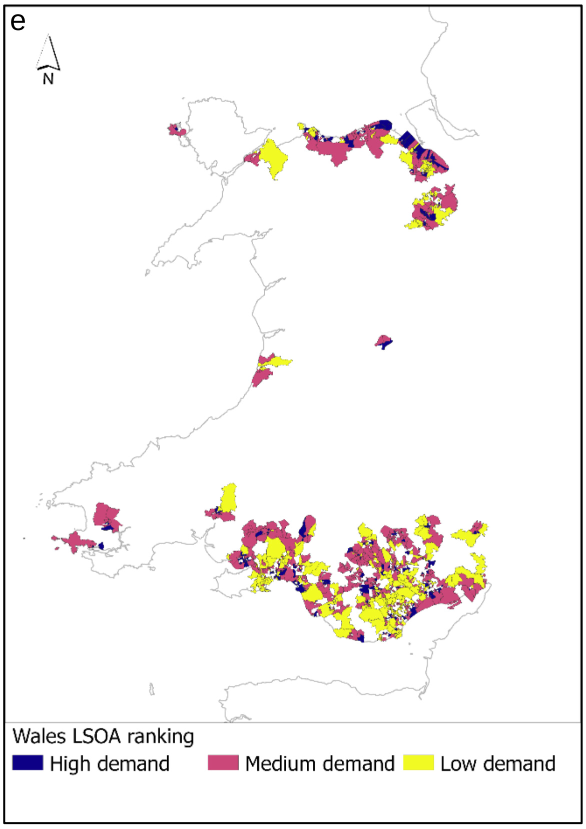


Figure 13. 'Wetlands for urban wellbeing' maps showing (a) Indicative 'wetlands for urban wellbeing' potential (b) % cover of wetland potential per 'demand' census area; and Relative 'demand' for urban wellbeing benefits across 'demand' census areas in (c) England, (d) Scotland and (e) Wales.

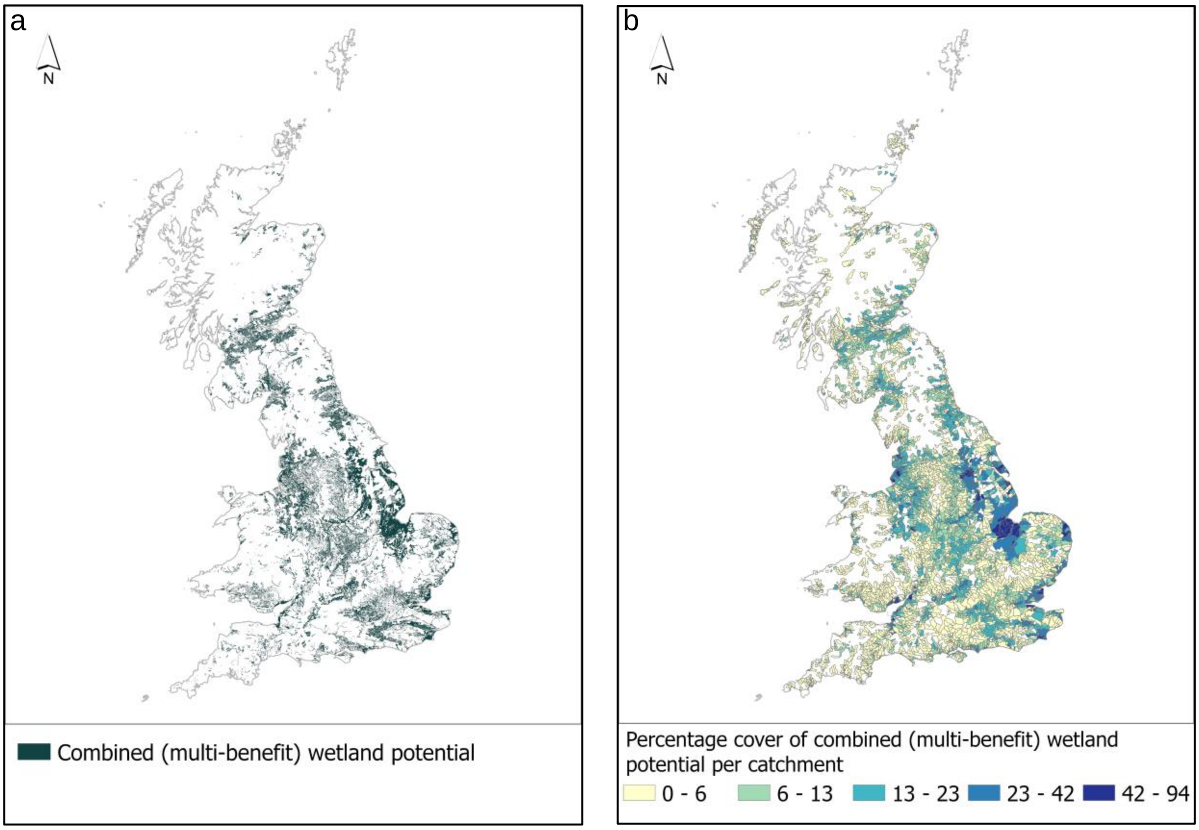
3.5 Potential for multiple benefits

The total area of mapped potential for wetlands targeted at our four themes, and accounting for overlaps (i.e. overlapping layers are only counted once), is 1,226,029 hectares (1,038,220 hectares in England, 145,739 hectares in Scotland and 42,070 hectares in Wales). Areas with potential for wetlands to deliver against multiple themes were identified in the Wash and Fens of Cambridgeshire and Lincolnshire, coastal areas of Essex, the Norfolk Broads, the Severn Estuary, Humberside, coastal Lancashire, parts of North Yorkshire and County Durham, the Scottish Central Belt, East Dumfries & Galloway, and South East Wales (Figure 14a; summarised by WFD waterbody catchment and Westminster parliamentary constituency (Office for National Statistics, 2024) in Figure 14b&c, respectively).

Twenty-nine percent (28.74%) of the overall wetland potential area incorporated more than one overlapping wetland theme (352,339 hectares of at least two overlapping wetland theme; 48,185 hectares of at least three overlapping themes; and 914 hectares of four overlapping wetland themes). This does not mean that other potential wetlands are unlikely to provide multiple benefits, but wetland restoration in regions with high overlap may offer more 'bang for buck' (see Section 4). Areas that delivered under more than one theme are shown in Figure 14d and are fairly evenly spread across England with clusters around the Wash and Lincolnshire coast, the Severn estuary, Lancashire, Durham and Northumberland. In Wales this overlapping potential is clustered in South Wales, and in Scotland, around the Central Belt. Areas of potential with more than two overlapping themes effectively follows the same pattern as just described. Small areas where all four themes overlap were found in a number of coastal locations in England and Wales.

The mapping identifies 5.6% of the total land area of Great Britain as potentially suitable for wetland restoration targeted at one or more of the four focal themes. The vast majority of mapped wetland potential (84%) is located in England, with wetland potential covering 8.3% of the total land area of England, compared with 2.4% of Wales and 1.9% of Scotland. A similarly high proportion of each of the individually mapped themes is located in England (ranging from 88% of urban wellbeing potential to 84% of flood resilience wetland potential). This reflects the distribution of demand (i.e. more areas with a need for wetland solutions in England) rather than a lack of suitable areas for wetland creation in Wales and Scotland.

Approximately 24% (297,338 hectares) of the total mapped wetland potential overlaps with grade 1 and 2 agricultural land (Figure 15; see Section 4).



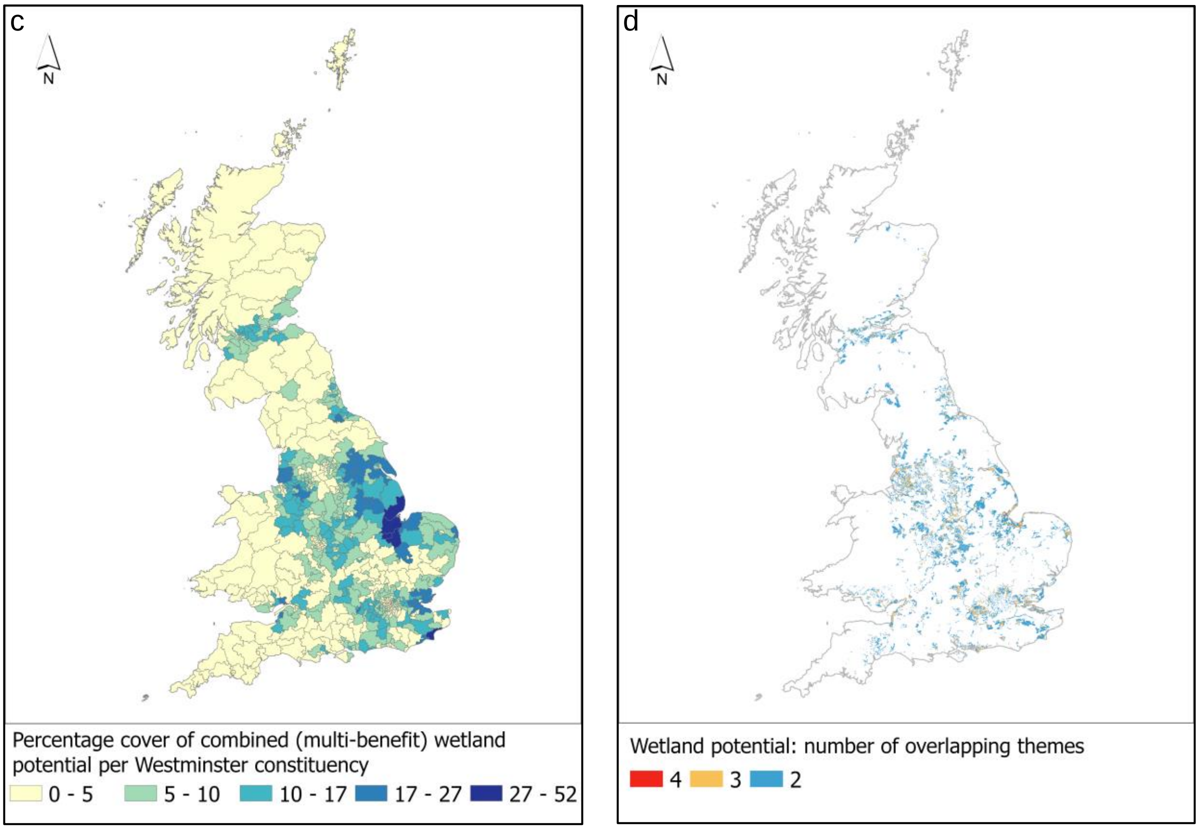


Figure 14. Indicative wetland potential map of Great Britain (a), produced by combining 'wetlands for water quality', 'wetlands for carbon storage', 'wetlands for flood resilience' and 'wetlands for urban wellbeing' potential maps; Indicative wetland potential summarised by (b) WFD catchment and (c) Westminster parliamentary constituency; and (d) areas with potential wetlands under more than one wetland benefit.

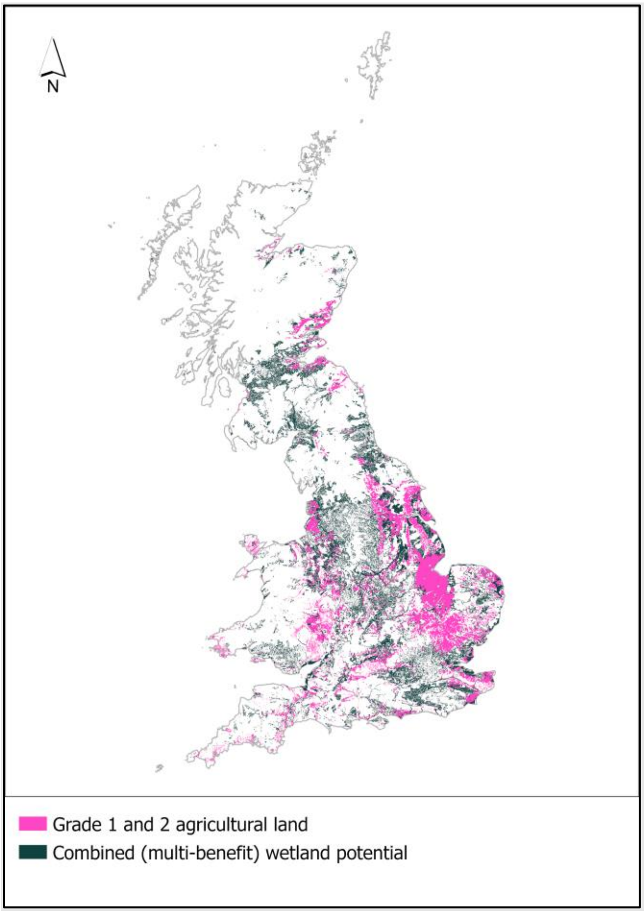


Figure 15. Overall potential versus agricultural value. Grades 1 and 2 represent the highest quality agricultural land (see Section 1.6.3).

3.6 Summary of natural capital accounts

3.6.1 Overall benefits

The estimated benefits and liabilities associated with the creation of 100,000 hectares of wetlands targeted equally at the four wetland themes (i.e., 25,000 hectares of each) are provided in Appendix V. The total gross benefits to society amount to £11 billion (assessed over 60 years in present value terms). The total liabilities, including creation and operational costs, amount to £2.2 billion, which gives a total net asset value of £8.8 billion over 60 years. The net losses to business (£1.5 billion) are far outweighed by the benefits to the rest of society.

There are many benefits that could not be quantified in the scope of this report (Appendix V). As such, these figures underestimate the true value of these wetlands.

Detailed results are provided in the NCA reports for each of the four wetland themes ('wetlands for urban wellbeing', 'wetlands for flood resilience', 'wetlands for water quality' and 'wetlands for carbon storage'). A summary of the key benefits and liabilities of each account is provided below.

3.6.2 Wetlands for water quality

The target area of 25,000 hectares used in the natural capital accounting for wetlands for flood resilience comprised 22,797 hectares in England and 2,009 hectares in Scotland. Due to a lack of data for Wales and Northern Ireland, water quality wetlands in these countries are not included in the asset register for this natural capital account.

Table 7 describes the distribution of benefits and liabilities to businesses and wider society of water quality wetland creation. In this account, the benefits to society amount to £1.7 billion (assessed over 60 years in present value terms), but loss of benefits to businesses (e.g. farms) amounts to £400 million, and therefore the gross asset value over 60 years amounts to approximately £1.3 billion. The main benefits arise from water quality improvement – which alone justifies the investment.

The liabilities in this account amount to £365 million over 60 years: £287 million for the creation of wetlands (assumed to be within the first 27 years of the analytical period) and £78 million over 60 years for the maintenance of water quality wetlands.

The total net asset value of water quality wetlands in England and Scotland amounts to £955 million over 60 years which highlights that although there are significant costs, there are significant net benefits of creating these wetlands.

Table 7. Natural capital asset valuation and liabilities associated with 25,000 hectares of wetlands for water quality wetland creation in England and Scotland (assessed over 60 years in present value terms). Red figures in brackets represent negative values (costs). All figures are in £m.

2024 prices	Valuation metric	Value to businesses (£m)	Value to the rest of society (£m)	Total (£m)
Asset values (monetised)				
Food provision	Opportunity cost of agricultural land changed to water quality wetlands	(400)		**(400)**
Water quality	Value of improvement in WFD status of rivers		546	**546**
	Avoided wastewater treatment costs		1,115	**1,115**
Recreation	Welfare value for created wetland		59	**59**
Total gross asset value	**Mix of values**	**(400)**	**1,720**	**1,320**
Liabilities				
Creation costs[1]		(287)		**(287)**
Maintenance costs[1]		(78)		**(78)**
Total gross liabilities		(365)		**(365)**
Total net asset values (monetised)		**(765)**		**955**

2024 prices	Valuation metric	Value to businesses (£m)	Value to the rest of society (£m)	Total (£m)
Other material unquantified benefits: Avoided carbon emissions from traditional wastewater treatment plants, habitat benefits				

Table notes:

[1] Costs that are necessary to produce benefits (e.g., water quality wetland habitat creation and maintenance costs).

3.6.3 Wetlands for flood resilience

The target area of 25,000 hectares used in the natural capital accounting for wetlands for flood resilience comprised 21,688 hectares in England, 2,096 hectares in Scotland and 1,216 hectares in Wales, based on the percentage of the population of Great Britain living in each country. Due to a lack of data on Northern Ireland, flood resilience wetlands in Northern Ireland are not included in the asset register for this natural capital account.

Table 8 reflects the distribution of benefits and liabilities to businesses and wider society of NFM wetland creation. The benefits to society amount to £1.3 billion (assessed over 60 years in present value terms), but loss of benefits to businesses (e.g. farms) amounts to £133 million, and therefore the gross asset value over 60 years amounts to approximately £1.2 billion. The main benefits arise from carbon sequestration and recreation. The benefits associated with the protection of agricultural land and buildings against flooding through the creation of NFM wetlands are harder to value. They make up a smaller proportion of the total gross asset value because agricultural land and buildings only benefit from the creation of NFM wetlands in the case of a flooding event. Given that these areas are not at risk of flooding on an annual basis, the benefits accrue to a subset of the total agricultural land and buildings protected by NFM wetlands each year.

The liabilities in this account amount to £318 million over 60 years for the creation of wetlands (although the wetlands are created within the first 27 years of the analytical period) and £74 million over 60 years for the maintenance of NFM wetlands.

The total net asset value of NFM wetlands in GB amounts to £800 million over 60 years, which highlights that, although there are significant costs, there are significant net benefits of creating these wetlands.

Table 8. Natural capital asset valuation and liabilities associated with 25,000 hectares of flood resilience wetland creation in Great Britain (assessed over 60 years in present value terms). Red figures in brackets represent negative values (costs). All figures are in £m.

2024 prices	**Valuation metric**	**Value to businesses (£m)**	**Value to the rest of society (£m)**	**Total (£m)**
Asset values (monetised)				
Food provision	Value of avoided damage to agricultural land from flooding (avoided income foregone)	2	-	2
	Opportunity cost of agricultural land changed to NFM wetlands	(248)	-	(248)
	Value of conservation grazing	14	-	14
Carbon sequestration	Value of CO2e sequestered by wetlands	-	617	617
Air quality regulation	Value of PM2.5 removal by woodland	-	113	113
Flood risk management	Avoided damage costs to buildings from flooding annually	99	37	136
Recreation	Welfare value for created wetland	-	401	401
Physical health	Avoided medical treatment costs	-	158	158
Total gross asset value	**Mix of values**	**(133)**	**1,326**	**1,192**
Liabilities				
Wetland creation costs[2]		(318)	-	(318)
Wetland maintenance costs[2]		(74)	-	(74)
Total gross liabilities		(392)	-	(392)
Total net asset values (monetised)		**(525)**	**1,326**	**800**
Other material unquantified benefits: Water supply, mental health, tourism, volunteering, education, amenity, landscape, water quality, biodiversity				

Table notes:

[1] Value of carbon sequestered increases over time in line with HM Treasury Appraisal Guidance (DESNZ, 2023).

[2] Costs that are necessary to produce benefits (e.g. NFM wetland habitat creation and maintenance costs).

3.6.4 Wetlands for carbon storage

The target area of 25,000 hectares used in the natural capital accounting for wetlands for blue carbon (saltmarsh potential) comprised 21,000 hectares in England, 2,100 hectares in Wales, 1,266 hectares in Scotland and 597 hectares in Northern Ireland.

Table 9 reflects the distribution of benefits and liabilities to businesses and wider society of large-scale saltmarsh creation in the UK. The benefits to society amount to a gross value of £2.8 billion (assessed over 60 years in present value terms). The main values in the account are generated from the carbon sequestered by saltmarsh (77% of total asset value), flood risk management (20% of total asset value) and recreation.

The liabilities associated with the cost of creating saltmarsh in the UK are estimated at £1 billion over the next 60 years, which is approximately 39% of the value of the benefits. Accounting for these costs, the total net asset value of wetland creation in the UK is approximately £1.7 billion.

Table 9. Natural capital asset valuation and liabilities associated with 25,000 hectares UK saltmarsh creation (assessed over 60 years in present value terms). Red figures in brackets represent negative values (costs). All figures are in £m.

2024 prices	Valuation metric	Value to businesses (£m)	Value to the rest of society (£m)	Total (£m)
Asset values (monetised)				
Food provision	Total income from livestock	47	-	47
Carbon[1]	Value of CO_2e sequestered by saltmarsh	-	2,152	2,152
	Cost of CO2e emitted by livestock	-	(252)	(252)
Flood risk management	Value of additional coastal wetland area for flood control	-	531	531
Recreation & tourism	Welfare value uplift for created saltmarsh	-	235	235
Water quality	Value of Nitrogen removal	-	48	48
	Value of Phosphorous removal	-	18	18
Total gross asset value	**Mix of values**	**47**	**2,732**	**2,778**
Liabilities				
Production costs[2]		(1,081)	**-**	(1,081)
Total net asset values (monetised)		**(1,034)**	**2,732**	**1,697**
Total net asset values (non-monetised)				
Biodiversity	Total SSSI area: 4,295 hectares			
Material non-monetised benefits				
Fishing (commercial), mental health.				

[1] Value of carbon emissions increase over time in line with BEIS (2018).

[3] Costs that are necessary to produce benefits (e.g., intertidal habitat creation costs).

3.6.5 Wetlands for urban wellbeing

The target area of 25,000 hectares used in the natural capital accounting for wetlands for urban wellbeing comprised 21,000 hectares in England, 2,000 hectares in Scotland, 1,250 hectares in Wales and 750 hectares in Northern Ireland, based on the proportion of the UK population living in each country. Wetlands for urban wellbeing in Northern Ireland are included in the asset register for this natural capital account, but the exact location of these wetlands has not been mapped due to a lack of available data.

Table 10 reflects the distribution of benefits and liabilities to businesses and wider society associated with 25,000 of wetland creation for urban wellbeing. In this account, the benefits to businesses from the creation of urban wetlands amounts to £1.1 billion and the benefits to society amount to £4.6 billion (assessed over 60 years in present value terms). The total gross benefits are estimated at £5.7 billion over 60 years. The main benefits arise from carbon sequestration, recreation, physical health, mental health and urban cooling.

The liabilities associated with the cost of creating and maintaining urban wetlands in GB are estimated at £344 million over the next 60 years, which is approximately 6% of the value of the benefits. These costs might fall to business or wider society, depending on the responsible stakeholder, but have been allocated to businesses in the account. Accounting for these costs, the total net asset value of urban wetland creation in GB is approximately £5.4 billion.

Table 10. Natural capital asset valuation and liabilities associated with 25,000 hectares of wetlands for urban wellbeing creation in Great Britain (assessed over 60 years in present value terms). Red figures in brackets represent negative values (costs). All figures are in £m.

2024 prices	Valuation metric	Value to businesses (£m)	Value to the rest of society (£m)	Total (£m)
Asset values (monetised)				
Carbon	Value of CO_2e sequestered by wetlands	-	632	632
Recreation	Welfare value for created wetland	-	2,808	2,808
Mental health	Avoided medical treatment costs of MHC cases	-	37	37
	Avoided productivity loss costs of MHC cases	32	-	32
Physical health	Avoided medical treatment costs	-	1,117	1,117
Urban cooling	Value of temperature regulation	1,074	-	1,074
Total gross asset value	**Mix of values**	**1,106**	**4,594**	**5,700**
Liabilities				

Wetland creation costs[2]		(272)	-	(272)
Wetland maintenance costs		(74)	-	(74)
Total net asset values (monetised)		**760**	**4,594**	**5,354**
Material non-monetised benefits				
Water quality; water supply; flood mitigation; biodiversity				

Table notes:

[1] Value of carbon sequestered increase over time in line with HM Treasury Appraisal Guidance (DESNZ, 2023)

[2] Costs that are necessary to produce benefits (e.g., urban wetland habitat creation and maintenance costs).

Discussion and FAQs

4 Discussion and FAQs

The main findings and messages around this analysis are compiled below, formed into a discussion around a number of key questions that are important for technical audiences to consider when interpreting the outputs, their uses and their limitations. Limitations specific to each wetland theme are largely included in Appendix III and the separate NCA reports ('wetlands for urban wellbeing', 'wetlands for flood resilience', 'wetlands for water quality' and 'wetlands for carbon storage').

Comparison of wetland potential across UK nations

While we endeavoured to make the maps and datasets as comparable as possible between nations, differences in the methods and criteria used to create underlying data mean that comparisons of maps between different nation of the UK should be undertaken cautiously. The national scale of contributing datasets means that comparison of relative potential within a nation can be undertaken with a high level of confidence.

The relatively high proportion of the land area mapped as wetland potential for England is not surprising, given that issues around water quality, flood risk and vulnerability to flooding and wellbeing are largely a reflection of population and agricultural intensity. England holds 87% of the GB population and a population density almost three times higher than Wales and six times higher than Scotland. In addition, 80% of the total croppable area of the UK is in England.

The majority of potential for intertidal wetlands (saltmarsh and tidal marshes) is also found in England, due to the relatively large areas of low-lying coastal areas compared to other nations.

Why is there no mapped wetland potential in some areas (catchments/census areas)?

For the wellbeing, water quality and flood resilience maps, potential locations for wetlands were only mapped within priority 'demand' areas. This helped to refine the map to areas where wetlands could provide the greatest benefits. The absence of mapped wetlands in an area, e.g. a river catchment, does not, therefore, imply that there are no suitable locations for wetlands in these places. A wider area of wetland potential is apparent from the TWI mapping (Box 1), much of which is located outside of our priority 'demand' areas. As such, there will be many more opportunities to create and restore wetlands for biodiversity, or as solutions to local issues, outside of the targeted wetland potential mapped here.

Users interested in exploring wetland potential outside of these priority areas are encouraged to browse other data in the Wetland Data Explorer tool. There is a wide variety of environmental data displayed in the tool under the themes of opportunities, issues, characteristics, causes, monitoring and boundaries.

Where are the key areas for wetlands that deliver multiple benefits?

Almost all wetlands deliver multiple ecosystem services, and indeed our economic analysis estimates the value of multiple ecosystem services delivered by wetlands prioritised under each primary theme. Similarly, wetland restoration outside of our mapped priority areas will provide value from a range of ecosystem services.

Nevertheless, the maps have identified several areas where wetland restoration would be a priority for at least three of the four wetland themes – particularly in the North of England, the

Midlands, catchments of the Thames Basin (West of London), South Wales and Central Scotland. Wetland restoration in these areas may offer more 'bang for buck' in terms of delivering key benefits. However, it is important to note that the prioritisation and filtering processes used have removed some of the potential for overlap. For example, whereas urban wetlands such as SuDs can be used to tackle localised flooding by storing surface water, urban areas are largely excluded from the flood resilience wetland potential layer due to the prioritisation of catchments with more rural land available for catchment-scale Natural Flood Management.

Does wetland 'quality' matter?

This analysis assumes that new and restored wetlands are of a suitable quality to deliver under the themes for which they are selected, as well as the co-benefits that healthy wetland ecosystems can provide. This would require wetlands to be designed with ecosystem service provision in mind, as well as long-term maintenance to ensure that they continue to provide the services into the future.

Treatment wetlands, flood resilience wetlands and urban wetlands may all (and are often intended to) accumulate sediment - often heavily laden with nutrients and other pollutants - that can become detrimental to the wetland if not properly maintained. All of these wetland solutions can, however, be designed both to capture sediment (which can be removed periodically) and provide wildlife-rich habitat.

While this analysis largely focussed on wetland creation, or restoration of reclaimed wetlands habitats (such as drained areas of the Fens), the UK's existing wetlands face numerous pressures from unsustainable development, pollution and climate change. Restoration of these wetlands to enhance natural function and provide wildlife-rich habitat is likely to bring significant economic, social and ecological benefits, potentially at a relatively low cost, and should be an important component of a future UK wetland strategy (WWT, 2023f).

The Wetland Data Explorer allows users to view a number of datasets relating to wetland degradation, which may help with identifying existing wetlands in need of restoration (e.g. WFD waterbody status, frequently polluting CSOs and OS infrastructure layers).

What does the mapped wetland potential mean for wetland biodiversity and ecosystem resilience?

This work is designed to recognise the role that wetlands have to play in addressing the environmental and societal challenges we face in the UK, rather than specifically targeting the enhancement of ecological networks, as defined by Lawton et al. (2010): 'suites of high quality sites containing the diversity and area of habitat that are needed to support species and which have ecological connections between them that enable species, or their genes, to move'. However, the creation and restoration of 100,000 hectares of new and restored wetlands will inevitably help the recovery of many declining wetland species and of UK nature more broadly.

Many of the mapped wetlands may not form key components of ecological networks: a treatment wetland, for example, may have less biological diversity than equivalent wetland with better water quality, and an urban sustainable drainage system (SuDS) may be relatively isolated from other wildlife sites. However, when sited appropriately and designed with biodiversity in mind (e.g. by incorporating diverse vegetation communities), such wetlands can still deliver significant biodiversity gains in otherwise nature-depleted areas, while also indirectly improving water quality and quantity in hydrologically connected wetlands. To ensure that nature-based solutions meet both societal challenges, at the same time as helping nature's recovery, the key focus should be on restoring natural ecosystem function (Catchment Based Approach, 2024).

While further work is needed to determine the degree to which our mapped wetland potential would contribute to improving ecological resilience and countering biodiversity loss, there are many areas of overlap where wetlands may be of particular importance to the enhancement of biodiversity and increased landscape resilience, for example:

- In England, 21% of the mapped freshwater wetland potential (wetlands for flood resilience, water quality and urban wellbeing) overlaps with one of Natural England's Habitat Networks (Natural England, 2019), specifically the Network Zones or Restoration Zones for one of eight wetland habitats (blanket bogs; lakes; lowland fens; lowland raised bogs; purple moor grass and rush pastures; reedbeds; rivers; and upland flushes, fens and swamps). These zones indicate where action may be undertaken to build greater ecological resilience for individual habitats.

- Almost the entirety of the mapped wetland potential overlaps with Network Zones for the lowland wetland types (excluding blanket bog and upland flushes, fens and swamps). Fifty-four percent of the total Network Zone area for lowland wetlands are in priority 'demand' catchments for flood resilience and water quality wetlands.

- Key areas of overlap with the Network Zones include many coastal towns (e.g. along the south, east and Lancashire coasts), the Fens, West London and Oxford, Shrewsbury, Hereford, Burton on Trent, and between Doncaster and York.

Areas where our priority wetlands overlap with designated habitat networks are likely to have particularly positive impacts on biodiversity and ecological resilience. The maps presented here can similarly be used to indicate where habitat networks are likely to create most additional value to society.

The Wetland Vision project produced a map of future wetland potential which shows where future wetlands have the greatest potential to benefit biodiversity, by identifying the most suitable areas of the country for a range of wetland habitats (excluding coastal wetlands) (Hume, 2008). The individual habitat maps identify large, contiguous areas of potential based on ecological and physical criteria, as well as historical extent and proximity to existing habitat and/or designated sites. Forty-two percent of our wetland potential mapping overlaps with the Wetland Vision Future Potential map. These areas of overlap may have a greater influence on ecological resilience.

The Central Scotland Green Network 'Opportunity Areas for wetlands' map identifies key sites for connecting areas of important wetland habitat so that species can move between them (CSGN, 2021). Twenty-three percent of the opportunity areas overlap with our mapped wetland potential areas, while 30% fall within our priority water quality or flood resilience catchments. This highlights additional scope for wetland creation outside of the maps presented here, while wetlands created as nature-based solutions in these areas are likely to bring additional benefits for biodiversity.

How should the natural capital accounts be used and what are the key limitations?

The account results show the feasible returns to society from a realistic wetland creation strategy – the ambition to restore and create 100,000 hectares across the UK by 2050. While the analysis involved targeting of wetland potential to areas of optimal benefit, the accounts do not prescribe that wetlands should be created in these precise locations. The wider wetland potential maps show that there is flexibility in where wetlands could actually go within the vicinity of the target wetlands, while the accounts use aggregated data on ecosystem service delivery across wider areas to produce average estimates at the national scale.

The results add to the existing evidence base demonstrating the economic returns to society of large-scale wetland creation focussed on wetlands as nature-based solutions. Demonstration of this at a UK scale can add weight to the case that nature-based solutions have an important role in protecting and restoring the UK economy while addressing the existential threats facing UK society.

While the wetland potential mapping and extraction of data for the accounting was undertaken at relatively fine spatial scale, the economic analysis used data averaged at regional or national scales to produce estimates at the UK or GB scale. The models could be adapted to produce estimates at finer (e.g. regional) scales. However, this would require further work to aggregate data at the appropriate scale, including feeding in more accurate local data.

It is important to note that the figures given are likely to be under-estimates of the true values of this wetland creation, given that:

I. many ecosystem services could not be quantified, due to lack of available data linking physical flow to monetary value. In particular, biodiversity benefits are missing from the accounts due a lack of data linking biodiversity gain/loss to monetary value. Biodiversity Net Gain metrics may in future, offer a standard tool by which the biodiversity value of restored wetlands could be quantified monetarily (Defra, 2024); and

II. secondary benefits associated with some of the wetland types have not been quantified, e.g. any flood resilience or water quality benefits of an urban wellbeing wetland that doesn't also fall within an optimal area for water treatment or flood resilience wetlands. This is due to the methodology around individual accounts being developed based on a specific wetland 'type', which would limit the use of equivalent benefits data and methods across the different themes. Further work is necessary to expand these key benefits across all accounts.

Specific applications of the individual accounts as well as their limitations and key areas for further research, are detailed in the account reports: ‘wetlands for urban wellbeing’, ‘wetlands for flood resilience’, ‘wetlands for water quality’ and ‘wetlands for carbon storage’).

At what scale is the mapping most useful?

The maps presented here are not prescriptive at the site level and do not replace the need for detailed site selection processes, feasibility studies, and regulatory processes. The intention is to illustrate the overall potential and to direct users’ thoughts in a strategic way, rather than precisely telling them where to put wetlands, or specifying where action should or will necessarily take place.

Due to the resolution of the data used to generate the underlying wetland potential layers (for example, the 30 x 30 metre DEM used to derive topographic wetness and to map saltmarsh potential for Northern Ireland and parts of Western Scotland), the maps are not suitable for viewing at the scale of an individual farm or field.

The mapping relied heavily on the use of open-source data, which, in some cases, was of a lower resolution/accuracy to commercially available datasets. When refining areas of potential or removing areas with constraints, we used arbitrary buffer distances based on expert judgement, which further reduces utility at very local scales. For example, open-source OS data for transport infrastructure is provided as polyline features, which were buffered by average feature widths prior to extraction from the wetland potential layers (Ordnance Survey, 2023a). OS MasterMap data provides feature data at a much higher accuracy (Ordnance Survey, 2024a), but it was not feasible to use this for national-scale mapping due to costs, processing times and the strategic purpose of the project. Many of the underlying datasets will become out of date (e.g. as new buildings are added to infrastructure datasets) such that the accuracy of the maps may further reduce over time.

For the reasons outlined above, we recommend that the maps are mostly used for looking at the strategic potential for wetland solutions over a broad area – both nationally and regionally – and as part of initial scoping for potential areas of focus, for example, at the LNRS scale. The maps are currently feeding into a number of LNRSs across England. These strategies aim to agree priorities for nature recovery and propose actions in the locations where it would make a particular contribution to achieving those priorities.

To aid interpretation at relevant scales, the wetland potential maps have been presented at a scale relevant to each wetland theme. Wetlands for water treatment and wetlands for flood resilience, for example, are summarised by WFD catchment, while wetlands for urban wellbeing are summarised by census area. All wetland types are summarised by Westminster parliamentary constituency, for the purposes of policy and advocacy work. The Wetland Data Explorer allows users to overlay various boundary data to allow interpretation of the maps for different purposes.

Should we be prioritising wetlands over other land use needs such as food security and energy production?

We have not specifically excluded productive agricultural land from the wetland potential mapping. While we are not recommending that all areas of potential that overlaps with high grade land is converted to wetlands, it is becoming increasingly important for policy makers and agricultural producers to consider the role of nature-based solutions (such as wetlands) in enhancing resilience in agriculture, while addressing climate change and providing food security.

In well-managed agricultural systems, wetlands are considered assets that support food production, good water management and ecosystem resilience, rather than as competing land-uses (Secretariat of the Convention on Wetlands, 2021). The Convention on Wetlands calls for transformative action to reverse the trend of wetland loss and degradation while simultaneously providing food security and responding to anticipated impacts of climate change on wetlands and agriculture.

The total area of mapped wetland potential across Great Britain equates to 7% (1,226,029 hectares) of the total agricultural area (17 million hectares; (Defra, 2023d)), though only around 24% (297,338 hectares) of the total overlaps with the most productive grade 1 and 2 agricultural land. The vast majority (95%) of the overlap is in England. The creation of an additional 100,000 hectares of wetland in the UK is the equivalent of 0.6% of the land in agricultural use.

These figures suggest that the creation and restoration of 100,000 hectares of wetlands across the UK could be achieved without removing vast areas of landscape out of food production. The actual area of agricultural conversion required is likely to be considerably lower given that many wetland types do not require the exclusion of agriculture: urban wetlands, for example, are unlikely to be built on farmed land, while many areas of restored saltmarsh and floodplain grasslands can still be grazed for much of the year.

Wetlands could also have positive benefits on food security in some areas, by increasing climate-resilience via flood protection and water storage, as well as capturing nutrient run-off.

Given the unparalleled environmental crises we face, nations around the world have committed to significant action on climate and nature, for example by halting species decline by 2030, to reach net zero carbon emissions by 2050 (DESNZ, 2023). Demand for other land use change, for example, for renewable energy production and associated grid infrastructure, housing development, and nature recovery more widely, warrants a joined-up approach to future UK land-use decisions. Wetlands can offer solutions across many of these areas.

How do the maps relate to other national wetland potential/nature-based solutions mapping?

Other studies have produced maps of particular wetland solutions for individual UK nations, as discussed in Section 1.3.2. A brief comparison of the mapped wetland potential from this project, with some of the other key national datasets (not exhaustive) is provided below. Users are encouraged to explore these other datasets alongside the WWT maps, in the Wetland Data Explorer, to get the fullest information for their area of interest.

- *WWT Wetlands for flood resilience map vs EA Spatial prioritisation of catchments suitable for using Natural Flood Management* (Environment Agency, 2024)

Eighty-five percent of the WWT priority flood resilience catchments fall within ‘Medium’ and ‘High’ priority catchments identified by the EA (1,198 out of 1,417; (Environment Agency, 2024)), with 61% overlapping with 'High' priority EA catchments. Catchments that do not overlap are largely located in more rural areas such as the Lake District, the Yorkshire Dales, Norfolk, and parts of Cornwall. This is likely due to our targeting towards catchments flowing into areas where social vulnerability and exposure to flooding coincide - which tend to occur in urban areas - and their contributing catchments. The EA dataset focusses on areas with properties at risk from flooding, without accounting for social vulnerability.

- *WWT Wetlands for Flood Resilience map vs NRW 'Demand for NFM' map.*

The Welsh Information for Nature-based Solutions (WINS) 'Demand for NFM' map defines the demand space for NFM as catchments feeding into urban areas at elevated risk from fluvial (river) flooding (Natural Resources Wales, 2018a). Risk level was taken from the Communities at Risk Register, which takes into consideration the severity and frequency of flooding, as well as vulnerability of the people affected (Natural Resources Wales, 2023a). Seventy-one percent of WWT priority flood resilience catchments fall within the WINS 'Demand for NFM' map. Differences in coverage are likely due to the differing datasets used to assess risk and vulnerability.

Other WINS maps explore the potential for nature-based solutions relating to marine and freshwater quality, natural flood management, woodland planting and urban and peri-urban green infrastructure. A wide-range of nature-based solutions and demand areas are mapped, which may be helpful for users wishing to explore wetland potential in Wales alongside other interventions and management techniques.

- *WWT Wetlands for Blue Carbon storage map vs 'Identification and mapping of potential sites suitable for saltmarsh habitat creation in Scotland through managed realignment under current and future sea levels' (Smeaton et al.* (2022)*).*

Potential sites for saltmarsh creation through managed realignment have been mapped via a modelling approach using LiDAR and regional tidal data by Austin et al. (2022), similar to the approach used here. Ten out of the 15 identified potential realignment sites overlap with the WWT high potential for carbon storage layer. All of the 15 sites identified by Austin et al. (2022) and Smeaton et al. (2022) are on the east coast, with half of these in the Firth of Forth. The authors point out that most of the area for managed realignment in Scotland will be in low-lying estuaries that have experienced a high degree of reclamation and high sediment availabilities. This is not to say that sites identified elsewhere are unsuitable and we recommend that more detailed assessment is undertaken on a site-by site basis.

Our maps highlight areas of high potential for carbon storage in the inner Solway, and the Hebridean islands of Tiree and South Uist. Our mapped potential in the Scottish islands and west coast was based on a coarse resolution global DEM (30x30 metre) with variable vertical resolution. Hence, mapped potential in these regions should be treated with caution. Austin et al. (2022) suggest that the likelihood of managed realignment activities being suitable or beneficial in these areas is low: saltmarshes have been less heavily impacted by humans in these areas due to the historically low human presence in combination with the glacial geomorphology.

Why is there so little wetland potential in the uplands?

The majority of the mapped wetland potential is located in lowland areas of the UK, with lower potential in the uplands (as defined in (Averis, et al., 2004)). Our catchments for flood resilience largely fell outside upland areas due to the prioritisation of catchments feeding into flood vulnerable areas, which tend to be located around urban areas. Several priority flood resilience catchments in the Pennines and Yorkshire Dales were identified, due to the proximity of downstream towns and cities. These catchments overlap with many of the habitat expansion zones for blanket bogs in England (Natural England, 2023a). NFM measures to restore peatlands in the headwaters of these catchments have the potential to influence downstream flood risk. There is increasing evidence from both field and modelling studies that peatland restoration measures can alter catchment runoff regimes, reduce peak flows and contribute to Natural Flood Management at the small (e.g. <20 km^2) scale, with evidence from modelling suggesting that peak flow reductions could potentially extend into larger catchments (Allott, et al., 2019).

The topographic wetness map used to derive the baseline wetland potential layer for flood resilience and water quality, which identifies areas of water accumulation based on topography alone (Box 1), does not map areas of upland water accumulation in peat-rich soils (blanket bog). Areas identified as leaky dams or gully-blocking opportunities in areas of degraded blanket bog, where located appropriately, may enable the restoration of wider areas of peatland than the areas mapped. Additional opportunities for NFM in upstream degraded blanket bogs, e.g. by *Sphagnum* reintroduction or conifer forest removal, have not been mapped in this study. However, a number of other groups, such as the Moors for the Future Partnership and NatureScot's Peatland ACTION, are actively implementing peatland habitat restoration for a number of reasons: reducing greenhouse gas emissions, improving habitat and biodiversity, and improving water quality and flood regulation. Maps of peatland condition are available from NatureScot (Nature Scot, 2024), and the England Peat Map project is mapping the extent, depth and condition of England's peat, using new and existing field survey data, satellite Earth observation, and a variety of modelling methods. The Peatlands of Wales maps also contain a range of data on peat location, depth, carbon emissions, etc. (Natural Resources Wales, 2022a).

We recommend viewing the WWT wetland potential maps alongside these other datasets on upland peat restoration potential. Locations of peaty soils can be found in the Wetland Data Explorer.

Why haven't we included other carbon-sequestering wetlands in the 'wetlands for carbon storage' work?

The focus of the 'wetlands for carbon storage' analysis is on blue carbon sequestered by restored saltmarsh. Per unit area, carbon sequestration rates in saltmarshes exceed those of seagrass meadows, terrestrial forests and the open ocean, with tidal marshes globally accumulating 12.63 Tg C $year^{-1}$ (Mason, et al., 2023) and references therein). A recent review of evidence (2022) has shown that saltmarsh regeneration could offset the equivalent of up to 0.51% of global energy-related CO_2 emissions – a substantial amount considering saltmarsh represents <1% of global land use. In the UK, the review states that if the recommended 22,000 hectares of saltmarsh (eftec, 2015) were successfully restored, an additional 0.14 Mt C $year^{-1}$ might be accumulated, equating to 0.05% of the UK's 2020 CO_2 emissions (IEA, 2022).

As quantified in the economic assessment, large-scale saltmarsh restoration can also provide significant benefits to coastal flood defence and water quality, while benefiting commercial fisheries and local communities, through food provision, recreation and increased wellbeing. They also provide habitat for biodiversity including migratory birds and fish, and commercial marine fish species.

Despite our focus on saltmarsh blue carbon, restoration of other wetland habitats can sequester significant amounts of carbon: in particular, peatlands and seagrass beds. Other groups are working to drive and coordinate action on these habitats across the UK.

Peatland restoration and protection is essential for climate regulation given that much of the UK's peatland is currently a net source of greenhouse gases - accounting for around 3.5% of the UK's total annual greenhouse gas emissions in 2018 (BEIS, 2019; IUCN Peatland Programme, 2021) - because of decades of unsuitable land management practices. The UK Peatland Strategy is working to drive and co-ordinate action on peatlands across the UK, which includes action to map restoration potential (IUCN Peatland Programme, 2018). Maps of peatland condition, extent, depth etc. are available (or in production) for all of the UK nations (see above).

The EA have derived a map of seagrass potential that can be used alongside the saltmarsh potential mapping to identify sites where an ecosystem approach to coastal restoration for carbon sequestration could be beneficial (Environment Agency, 2020).

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Appendix

6 Appendix

Appendix I. UK wetland extent

Table A1. Data sources used to map indicative current UK wetland extent. Datasets used across multiple countries are indicated with country initials and are only provided once[5].

Country	Dataset	Source	Attributes extracted
England	Priority Habitats Inventory (England)	Natural England (2024). Available at: https://www.data.gov.uk/dataset/4b6ddab7-6c0f-4407-946e-d6499f19fcde/priority-habitats-inventory-england (Accessed 2023).	All wetland habitat types
	OS OpenMap – Local (E|S|W)	Ordnance Survey (2024). Available at: https://www.ordnancesurvey.co.uk/products/os-open-map-local (Accessed 2023).	Surface Water_area (includes most rivers, streams, larger waterbodies and many small waterbodies)
	Habitat Networks (England) - Lakes	Natural England (2024). Available at: https://www.data.gov.uk/dataset/a8e54416-2bb1-4398-8f47-2d1623f90982/habitat-networks-england-lakes (Accessed 2023).	All
	Habitat Networks (England) - Rivers	Natural England (2024). Available at: https://www.data.gov.uk/dataset/ad8530f8-aaf1-4274-9ae6-25c4602b6121/habitat-networks-england-rivers (Accessed 2023).	All
	UK Ramsar sites[6] (E|S|W|NI)	Joint Nature Conservation Committee (2019). Available at: https://www.data.gov.uk/dataset/9deccaac-5633-41ed-a6b0-a2802d4dd7ac/uk-ramsar-sites (Accessed 2023).	All, clipped to coastline (Mean High Water)
	OS Boundary-Line (E|S|W)	Ordnance Survey (2023). Available at https://www.ordnancesurvey.co.uk/products/boundary-line (Accessed 2023)	Clipped wetlands to *country_region*
Scotland	Habitat Map of Scotland	NatureScot (2023). Available at: https://opendata.nature.scot/datasets/habitat-map-of-scotland/explore (Accessed 2023).	All wetland habitat types
	'Scotland Habitat and Land Cover Map – 2020'	NatureScot (2021). Available at: https://spatialdata.gov.scot/geonetwork/srv/api/records/88cea3bd-8679-48d8-8ffb-7d2f1182c175	All wetland habitat types

[5] E = England, W = Wales, S=Scotland, NI=Northern Ireland

[6] Wetlands of international importance designated under the Ramsar Convention https://www.ramsar.org/our-work/wetlands-international-importance (available at https://www.data.gov.uk/dataset/9deccaac-5633-41ed-a6b0-a2802d4dd7ac/uk-ramsar-sites)

Country	Dataset	Source	Attributes extracted
Wales	Environment (Wales) Act Section 7 Terrestrial Habitats of Principle Importance	Natural Resources Wales (2023). Available at: https://www.data.gov.uk/dataset/84555207-c64f-4365-8d2a-5f431804da63/environment-wales-act-section-7-terrestrial-habitats-of-principle-importance (Accessed 2023).	All wetland habitat types
Northern Ireland	Saltmarsh extent	Strong, J.A., Mazik, K., Piechaud, N., Bryant, L., Wardell, C., Hull, S., Tickle, M., Norrie, E-M., McIlvenny, H., and Clements, A. (2021) Blue Carbon Restoration in Northern Ireland – Feasibility Study. National Oceanography Centre, University of Hull, Ulster Wildlife. *DAERA Challenge Fund*.	All
	Priority Habitats_Fens	OpenDataNI (2024) 'Priority Habitats – Fens'. Available at: https://www.data.gov.uk/dataset/820125de-f5c7-4193-b892-7473645d240a/priority-habitats-fens (Accessed 2023).	All
	Peatland	OpenDataNI (2023) 'Priority Habitats – Peatland'. Available at: https://www.data.gov.uk/dataset/34e6b4fe-2872-4822-8969-e9a5a1367079/priority-habitats-peatland (Accessed 2023).	All
	Lakes of Northern Ireland	OpenDataNI (2021) 'Lakes of Northern Ireland'. Available at: https://www.data.gov.uk/dataset/4a154cdc-6236-4eae-892e-155a2d14923e/lakes-of-northern-ireland (Accessed 2023).	All
	Areas of Special Specific Interest	OpenDataNI (2016) 'Areas of Special Scientific Interest'. Available at: https://admin.opendatani.gov.uk/dataset/areas-of-special-scientific-interest (Accessed 2023).	Wetland habitat types
	Grassland Inventory (wet-grassland types)	OpenDataNI (2023) 'Priority Habitats - Grassland Inventory Update'. Available at: https://www.data.gov.uk/dataset/c52a0bf6-3466-4d08-98e4-df595ff61919/priority-habitats-grassland-inventory-update (Accessed 2023).	Wet grassland NVC types
	OSNI Open Data - Largescale Boundaries - NI Outline	OpenDataNI (2023). Available at: https://www.opendatani.gov.uk/dataset/osni-open-data-largescale-boundaries-ni-outline (Accessed 2024)	Wetland layers clipped to coastline

WWT

Appendix II. Output maps

Table A2. Maps produced at each stage of the mapping process, ArcGIS Online links their geographical coverage, and notes on accessibility.

Mapping stage	Map name; hyperlinks; (coverage[7])	Accessibility
1. Selection of areas with high 'demand' for wetland solutions	'Demand' areas for 'wetlands for flood resilience' potential (E|S|W|•) 'Demand' areas for 'wetlands for water quality' potential (E|S|W|NI)	Open access
2. Mapping wetland potential within selected areas of 'demand'	WWT 'Wetlands for Flood Resilience' potential (E|S|W|•) WWT 'Wetlands for Water Quality' potential (E|S|W|•) WWT 'Wetlands for Urban Wellbeing' potential (E|S|W|•) WWT 'Wetlands for Carbon Storage' potential (E|S|W|NI) % area, number and hectares of total wetland potential per WFD waterbody catchment (E|S|W|•) % area, number and hectares of 'wetlands for flood resilience' potential per WFD waterbody catchment (E|S|W|•) % area, number and hectares of 'wetlands for water quality' potential per WFD waterbody catchment (E|S|W|•) % area, number and hectares of 'wetlands for urban wellbeing' potential per census area (E|S|W|•) % area, number and hectares of total wetland potential per Westminster constituency (E|S|W|•)	Open access
3. Mapping relative potential for key benefits	Relative demand for flood resilience wetlands (non-tidal) (E|S|W|•)	Available upon request

[7] E = England, W = Wales, S=Scotland, NI=Northern Ireland

Mapping stage	Map name; hyperlinks; (coverage[7])	Accessibility
	Relative demand for water quality wetlands (E|S|W|•)	Available upon request
	'Wetlands for Urban Wellbeing' potential summarised by GB census area (LSOA) (E|•|•|•)	Open access
	'Wetlands for Urban Wellbeing' potential summarised by GB census area (Data Zone) (•|S|•|•)	Open access
	'Wetlands for Urban Wellbeing' potential summarised by GB census area (LSOA) (•|•|W|•)	Open access
4. Mapping potential for multiple key benefits (combined wetland potential map)	Combined 'multi-benefit' wetland potential map (E|S|W|•)	Open access

Appendix III. Detailed methods.

A3. Wetlands for water quality mapping

A3.1. Selection of areas with high 'demand' for water quality solutions

A WFD waterbody catchment was identified as a 'demand' area if at least one of these criteria was met:

a. coastal waterbodies with a failing ('Bad' or 'Poor') WFD status (SEPA, 2023a; Natural Resources Wales, 2015a; Environment Agency, 2019b; DAERA, 2022b; SEPA, 2023b);

b. river catchments with a failing WFD status, which includes those in drinking water protected areas (Environment Agency, 2019a; SEPA, 2023a; Natural Resources Wales, 2023b; DAERA, 2021; SEPA, 2023c; Environment Agency, 2022; DAERA, 2022b; Natural Resources Wales, 2015b; SEPA, 2023d); and

c. river catchments with recently high rates of housing development and high projected future household numbers[8] (Environment Agency, 2019a; SEPA, 2023a; Natural Resources Wales, 2023b; Office for National Statistics, 2022; Office for National Statistics, 2020; Welsh Government, 2020; National Records of Scotland, 2018; DAERA, 2021; NISRA, 2018).

Caution should be exercised when comparing wetland potential between UK nations, due to differences between equivalent datasets. For example, the Northern Ireland household projection data is based on 2016 statistics, whereas equivalent data for other nations is based on 2018 statistics.

A3.2. Mapping potential locations for 'wetlands for water treatment' within 'demand' areas

We used a topographic wetness index (TWI) (Box 1) as the underlying layer to identify potential wetland locations within the 'demand' areas, where wetlands could have positive impacts on downstream water quality. Potential wetland locations in close proximity to potential pollution sources were extracted (Figure A1), and comprised locations:

- within or 300 metres around agricultural land categorised as class 3 or 4 (moderate to poor quality land likely to require relatively high chemical input to achieve high yields, and hence where highest degree of pollutant runoff is likely) (Welsh Government, 2017;

[8] Included catchments with a percentage change in projected households (averaged across all Local Authority (LA) and Higher Administrative areas (England & Wales) and Council areas (Scotland)) of 1% or greater (from 2018 to 2041), or in which the number of new builds (averaged across LAs) built between 2021-2022 was 100 or greater.

James Hutton Institute, 1981; Defra, 1988);

- within or 300 metres around active forestry operations i.e. areas operating under felling licences (Forestry Commission, 2020a; Scottish Forestry, 2023; Natural Resources Wales, 2024b);
- within or 300 metres around high surface runoff areas (non-urban), defined as areas of slope greater than 20 degrees that are on improved grassland and arable land, (i.e., steep, farmed land) (Hawker & Neal, 2021; Marston et.al., 2021);
- within or 300 metres around urban areas: built-up areas defined by the Ordnance Survey (Ordnance Survey, 2024b);
- within or 300 metres around factory and industry discharges to water (Defra, 2012b); and
- within or 300 metres around frequently polluting CSOs, were extracted (Scottish Water, 2023; The Rivers Trust, 2021).

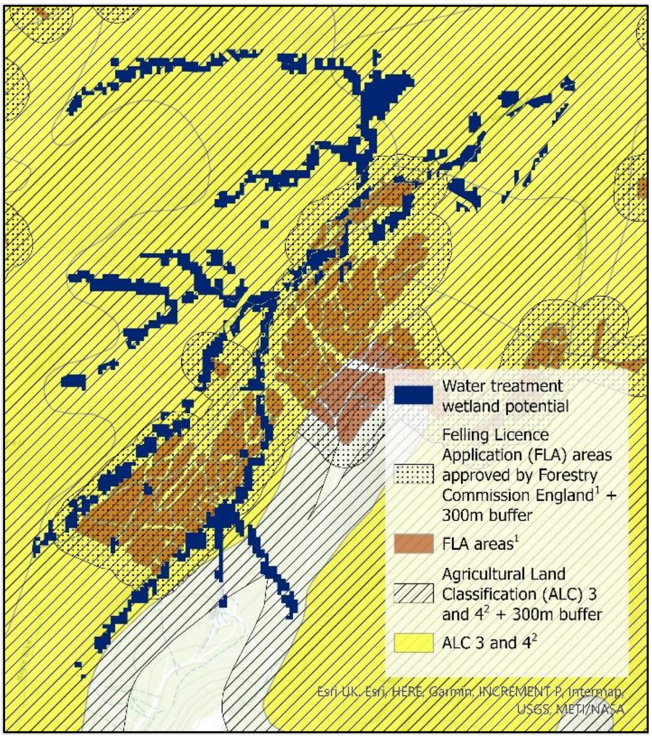

Figure A1. Extract showing 300 metre buffers around two potential pollution source datasets: Felling Licence Applications and Agricultural Land Classification 3 and 4 (Forestry Commission, 2020a; Defra, 1988).

Caution should be taken when comparing the resulting maps between nations, due to differences in the methods used to derive equivalent datasets for individual nations. For example, in Scotland, only spill data for CSOs monitored and reported to SEPA were publicly available at the time of analysis (Scottish Water, 2023), which may result in the identification of fewer locations for wetlands relative to England and Wales where all CSOs are reported on

(Surfers Against Sewage, 2023). Additionally, agricultural land classifications, used to approximate agricultural productivity, were created at different points of time for different nations (over a range of around 20 years).

We used the following constraints to wetland creation to remove unfeasible locations from the initial set of wetland potential areas:

- *Roads*, buffered by 20 metres (Ordnance Survey, 2023a);
- *Surface and tidal waters* (Ordnance Survey, 2023a; Ordnance Survey, 2023b; Hughes, et al., 2004);
- *Buildings*, buffered by 30 metres (Ordnance Survey, 2023a);
- *Railways*, buffered by 30 metres (Ordnance Survey, 2023a);
- *OS functional sites* (area/extent of functions and activities associated with air transport, education, medical care, road transport and water transport) (Ordnance Survey, 2023a);
- Important grassland and woodland habitats, including orchards (Natural England, 2023b; Scottish Government, 2023b; Natural Resources Wales, 2021; Natural England, 2023a; Natural Resources Wales, 2016a; NatureScot, 2023; Natural Resources Wales, 2023c); and
- Priority wetland habitat (Natural England, 2023c; Natural England, 2023d; Natural England, 2023e; Natural Resources Wales, 2022b; NatureScot, 2017; NatureScot, 2020a).

The resulting *wetland potential* layer was clipped to wetland (impermeable) soil types i.e. where wetlands could be created with minimal requirements for artificial substrate lining (Soil Survey of Scotland Staff, 1981; Farewell et. al., 2024). Any areas of wetland potential less than or equal to 0.2 hectares were removed to create the final '*wetlands for water quality*' layer.

A3.3. Prioritising 'demand' areas where wetlands can deliver most water quality benefits.

To map the relative potential for 'wetlands for water quality' to improve water quality at the catchment scale, we followed a similar approach to that used to define target areas for the economic analysis of water quality wetlands (Section 2.2.3; see the natural capital account for a full account of these methods). The focus was primarily on the ability of wetlands to improve WFD status via phosphorus (P) removal, using available data on target P load reduction and P removal efficiency of Constructed Treatment Wetlands. While data availability limits the ability to include other pollutants in this analysis, we assume that wetland creation for P removal will have a positive impact on a range of other pollutants, particularly from diffuse sources.

First, the attributes table of the *priority 'demand' catchment* layer (Appendix A3.1) was populated to indicate whether any of the following criteria was met for each 'demand' catchment:

- The **potential wetland area is sufficient for water quality to improve to 'Good' WFD status**: the wetland area needed to achieve 'Good' status in each catchment was estimated according to the P load reduction required to achieve 'Good' WFD status (according to the current P load in a waterbody catchment vs the target load required to achieve 'Good' status[9] and a P removal efficiency[10] of 0.67g m^{-2} $year^{-1}$ (Lyu, Headley, Kadlec, Jefferson, & Dotro, 2024));

- The **Reason for Not Achieving Good Status (RNAGS)** (Environment Agency, 2015) **is phosphate**. This increases the correlation between the wetland potential prioritised based on potential to remove phosphorus (see above point), and the ability of these wetlands to impact the WFD status of waterbodies within and downstream of the wetlands;

- **Current WFD status is 'Bad' or 'Poor'** (from modelled concentrations);

- The **proportion of wetland area created on higher grade (grades 1 and 2) agricultural land is 70% or lower**.

The priority 'demand' catchment layer was then queried, and catchments allocated a 'relative benefits' rank from 1 (highest potential for water quality benefits) to 3 (lowest potential for water quality benefits). Table A3 shows the criteria used to rank catchments. Catchments were symbolised by their rankings to map the relative potential for wetland solutions to address water quality issues.

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[9] Target P load reduction was calculated for each catchment using national datasets (PR19 data for England and equivalent data for Scotland) produced using the SIMCAT SAGIS models (Environment Agency, 2019c; SEPA, 2012), which show forecasted phosphate concentrations, loads and source apportionment for sampling points in waterbodies. Data was first summarised by waterbody. Mean flow was then back calculated from the mean P load and concentration. Mean flows and the target concentrations required to achieve 'Good' WFD status were used to calculate the target phosphorus load reduction required to achieve 'Good' status. The quantity of P removal required to achieve the target load was derived. The area of wetland required to achieve this reduction was derived using the specified removal efficiency, to assess whether mapped wetland potential was sufficient to achieve this reduction.

[10] A P removal efficiency of 0.67g m^{-2} $year^{-1}$ is reported as the median mass removal rate for tertiary surface flow treatment wetlands with targeted upstream P removal, applied to domestic wastewater treatment (Lyu et. al., 2024). While higher removal efficiencies are reported for different wetland types and settings this conservative estimate was chosen because (a) treatment wetlands for wastewater treatment are only a subset of the instances where treatment wetlands could provide solutions. For wetlands used in wider catchments, background phosphorus levels, and hence removal rates, are likely to be lower as compared to wastewater scenarios; and (b) the Lyu study used a global dataset: lower efficiencies are likely in temperate regions, as compared with warmer climes.

Table A3. Ranking applied to priority 'demand' catchments for water quality wetlands (Section 2.1.4), based on the potential for wetlands to provide water quality benefits.

Rank	Criteria
1 (highest potential for water quality benefits)	Catchments with potential wetland area sufficient for water quality to improve to 'good' WFD status; AND where the RNAGS is phosphate AND EITHER the current WFD status is 'Bad'; OR the current status is 'Poor' and 70% or less of the wetland potential is on high grade agricultural land[11].
2	Catchments with enough potential wetland area to improve water quality sufficiently to achieve WFD 'good' status; AND 70% or less of the wetland potential is on high grade agricultural land AND does not meet the other criteria for rank '1'.
3 (lowest potential for water quality benefits)	All other 'wetlands for water quality' 'demand' catchments (Appendix A3.1).

A4. Wetlands for carbon storage mapping

For England, the 'potential habitat creation sites within the current floodplain' data layer, developed by the Marine Management Organisation, shows where intertidal habitats could be created in the current (coastal) floodplain (MMO, 2019). It highlights areas where 'managed realignment' and/or regulated tidal exchange (RTE) techniques could be used to inundate land which is currently defended. The methods used to develop this layer were replicated, where possible, to create equivalent intertidal wetland potential maps for other UK nations. These were subsequently refined into a combined UK 'wetlands for carbon storage' (saltmarsh potential) layer. In summary, the following procedures were followed:

A4.1. Creating an intertidal wetland potential layer

England

For England, the Environment Agency's 'Flood Zone 3' polygon layer (Environment Agency, 2023a) was used as the basis for the mapping, with flood zones categorised as 'tidal' and 'tidal/fluvial' extracted for further processing (MMO, 2019), i.e., floodplains classed as 'fluvial' only were removed.

The MMO then used a mixture of automated and manual processes to exclude the following areas (deemed unsuitable for saltmarsh creation) from the flood layer (see (MMO, 2019) for

[11] This prioritises the creation of wetlands for water quality where the need is higher but minimises the use of agricultural land for creating wetlands.

detailed methods, including limitations and data sources):

- Floodplain areas more than 10 kilometres from the coast (or more than 2 kilometres from the banks of constrained tidal rivers and estuaries);
- Urban areas and major road and rail infrastructure;
- Industrial sites, significant residential areas, and caravan parks;
- Sites which are less than 10 hectares in size;
- Sites which are not currently defended from flooding (by an embankment, seawall, or similar);
- Existing managed realignment/RTE sites;
- Sites which are deemed too exposed or of the wrong substrate (i.e. open coast/beaches, shingle, dunes); and
- Disconnected floodplain areas (cut off by urban areas, major roads (motorways and category A roads) and major railways).

Wales, Scotland and Northern Ireland

For Wales, Flood Zone 3 'tidal' and 'tidal/fluvial' polygons were extracted from the *Flood Map for Planning Flood Zones 2 and 3* layer (Natural Resources Wales, 2023d), to produce a tidal flood map for Wales for further processing.

For Scotland and Northern Ireland, an equivalent tidal flood map was produced using (i) for both nations: a 30x30 metre Shuttle Radar Topography Mission (SRTM) digital elevation model (DEM) (NASA JPL, 2013), and (ii) for Scotland only: high resolution (50 cm to 1 m) LiDAR for Scotland, Phases 1-5 digital terrain models (DTMs) (Scottish Government, 2022). LiDAR coverage (in Scotland) was only available for the east coast and west coast (mainland, from the southern border up to the Firth of Clyde). Average estimated sea levels for a 1 in 200 year flood event (on which the Flood Zone 3 tidal maps for England and Wales are based) were extracted from the Coastal Design Sea Levels data for coasts and estuaries (Environment Agency, 2023b; Environment Agency, 2023c), on a regional basis. Raster pixels of a lower or equal elevation to the averaged sea-level values for the relevant region, were extracted from the DEM.

Table A4 lists the datasets and processes used to refine the tidal flood layers for Wales, Scotland, and Northern Ireland, to produce *intertidal wetland potential* layers broadly equivalent to the England layer.

Table A4. Datasets and actions used to refine tidal flood layers for Scotland, Wales and Northern Ireland (See Appendix IV for copyright information).

Dataset name (and source)	Source	Country[12]	Actions performed on dataset
Saltmarsh Extents	(Natural Resources Wales, 2017a)	W	Erased all existing saltmarsh from tidal flood layer
Countries (December 2017) Full Clipped Boundaries in UK (WGS84)	(Office for National Statistics, 2018)	W, S	Clipped tidal flood layer to coastal boundary (Mean High Water mark)
Neptune Coastline Campaign (NCC) Open Data: Land Use 2014	(Comber, et al., 2016)	W, NI	Erased industry, caravans, urban, built-up areas, transport areas from tidal flood layer (Dataset incomplete for some small sections of Northern Ireland coast - features in these sections were removed by eye using Esri World Imagery (see below)
Built-up Areas (December 2011) Boundaries V2	(Office for National Statistics, 2017)	W	Erased built up areas from areas not covered by NCC Land Use layer (see above)
OS Open Roads	(Ordnance Survey, 2022a)	W, S	Created 'major roads' polygon layer by buffering road polylines as follows: Collapsed carriageways - 15m each side of line; Dual Carriageways - 10m each side; Roundabouts - 5m each side; single carriageways - 7.5m each side; Sliproads - 5m each side. Erased buffered areas from tidal flood layer
OS VectorMap District - Railways	(Ordnance Survey, 2022b)	W, S	Extracted multi-track railways and buffered by 5m either side of line. Erased buffered area from tidal flood layer.
Marine Article 17 Habitats Features	(Natural Resources Wales, 2018b)	W	Erased mudflats and sandflats, subtidal and intertidal reefs, and sand banks, from tidal flood layer
UK Managed Realignment and Regulated Tidal Exchange Schemes (ABPmer)	(ABPmer, 2019)	W, S, NI	Erased existing MR and RTE schemes from tidal flood layer
Shoreline Management Plan Policies	(Natural Resources Wales, 2023e)	W	Erased coastal sites where No Active Intervention (NAI) planned
LiDAR for Scotland Phases 1-5 – DTM datasets	(Scottish Government, 2022)	S	Used average estimated sea levels for a 1 in 200 year flood event, taken from the EA's Coastal Design Sea Levels data for coasts and estuaries (see below). Extracted all areas of DEM below this sea level value. Converted raster to polygon and used as tidal flood layer. (included coverage for east coast and west coast (mainland): up to and including Firth of Clyde)
NASA Shuttle Radar Topography Mission	(NASA JPL, 2013)	S	Used average estimated sea levels for a 1 in 200 year flood event, taken from Coastal Design Sea Levels data (see below) for coasts and estuaries17. Extracted all areas

[12] W = Wales, S=Scotland, NI=Northern Ireland

Dataset name (and source)	Source	Country[12]	Actions performed on dataset
(SRTM) Global 1 arc second DEM			of DEM below this sea level value. Converted raster to polygon and used as tidal flood layer. Tidal food map produced using a combination of high resolution Lidar data and 30x30m SRTM Digital Elevation Model1. Average estimated sea levels for a 1 in 200 year flood event was taken from the EA's Coastal Design Sea Levels data for coasts and estuaries16.
		NI	Used average estimated sea levels for a 1 in 200 year flood event, taken from Coastal Design Sea Levels data (see above) for coasts and estuaries. Extracted all areas of DEM below this sea level value. Converted raster to polygon and used as tidal flood layer.
Coastal Design Sea Levels - Coastal Flood Boundary Extreme Sea Levels Coastal Design Sea Levels - Coastal Flood Boundary Extreme Sea Levels Estuary	(Environment Agency, 2023b) (Environment Agency, 2023c)	S, NI	See above. To reduce processing constraints and to increase the accuracy of extracted tidal flood zones, estimated sea levels for a 1 in 200 year flood event were averaged for nine coastal 'areas' of Scotland: Wick-Fraserburgh, Moray and Cromarty Firths, Fraserburgh-Arbroath, Arbroath-Lamberton, Firth of Forth & River Tay, Solway Firth, Mull of Galloway-Castle Levan, River Clyde and 'West and north coasts & Orkney'.
Saltmarsh Survey of Scotland	(NatureScot, 2016a)	S	Erased all existing saltmarsh from tidal flood layer
Settlements – Scotland	(Scottish Government, 2023c)	S	Erased all settlements (built-up areas of 500 people or more) from tidal flood layer
Habitat Map of Scotland	(NatureScot, 2017)	S	Erased all dune, shingle, rock and beach habitats.
World Imagery (Esri)	(Esri, Maxar, Earthstar Geographics, & GIS User Community, 2024)	S, NI	Erased caravan sites and industrial areas manually (by eye) using satellite imagery
Current Saltmarsh Extent (NI)	(Strong, et al., 2021)	NI	Buffered and erased existing saltmarsh extent.
OSNI Open Data - 50K Transport - Transport lines	(OpenDataNI, 2023a)	NI	Created major roads polygon layer by buffering road lines as follows: Motorways - 15m each side of line (30m); Dual carriageways - 10m each side (20m); A roads - 7.5m each side (15m). Extracted multi-track railways and buffered by 5m either side of line. Erased buffered areas from tidal flood layer.
Settlement Development Limits (2015)	(NISRA, 2015)	NI	Erased all settlements (built-up areas of 500 people or more) from tidal flood layer
OSNI Open Data - Largescale Boundaries - NI Outline	(OpenDataNI, 2023b)	NI	Clipped tidal flood layer to coastal boundary.

A4.2. Refining the intertidal wetland layer by potential for saltmarsh creation

We merged the *intertidal wetland potential* maps (including the MMO layer for England) into a UK map and carried out further processing to identify areas that are most likely to form saltmarsh (and hence store carbon) if existing coastal defences are removed/realigned.

First, average Highest Astronomical Tide height (HAT; (Environment Agency, 2023b)) was assigned to each intertidal wetland polygon and the polygons converted to raster format at the same resolution and pixel alignment as the STRM DEM (Table A4). The DEM was clipped to the intertidal wetland layer, and the HAT values were used to reclassify all pixels of the clipped DEM as 'height below HAT' or 'height equal to or greater than HAT'. The reclassified raster was polygonised and all areas of 'height equal to or greater than HAT' were removed from the intertidal wetlands layer. While areas above HAT may become important for carbon storage in the future, due to sea level rise, our map addresses the *current* potential.

Next, we used coastal salinity data from the most recent 20 year time period (2004 to 2023; (Painting et al, 2023)) to interpolate (using Inverse Distance Weighting analysis in ArcGIS Pro) a salinity surface for UK coastal and estuarine waters. Salinity data for this time period was not available for Scotland (apart from the inner Solway Firth), so this step was not undertaken for Scotland. The salinity layer was reclassified to identify areas above and below a threshold salinity of 10 parts per thousand (ppt). Polygons of the intertidal wetland layer whose centre fell within a low salinity area (<10 ppt) were erased from the layer. The potential of saltmarshes as blue carbon ecosystems relates not only to carbon accumulation, but also to their low methane emissions. Methanogenesis is inhibited at high salinities, such that methane flux is widely regarded to be negligible above 18 ppt (Mason, et al., 2023). Below a salinity 5 ppt, freshwater tidal marsh habitats, such as reedbeds, are more likely to form. A threshold salinity of 10 was chosen here to avoid excluding areas of brackish marsh that are less optimal in terms of carbon storage, but which may have significant co-benefits that could potentially balance these costs.

Size-filtering using a minimum size for contiguous areas of 10 hectares, was re-applied to remove any small, isolated sites resulting from the above processes.

The layer was then split into areas within and outside of SSSIs. Within SSSIs, conversion of sites with existing high conservation value to saltmarsh is unlikely to be a priority, due to the loss of valuable freshwater and brackish habitats and biodiversity behind current coastal defences, as well as due to legislative constraints. However, as the challenges of protecting high value sites from future sea level rise increases, conversion to intertidal habitat may become inevitable. This needs to be assessed on a site-by site basis.

Areas within SSSIs are, therefore, included in the final 'wetlands for carbon storage' potential map, but highlighted as a different colour.

A5. Wetlands for flood resilience mapping

A5.1. Selection of areas with high 'demand' for flood resilience solutions

WFD river waterbody catchments

The *Social Flood Risk Index* (SFRI) takes account of the number of people living within the floodplain and the overall social vulnerability of the neighbourhood, for each UK census area (Sayers et. al., 2017). Our prioritisation method identifies WFD waterbody catchments (hereinafter referred to as catchments) that feed into areas with high to extreme SFRI, assuming that catchment-scale NFM in these areas is likely to offer the greatest benefits to communities (Sayers et. al., 2017).

For each GB nation separately, tidal areas were removed from surface water and fluvial/coastal flood risk datasets (Environment Agency, 2023d; SEPA, 2023e; Natural Resources Wales, 2020; SEPA, 2023f; Environment Agency, 2023e; SEPA, 2023g), as intertidal flooding is analysed separately (see below). Flood risk data was then filtered to 'high' and 'medium' risk (Table A5), to produce a *flood risk* layer for further processing. Any census areas that did not overlap with the *flood risk* layer (see above) were removed.

Table A5. Annual flood probability thresholds for different flood risk categories used in England, Wales, and Scotland (Environment Agency, 2023d; SEPA, 2023e; Natural Resources Wales, 2020; SEPA, 2023f; Environment Agency, 2023e).

	Annual probability of flooding			
	High risk	**Medium risk**	**Low risk**	**Very low risk (surface water only)**
England & Wales	>1 in 30 (3.3%)	1 in 100 (1%) to 1 in 30 (3.3%)	1 in 1000 (0.1%) to 1 in 100 (1%)	<1 in 1000
Scotland	>1 in 10 (10%)	1 in 200 (0.5%) to 1 in 10 (10%)	1 in 1000 (0.1%) to 1 in 200 (0.5%)	n/a

Census areas with 'high', 'very high', 'acute' and 'extreme' values of *SFRI* ('SFRI Present Day, Fluvial & Coastal, Group' category) were intersected with the catchments layer. For each catchment, the following parameters were added to the layer attributes:

- overlap with high-extreme *SFRI* filtered to Flood Risk (Yes/No);
- percentage cover of built-up area (Office for National Statistics, 2017);
- areal extent of *flood risk* layer; and
- proportion of the *flood risk* area that is built on (Ordnance Survey, 2023a).

Catchments that intersected with the filtered *SFRI* data layer and have a *flood risk* area that is built on (buildings covering 0.5% or greater of the *flood risk* area), were selected.

A watershed analysis was performed on the selected catchments in order to identify contributing upstream catchments: the percentage cover of the watershed area was assigned to any additional catchments (i.e. not including the selected ones) covered by the watershed. Catchments with watershed coverage of 20% or greater were merged with the catchments selected above.

All catchments and their upstream contributing catchments that had a built-up area coverage of 50% or less, i.e. with sufficient land available on which to undertake natural flood management schemes at a catchment-scale, were selected as priority 'demand' areas for flood resilience wetlands.

Intertidal areas

Priority 'demand' areas for intertidal flood resilience wetlands (created via managed realignment) were based on communities both exposed to and vulnerable to coastal flooding. 'Demand' areas were identified using the following steps:

1. A *risk of tidal flooding* layer for Great Britain was created by merging tidal flood risk layers for England[13] (Environment Agency, 2023d), Wales (Natural Resources Wales, 2020) and Scotland (SEPA, 2023g). The resulting layer was filtered to include only areas at 'high' and 'medium' risk of flooding;

2. The *OS buildings* layer (Ordnance Survey, 2023a) was clipped to the *risk of tidal flooding* layer;

3. Census areas with 'high', 'very high', 'acute' and 'extreme' values of *SFRI* (SFRI Present Day, Fluvial & Coastal, Group' category) were extracted from the Climate Just data layer (Sayers et. al., 2017).

4. Resulting census areas that intersected with the *buildings in the tidal floodplain* layer (Step 2) were extracted as 'demand' areas. SFRI does not distinguish between fluvial and coastal flooding. This approach ensured that only census areas where there are properties exposed to coastal flooding, were included as 'demand areas'.

A5.2. Mapping potential locations for 'wetlands for flood resilience' within 'demand areas'

Methods were adapted from the Environment Agency's (EA) Working with Natural Processes (WWNP) potential maps and the Thames NFM opportunity mapping to ensure the method was compatible across four UK nations (Haughton, 2020; Environment Agency, 2021).

Wetland potential maps have been created for runoff interception bunds, floodplain inundation, leaky dams/gully blocking, offline storage areas, floodplain wet woodland and managed

[13] This dataset was clipped to 'tidal' areas of the Flood Zone 2 dataset (Environment Agency, 2023h).

realignment (Table 1), using the following processes:

Runoff interception bunds

Flow direction and flow accumulation raster layers were created from a 30 x 30 metre Digital Elevation Model (DEM) (Hawker & Neal, 2021). To identify flow paths, a size threshold was set to limit the flow path model to a realistic land area from which flow is likely to be intercepted by the creation of bunds. The threshold was set at 0.5 to 300 hectares for permeable soils, and 0.3 to 30 hectares for impermeable soils. The lower threshold represents the approximate size of an agricultural field, while the upper threshold approximates an area above which bunds are unlikely contain flows. Flows will accumulate more quickly on bunds placed on impermeable soils, so a lower size threshold was used to limit the flow path accumulation area on these soils. Flow paths that met the threshold requirement were buffered by 50 metres. The Topographic Wetness Index (TWI) layer (Box 1) was clipped to the buffered flow paths to locate areas within flow paths that could be used to intercept and accumulate water.

Floodplain inundation

'Tidal' waters were removed from risk of fluvial/coastal flooding layers (SEPA, 2023e; Natural Resources Wales, 2020; Environment Agency, 2023d; SEPA, 2023g). All areas at 'low' and 'very low' risk of flooding from rivers (Table A5) that fell within or partially within a 30 metre buffer of the *OS Open Rivers* data, were extracted for inclusion in the analysis (Ordnance Survey, 2023b). These low flood risk areas close to watercourses are most likely to be areas that are currently prevented from flooding due to artificial channel and bank modifications.

Leaky dams and gully blocking

These two interventions are combined into a single layer to show the potential to slow and hold back water on smaller headwater streams, where creation of water storage features is less feasible.

Percentage slope rise was calculated from a 30 x 30 metre DEM and areas of slope greater than 10.5% rise (6 degrees) were extracted (Hawker & Neal, 2021). Areas with a 'high' risk of surface water flooding (Natural Resources Wales, 2020; SEPA, 2023f; Environment Agency, 2023e) were clipped to the extracted *slope* layer.

A *stream order* layer was created from the DEM and filtered to stream orders 1 and 2, identifying smaller watercourses where leaky dams/gully-blocking could be used. The extracted streams were buffered by 50 metres and areas of the clipped *surface water flood risk* layer (created above) that intersected with these buffers were extracted as areas where leaky dams and gully blocking could be suitable.

Offline storage areas

For offline storage areas, rather than identifying areas of currently 'high' surface water accumulation (see (Environment Agency, 2021)), we used topographic wetness (TWI; see Box 1) to identify potential locations for wetlands that could store surface runoff and retain flood water. These locations were subsequently limited to being in proximity to 'high' risk areas so that they could potentially be used to store water in these ‘problem’ areas, while potentially also providing more permanent wetland habitat over a wider area.

A raster of percent slope was derived from a 30 x 30 metre DEM (Hawker & Neal, 2021). Areas of shallow slope less than or equal to a 2% rise (1.5 degrees) were extracted and used to clip the TWI layer, to identify flat ground where water is predicted to accumulate. A 100 metre buffer applied to the ‘high’ risk of flooding from surface water layers (Natural Resources Wales, 2020; SEPA, 2023f; Environment Agency, 2023e) was used to clip the resulting TWI layer. This located storage potential in proximity to areas of ‘high’ surface water flood risk, while eliminating more distant areas that are less likely to offer flood relief to these ‘high’ risk areas. In large, flat landscapes such as the Somerset Levels and Moors, this prevented the inclusion of large, connected areas of storage potential that were not in direct proximity to high-risk areas.

Floodplain wet woodland

Tidal areas were removed from fluvial/coastal flood risk datasets (Environment Agency, 2023d; SEPA, 2023e; Natural Resources Wales, 2020; SEPA, 2023g) and merged into a *fluvial flood risk* layer for Great Britain, which was filtered to ‘high’ and ‘medium’ flood risk (Table A3). The resulting layer was used as the *floodplain wet woodland potential* layer for further processing (see below).

Managed realignment

A 5-kilometre buffer around ‘demand’ areas identified in Section A5.1 ‘Intertidal areas’ was used to extract areas of the *intertidal wetland potential* layer created in Section A4.1, that may provide flood resilience to at-risk communities. The exact locations and interventions that are likely to protect such communities depend greatly on local (e.g. hydrological) factors. As such, this layer should be taken as a broad approximation of where managed realignment could be considered an option but should not be taken as an assessment of feasibility or effectiveness of this measure in reducing flood risk at site level.

Removal of constraints/obstacles and setting minimum size threshold

A range of datasets were used to identify areas that are unlikely to be suitable for NFM interventions. These are by no means exhaustive, being based on the availability of open-source data at the time of the analysis: users may wish to consider other constraints when interpreting the maps. Table A6 lists the constraints and obstacles that were removed from each of the non-tidal (excluding those created by managed realignment) flood resilience wetland potential layers. A minimum size threshold specific to each intervention type (Table A6) was applied to the wetland potential layer, by erasing isolated polygons below the threshold size. This removed tiny slivers of potential that were left over after constraint/obstacle removal. In addition, interventions below a certain size are likely to be less effective, less resilient, and less economically viable to install.

Table A6. Constraints and obstacles removed from non-tidal flood resilience potential layers, including buffers (where applicable) and minimum size thresholds applied.

Constraint/obstacle to wetland creation	Data sources	Buffer (m)	Runoff interception bunds	Floodplain inundation	Leaky dams/gully blocking	Offline storage areas	Floodplain wet woodland
Roads	(Ordnance Survey, 2023a)	20	✓	✓	✓	✓	✓
Buildings	(Ordnance Survey, 2023a)	30	✓	✓	✓	✓	✓
Railways	(Ordnance Survey, 2023a)	30	✓	✓	✓	✓	✓
OS functional sites[14]	(Ordnance Survey, 2023a)		✓	✓	✓	✓	✓
Surface and tidal waters	(Ordnance Survey, 2023a; Ordnance Survey, 2023b; Hughes, et al., 2004)		✓	✓	✓	✓	✓
Priority wetland habitat	(Natural England, 2023c; Natural England, 2023d; Natural England, 2023e; Natural Resources Wales, 2022b; NatureScot, 2017; NatureScot, 2020a)		✓	✓	✓	✓	✓

[14] area/ extent of functions and activities associated with air transport, education, medical care, road transport and water transport.

Constraint/obstacle to wetland creation	Data sources	Buffer (m)	Runoff interception bunds	Floodplain inundation	Leaky dams/gully blocking	Offline storage areas	Floodplain wet woodland
Important grassland and woodland habitats, including orchards	(Natural England, 2023b; Scottish Government, 2023b; Natural Resources Wales, 2021; Natural England, 2023a; Natural Resources Wales, 2016a; NatureScot, 2023; Natural Resources Wales, 2023c).		✓	✓	✓	✓	✓
Statutory main rivers	(Natural Resources Wales, 2023f; Environment Agency, 2023f)	100			✓		
Canals	(Ordnance Survey, 2023b)	20			✓		
Lakes	(Hughes, et al., 2004)	50			✓		
Grade 1 Agricultural Land	(Welsh Government, 2017; James Hutton Institute, 1981; Defra, 1988)					✓	✓
Existing woodland	(Forestry Commission, 2020b)					✓	
Saltmarsh	(NatureScot, 2016a; Defra, 2023f; Natural Resources Wales, 2017a)						✓
Peatland	(Evans, et al., 2020; NatureScot, 2016b; Natural England, 2023f)						✓
		Minimum size threshold (m² (ha))	1000 (0.1)	500 (0.05)	100 (0.01)	1000 (0.1)	1000 (0.1)

Final processing

The resulting *non-tidal wetlands for flood resilience* layer was clipped to the *priority 'demand' catchments* layer (Section A5.1 'WFD river catchments') and to wetland soil types (Soil Survey of Scotland Staff, 1981; Farewell et. al., 2024). Overlaps between wetland potential layers for different interventions were removed (order of priority: floodplain inundation, offline storage areas, floodplain wet woodland, runoff interception bunds, leaky dams and gully blocking). The size thresholds from the above methodologies were reapplied.

Areas of potential for managed realignment were merged with the resulting layer: where managed realignment overlapped with non-tidal wetland potential, managed realignment was prioritised where these wetlands overlapped with the risk of tidal flooding layer (see Section A5.1 'Intertidal areas').

A5.3. *Prioritising 'demand' areas where wetlands can deliver most flood resilience benefits.*

To further prioritise the 'demand' catchments (Section A5.1) by their relative potential to provide flood resilience benefits, we followed a similar approach to that used to define target areas for the economic analysis of flood resilience wetlands (Section 2.2.3; see the natural capital account for a full account of these methods). This focussed on identifying catchments where wetlands are likely to be most effective in defending against flooding, based on a range of criteria: from the feasibility for catchment-wide flood risk management, to the risk of future flooding in a catchment.

This analysis focussed specifically on the benefits provided by non-tidal wetlands i.e. excluding those that would be created by managed realignment.

Three steps were followed: Steps 1 and 2 describe the criteria used to prioritise the 'demand' areas (and potential wetlands located within them) to those with the most potential for flood regulation, and those that are most likely to provide flood benefit. Step 3 describes the ranking of 'demand' catchments based on whether or not they met the criteria for Step 1, as well as the level of future flood risk in those catchments.

Step 1. Refining wetland potential

The priority flood resilience wetland locations (from Section A5.2) were refined by:

- Increasing the **minimum size threshold** for offline storage areas, floodplain wet woodlands, and flood inundation wetlands: larger interventions are likely to be more effective in defending against flooding and are more cost effective to create and maintain. Potential wetlands less than one hectare were excluded for these three NFM types;

- Prioritising wetlands in 'demand' catchments with a larger potential area for NFM measures: **catchment-scale NFM** is likely to be more effective at protecting against flooding. Wetlands in catchments where the combined area of flood resilience wetland potential covered less than 10% of the catchment area, were excluded; and

- Prioritising wetland creation on **less productive agricultural land**, thus reducing the opportunity cost associated with lost agricultural capacity. Wetlands in ‘demand’ catchments where over 50% of the flood resilience wetland potential overlapped with high-grade agricultural land, were excluded. Significant overlap between floodplain areas, wetland creation potential, and high-grade agricultural land, means that complete avoidance of high-grade agricultural land is not possible.

Step 2. Prioritising wetlands in catchments with ‘high risk’ of future flooding

The next step involved prioritising the remaining wetlands (in ‘demand’ catchments) that have a high risk of future flooding, or catchments with the largest proportion of their land area feeding into these ‘high risk’ catchments. Areas of ‘high risk’ (i.e. those that could benefit most from flood risk reduction), were derived for catchments containing the refined wetlands, by:

England and Wales

a) Selecting areas of current ‘medium’ (Table A5) flood risk that currently benefit from flood defences (Environment Agency, 2023g; Natural Resources Wales, 2023g). These areas currently have a ‘medium’ risk of flooding because of the adjacent flood defences. However, as engineered flood defences age and as climate change increases the frequency and intensity of flood events, it is expected that the risk level in these ‘medium’ risk areas will increase;

b) Selecting areas of current ‘high’ flood risk that are not currently defended, and therefore would be likely to benefit from the creation of flood resilience wetlands to reduce flood risk;

c) Combining the outputs of (a) and (b) into a combined *high risk* layer and removing mapped potential locations for flood resilience wetlands areas of mapped flood resilience wetlands[15], as well as priority wetland habitats (i.e. those of national importance) (Natural England, 2023c; Natural England, 2023d; Natural England, 2023e; Natural Resources Wales, 2022b), to leave the at-risk areas that could benefit from flood-resilience wetlands; and

d) Calculating the areal extent of the *high-risk* area for each ‘demand’ catchment.

Scotland

a) Deriving the percentage increase in the area of ‘medium’ fluvial flood risk predicted due to climate change for each of the refined ‘demand’ catchments, calculated as the difference in extent between current and *future flood risk* (SEPA, 2023e)[16]. Mapped

[15] To leave the area of ‘high risk’ that would be protected from flooding by these wetlands.
[16] Data on areas protected by flood defences in Scotland were not publicly available at the time of this analysis, hence why a different approach was taken for Scotland.

potential locations for flood resilience wetlands, as well as existing wetlands (NatureScot, 2017; NatureScot, 2020a) were deleted from the flood risk layers prior to this analysis;

b) Clipping areas of current 'high' fluvial flood risk to the refined 'demand' catchments. Areas overlapping with flood resilience wetland potential, as well as existing wetlands (NatureScot, 2017; NatureScot, 2020a) were deleted from the flood risk layer;

c) Combining outputs of (a) and (b) into a *high-risk* layer for Scotland; and

d) Calculating the areal extent of the *high-risk* area for each 'demand' catchment.

Step 3. Ranking 'demand' catchments by potential for flood risk benefit

Priority 'demand' catchments were ranked by their relative potential to provide flood resilience benefits based on the information derived in Steps 1 and 2. Table A7 shows the criteria used to rank catchments. Catchments were symbolised by their rankings in order to map the relative potential for wetlands to deliver flood resilience benefits.

Table A7. Ranking applied to priority 'demand' catchments for flood resilience wetlands (Section 2.1.4), based on the potential for catchment-scale NFM to provide flood resilience benefits.

Rank	Criteria
1 (highest potential for flood resilience benefits)	Catchments containing the refined priority flood resilience wetlands (Step 1 above) and: • For England and Wales, catchments containing more than 50 hectares of *high risk* area; • For Scotland, catchments containing more than 20 hectares of high fluvial flood risk area or with a predicted 100% or greater increase in medium flood risk extent due to climate change; or • Catchments containing >10% of the watershed feeding into these catchments[17].
2	Catchments containing the refined priority flood resilience wetlands (Step 1 above) that did not meet the other criteria for Rank 1.
3 (lowest potential for flood resilience benefits)	Remaining 'demand' catchments that did not contain the refined priority flood resilience wetlands (Step 1 above), and with wetland potential covering greater than 0.5% of the catchment area.

A6. Wetlands for urban wellbeing

A6.1. Selection of areas with high 'demand' for wellbeing enhancement

'Demand' areas were defined as: LSOAs classed as urban (Defra, 2013) for England and Wales; and Data Zones in Class 1 and 2 areas (large urban areas and other urban areas respectively) for Scotland (Scottish Government, 2014b). Census areas that met these criteria were combined into a single GB-wide wetlands for urban wellbeing 'demand' layer.

A6.2. Mapping potential locations for 'wetlands for urban wellbeing' within priority 'demand' census areas

The potential locations for urban wellbeing wetlands are based on the derived Topographic Wetness Index (TWI) layer (Box 1).

TWI wetland parcels that fell within (either in part or in their entirety) 300 metres of the 'demand' areas were extracted and converted to polygon features.

We then filtered the resulting TWI layer, based on:

Proximity to urban areas

This identified the sites suitable for freshwater wetlands in proximity to urban areas. Natural

[17] A watershed analysis was performed on these catchments to identify upstream contributing catchments: the percentage cover of the watershed area was assigned to any upstream catchments that overlapped with the watershed.

England's Accessible Natural Greenspace Standard (ANGst) recommends that everyone, wherever they live, should have an accessible natural greenspace of at least 2 hectares in size, no more than 300 metres (5 minutes walk) from home (Natural England, 2010). We therefore filtered the TWI layer to include only parcels that fell within (either in part or in their entirety) 300 metres of a built-up area (Scottish Government, 2023c; Office for National Statistics, 2017). Where the filtered wetlands extended more than 2 kilometres from a built-up area, these polygons were clipped to include only wetlands within a 2 kilometre buffer of built-up areas. This eliminated areas of potential where access could be difficult.

Existing access levels

To select areas of wetland potential that are likely to be relatively accessible based on the current levels of access (and hence where urban wetland creation is less likely to require new access routes), we derived two proximity variables: proximity to existing accessible greenspaces; and proximity to existing access routes.

Proximity to existing accessible greenspaces

Areas of potential for wetlands that intersected with existing accessible greenspaces (within a 1 metre tolerance range; (Table A6)) were selected as potential wetlands for urban wellbeing.

Accessible greenspaces were defined using the greenspace datasets and typologies defined as 'publicly accessible' in the England Green Infrastructure Mapping Database (Moss, 2023), where:

"A greenspace was defined as publicly accessible if (on the usual balance of probability) it was intended specifically to provide public access, or one to which the public would usually expect to have reasonable access (such as a cemetery), or one over which there is a public right to open access (this does not include spaces over which there may be a Public Right of Way only). Spaces deemed publicly accessibility are likely to be accessible to the public at any reasonable time, free to entry and available for a range of pastimes (subject to bylaws and/or restrictions). However, because the approach to assigning public accessibility was typologically driven, some spaces may be incorrectly coded. Some spaces shown as accessible may in fact not be whilst others missing from the map may in fact be accessible."

Woodland and foreshore were only included if polygons fell (a) within a publicly accessible greenspace polygon, or (b) within 20 metres of a 'traffic-free' access route (see below for definition). This is a very high-level depiction of woodland/foreshore access derived for the purposes of refining the wetland potential mapping in a broadly consistent way across nations. Other datasets on woodland access such as the England Green Infrastructure Mapping Database, should be used to give a more complete picture for individual nations.

Mapping of open access land is not publicly available for Scotland, hence wetland potential polygons within land use types least likely to be open access (Table A8) were eliminated from the mapping. This gave a limited approximation of open access land. As such, not all potential wetlands identified in Scotland will be accessible, while other wetlands that are indeed open access may have been eliminated.

Table A8. Greenspace Datasets and attributes assumed to be publicly accessible.

Country[18]	Dataset	Source	Notes on inclusion
E,S,W	OS Open Greenspace	(Ordnance Survey, 2024c)	Included: cemeteries, play spaces, playing fields, public parks or gardens, religious grounds
E,S,W	Local Nature Reserve	(Natural Resources Wales, 2024c); (Natural England, 2024b); (Scottish Government, 2023d)	Included
S,W	National Nature Reserve	(Natural Resources Wales, 2022c); (NatureScot, 2022)	Included
E	CRoW Act 2000 – Access layer; and CRoW Act 2000 – Section 15 Land	(Natural England, 2024c); (Natural England, 2024d)	Included
W	NRW common land, open country, other dedicated land, statutory land and public forest	(Natural Resources Wales, 2016b); (2016c); (2017b); (2016d); (2017c)	Included
E	Millennium Greens	(Natural England, 2024e)	Included
E,S,W	Country Parks	(Natural England, 2024f); (NatureScot, 2020b); (Natural Resources Wales, 2015c)	Included
E	Doorstep Greens	(Natural England, 2024g)	Included
E,S,W	OS OpenMap – Local	(Ordnance Survey, 2023a)	Woodland and Foreshore clipped to 20 metre access route buffer
E,S,W	National Forest Inventory Woodland	(Forestry Commission, 2020b)	Clipped to 20 metre access route buffer
E,S,W	Ancient Woodland	(Natural England, 2023b); (Scottish Government, 2023b); (Natural Resources Wales, 2021)	Clipped to 20 metre access route buffer
S	SNH Carbon & Peatland map 2016[19]	(NatureScot, 2016b)	Excluded: airfield, arable, built up, caravan sites, cliffs, coniferous (plantation), factory, estuary, forest ripping,

[18] E = England, W = Wales, S=Scotland
[19] Dataset based on LCS88 land parcels.

Country[18]	Dataset	Source	Notes on inclusion
			golf course, improved pasture, industrial peat, links area, open canopy (young plantation), quarries, rail, water.

Proximity to existing access routes

Proximity to access routes was determined by extracting wetlands within 20 metres of a 'traffic-free' access route, either in part, or in their entirety. Data from the following sources were merged to create a 'traffic-free access routes' layer:

- Open Street Map (OSM) *Highways* data (features included: 'bridleway'; 'cycleway'; 'footway'; 'living_street'; 'path'; 'pedestrian'; 'residential'; and 'steps' (OpenStreetMap contributers, 2020);
- *National Trails* (Natural England, 2024h); (Natural Resources Wales, 2022d);
- *National Forest Estate Recreation Routes* (Scottish Government, 2024b);
- Coastal path routes (Natural Resources Wales, 2024d); (Natural England, 2024i)[20];
- *National Cycle Network* (traffic-free routes only) (Sustrans, 2020).

It is unlikely that all of the extracted OSM features have public right of way (PROW), although many UK PROWs are included in OSM. Proximity to an access route does not necessarily mean that a wetland would be visible, nor indeed accessible from the route. Our attempt to classify accessible wetlands is, therefore, imperfect, and urban wetland creation schemes should consider access needs on a site-by-site basis.

Potential wetlands, selected based on their relative accessibility (either due to from being within an existing greenspace or in close proximity to an access route), were merged into a single *accessible wetland opportunities* layer.

Exclusion of infrastructure

The *accessible wetland opportunities* layer was further refined through the exclusion of areas unlikely to be developed into wetlands, based on presence of existing infrastructure and surface waters. The following exclusions were made using OS OpenMap Local data (Ordnance Survey, 2023a):

[20] The England Coast Path was renamed the King Charles III England Coast Path (Natural England, 2024i) in 2023.

- *Roads*, buffered by 5 metres: ‘A Road’, ‘B Road’, ‘Guided Busway Carriageway’, ‘Minor Road’, ‘Primary Road’, ‘Motorway’ (separate carriageways);
- *Roads*, buffered by 10 metres: 'A Road, Collapsed Dual Carriageway', 'B Road, Collapsed Dual Carriageway', 'Primary Road, Collapsed Dual Carriageway';
- *Roads*, buffered by 15 metres: ‘Motorway, Collapsed Dual Carriageway’;
- *Railways*, buffered by 5 metres;
- *Buildings*, buffered by 5 metres (eliminated mostly residential areas with limited opportunities for wetland creation for public use);
- *Surface* and *Tidal waters*; and
- *Functional sites* (area/ extent of functions and activities associated with air transport, education, medical care, road transport and water transport).

Filtering wetlands by size

A minimum size threshold of 0.4 hectares was applied to the accessible wetland potential layer. This represents approximately 4 pixels of the elevation model used to create the TWI layer, which we deemed appropriate to minimise any errors in the TWI calculations at the individual pixel level. Opportunities for very small urban wetlands are therefore underestimated in the final ‘wetlands for urban wellbeing’ layer. Our prioritisation (ranking) of ‘demand’ census areas by the relative potential of wetlands located within them to provide wellbeing benefits (Section A6.3), can be used to identify census areas where a range of urban wetland types, including small community wetlands, could be particularly beneficial. We recommend that this layer is viewed alongside the *indicative locations for ‘wetlands for urban wellbeing’* layer.

We applied an upper threshold of 100 hectares to ‘wetlands for urban wellbeing’, on the assumption that wetlands approaching the upper limit of this threshold are likely to be situated on the rural fringes of urban areas, which may also be less accessible than wetlands located within urban boundaries. The wellbeing benefits of these wetlands would not, therefore, be extended across the local population.

A6.3. Prioritising ‘demand’ areas where wetlands can deliver most wellbeing benefits.

To ensure that wetland interventions are as effective as possible at tackling the wellbeing crisis, restoration should be focused on locations where current access to natural spaces is low, poor mental health is rife and where there are high levels of deprivation and vulnerability to flooding.

Prioritisation of the census areas with the highest demand for ‘wetlands for urban wellbeing’ involved ranking ‘demand’ census areas (Appendix A6.1) where wetland potential was identified, based on three key variables as follows:

- **Neighbourhood Flood Vulnerability Index (NFVI; Box A1):** Wetlands targeted at flood resilience in urban areas, for example, via SuDS, are likely to have a bigger impact on wellbeing in neighbourhoods with higher neighbourhood flood vulnerability (Sayers et. al., 2017). The NFVI is calculated on a continuous scale, with higher values representing more flood vulnerable neighbourhoods (i.e. communities experiencing a greater loss in wellbeing when floods occur) (Sayers et. al., 2017). Census areas were ranked by NFVI, with highest NFVI values representing areas of greatest demand for wetlands for urban wellbeing (Sayers et. al., 2017);

- **Level of existing access to accessible greenspace:** Census areas were ranked by the percentage cover of existing accessible greenspace (Table A8). Areas with the lowest percentage cover were assumed to have the greatest demand for a green or blue space, and vice-versa;

- **Mental health indicator (see above):** Census areas were ranked using data on the rate of mental health conditions in the population, which is available for all census areas. Data included: the percentage of registered patients with a diagnosis of depression for England (Daras & Barr, 2021); GP-recorded mental health conditions (rate per 100 people) for Wales (Welsh Government, 2022); and the proportion of the population being prescribed drugs for anxiety, depression or psychosis, for Scotland (Scottish Government, 2020b).

  Census areas with the highest rates of mental health conditions were assumed to have the highest demand for wetlands for urban wellbeing.

Rankings were undertaken separately for each nation, as differences in the mental health data for different nations mean that comparison of the relative potential between nations is not possible.

A combined rank for each census area was calculated for each nation, by summing the ranks for each of the above criteria. Higher overall ranks (low values) represent areas with the highest 'demand' for urban wetlands.

To reflect this as a prioritised 'demand' map, the combined rankings were attributed to the relevant LSOA/Data Zone polygon layer for each nation and symbolised to reflect the gradient from highest to lowest 'demand'.

Box A1. The Climate Just Neighbourhood Flood Vulnerability Index (NFVI; Sayers, et al., 2017)

The NFVI provides insight into the social vulnerability of a neighbourhood should a flood occur there. The index combines five characteristics of vulnerability: susceptibility, ability to prepare, ability to respond, ability to recover and community support. The NFVI and the Index of Multiple Deprivation (IMD; ref) take account of many similar characteristics of deprivation (for example, income and employment). The NFVI, however, focuses more specifically on those characteristics that make a neighbourhood vulnerable to a loss in wellbeing following a flood, rather than the more general expression of deprivation provided by the IMD.

Appendix IV. Dataset sources and credits

Table A9. Data sources and copyright statements for data sources used in wetland potential mapping for the four wetland themes.

Dataset (including country[21])	Reference	Copyright statement	Wetland theme			
			Water quality	Flood resilience	Carbon storage	Urban wellbeing
1:250,000 Soil Map (National Soil Map) Version 1.3/1.4 (•|S|•|•)	(Soil Survey of Scotland Staff, 1981)	© Soil Survey of Scotland Staff (1981).	✓	✓		
Ancient Woodland (England) (E|•|•|•)	(Natural England, 2023b)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2023.	✓	✓		✓
Ancient Woodland Inventory (Scotland) (•|S|•|•)	(Scottish Government, 2023b)	Copyright Scottish Natural Heritage Contains Ordnance Survey data © Crown copyright and database right (2019)	✓	✓		✓
Ancient Woodland Inventory 2021 (•|•|W|•)	(Natural Resources Wales, 2021)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.	✓	✓		✓
Areas of Special Scientific Interest (•|•|•|NI)	(NIEA, 2016; Northern Ireland Environment Agency, 2016)	© NIEA.			✓	
Built-up Areas (December 2011) Boundaries V2 (E|•|W|•)	(Office for National Statistics, 2017)	Ordnance Survey and ONS Intellectual Property Rights.			✓	✓
Carbon and Peatland 2016 map (•|S|•|•)	(NatureScot, 2016b)	© SNH and JHI Available under a Non-Commercial Government Licence.		✓		
CRoW Act 2000 - Access Layer (E|•|•|•)	(Natural England, 2024c)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2023.				✓
CRoW Act 2000 - Section 15 Land (E|•|•|•)	(Natural England, 2024d)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2023.				✓

[21] E = England, W = Wales, S=Scotland, NI=Northern Ireland

Dataset (including country[21])	Reference	Copyright statement	Wetland theme			
			Water quality	Flood resilience	Carbon storage	Urban wellbeing
CSGN Habitat Networks and Opportunity Areas (•|S|•|•)	(CSGN, 2021)	Contains data from multiple sources: National Forest Inventory (2017) - Forestry Commission © Crown copyright and database right [2021] Ordnance Survey [100021242]; Landcover Map of Scotland 88 - MLURI; Local Nature Conservation Sites - Landmark; Native Woodland Survey of Scotland (2012) - Reproduced by Permission of Ordnance Survey on behalf of HMSO © Crown copyright and database right [2021] Ordnance Survey Licence number 100043970; Habitat Map of Scotland, Local Biodiversity Sites, Sites of Importance for Nature Conservation - © SNH.	✓	✓		
Coastal Classifications	(SEPA, 2023b)	Licensed under the Open Government Licence v.3.0. © SEPA, 2023.	✓			
Coastal Design Sea Levels - Coastal Flood Boundary Extreme Sea Levels (E|S|W|NI)	(Environment Agency, 2023b)	© Environment Agency copyright and/or database right 2019. All rights reserved.			✓	
Coastal Design Sea Levels - Coastal Flood Boundary Extreme Sea Levels Estuary (E|S|W|NI)	(Environment Agency, 2023c)	© Environment Agency copyright and/or database right 2019. All rights reserved.			✓	
Coastal Flood maps (•|S|•|•)	(SEPA, 2023g)	Licensed under the Open Government Licence v.3.0. © SEPA, 2023.		✓		
Countries (December 2017) Full Clipped Boundaries in UK (WGS84) (•|S|W|•)	(Office for National Statistics, 2018)	Contains public sector information licensed under the Open Government Licence v3.0. Contains both Ordnance Survey and ONS Intellectual Property Rights.			✓	
Country Parks (E|•|•|•)	(Natural England, 2024f)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2023.				✓
Country Parks (•|S|•|•)	(NatureScot, 2020b)	© Crown Copyright. All rights reserved. Licensed under the Open Government Licence v.3.0.				✓
Country Parks (•|•|W|•)	(Natural Resources Wales, 2015c)	© Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right.				✓
Current Saltmarsh Extent (•|•|•|NI)	(Strong, et al., 2021)	Data provided and permission granted by Ulster Wildlife Trust.			✓	
Data Zone Boundaries 2011 (•|S|•|•)	(Scottish Government, 2014a)	Copyright Scottish Government, contains Ordnance Survey data © Crown copyright and database right (insert year).				✓

WWT

Dataset (including country[21])	Reference	Copyright statement	Wetland theme			
			Water quality	Flood resilience	Carbon storage	Urban wellbeing
Dissolved oxygen, temperature and salinity measurements in coastal and estuarine waters in the UK from 1990 to 2018 (E|S|W|NI)	(Painting et al, 2023)	Painting et al (2023). Dissolved oxygen, temperature and salinity measurements in coastal and estuarine waters in the UK from 1990 to 2018. Cefas, UK. V1. doi: https://doi.org/10.14466/CefasDataHub.141			✓	
Doorstep Greens (E|•|•|•)	(Natural England, 2024g)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2023.				✓
Drinking Water Protected Areas (•|S|•|•)	(SEPA, 2023c)	© SEPA, 2022.	✓			
Drinking Water Protected Areas (Surface Water) (E|•|•|•)	(Environment Agency, 2022)	© Environment Agency copyright and/or database right 2022. All rights reserved.	✓			
Environment (Wales) Act Section 7 Terrestrial Habitats of Principle Importance (•|•|W|•)	(Natural Resources Wales, 2022b)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.	✓	✓		
Event Duration Monitoring - Storm Overflows - 2021 (England and Wales) E|•|W|•)	(The Rivers Trust, 2021)	Produced by The Rivers Trust. © Environment Agency copyright and/or database right 2022. All rights reserved. © Dŵr Cymru/Welsh Water.	✓			
FABDEM V1-0 (E|S|W|NI)	(Hawker & Neal, 2021)	© Hawker and Neal (2021)	✓	✓		✓
Felling Licence Applications (•|•|W|•)	(Natural Resources Wales, 2024b)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.	✓			
Felling Licence Applications England (E|•|•|•)	(Forestry Commission, 2020a)	Open Government Licence v3.0. © Crown copyright 2016.	✓			
Felling Permissions and Licences (•|S|•|•)	(Scottish Forestry, 2023)	© Scottish Forestry, 2023. Licensed under the Open Government Licence v3.0.	✓			
Flood Map for Planning Flood Zones 2 and 3 (•|•|W|•)	(Natural Resources Wales, 2023d)	Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved. Some features of this information are based on digital spatial data licensed from the UK Centre for Ecology & Hydrology © UKCEH. Defra, Met Office and DARD Rivers Agency © Crown copyright. © Cranfield University. © James Hutton Institute. Contains OS data © Crown copyright and database right.			✓	

Dataset (including country[21])	Reference	Copyright statement	Wetland theme			
			Water quality	Flood resilience	Carbon storage	Urban wellbeing
Flood Map for Planning (Rivers and Sea) - Flood Zone 3 (E|•|•|•)	(Environment Agency, 2023a)	© Environment Agency copyright and/or database right 2023. All rights reserved. Some features of this map are based on digital spatial data from the Centre for Ecology & Hydrology, © NERC (CEH).			✓	
Habitat Map of Scotland (•|S|•|•)	(NatureScot, 2017)	© SNH. Contains Ordnance Survey data © Crown copyright and database right (2017). Contains Forestry Commission information licensed under the Open Government Licence v3.0. Contains SEPA data © Scottish Environment Protection Agency and database right [2016]. All rights reserved. © RSPB © Historic Environment Scotland © Scottish Government	✓	✓	✓	
Habitat Networks (England) – Lakes (E|•|•|•)	(Natural England, 2023d)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2023.	✓	✓		
Habitat Networks (Individual Habitats) (England) (E|•|•|•)	(Natural England, 2023a)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2020.	✓	✓		
House building, UK: permanent dwellings started and completed by country (E|S|W|NI)	(Office for National Statistics, 2022)	© Office for National Statistics, 2023. Licensed under the Open Government Licence v.3.0.	✓			
Household projections for England (E|•|•|•)	(Office for National Statistics, 2020)	© Office for National Statistics, 2020. Licensed under the Open Government Licence v.3.0.	✓			
Household Projections for Scotland (•|S|•|•)	(National Records of Scotland, 2018)	© National Records of Scotland, 2018. Licensed under the Open Government Licence v.3.0.	✓			
King Charles III England Coast Path Route	(Natural England, 2024i)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2024.				✓
Land Capability for Agriculture, Scotland (•|S|•|•)	(James Hutton Institute, 1981)	Land Capability for Agriculture, Scotland. Copyright and database right The James Hutton Institute 2016. Used with the permission of The James Hutton Institute. All rights reserved. Any public sector information contained in these data is licensed under the Open Government Licence v.2.0.		✓		
Local Nature Reserves (E|•|•|•)	(Natural England, 2024b)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2023.				✓
Local Nature Reserves (•|•|W|•)	(Natural Resources Wales, 2024c)	© CNC/NRW All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right. Data may be re-used under the terms of the Open Government Licence.				✓

Dataset (including country[21])	Reference	Copyright statement	Wetland theme			
			Water quality	Flood resilience	Carbon storage	Urban wellbeing
Local Nature Reserves (•|S|•|•)	(Scottish Government, 2023d)	© Crown Copyright. All rights reserved. Licensed under the Open Government Licence v.3.0.				✓
LiDAR for Scotland Phase 1-5 DTM (•|S|•|•)	(Scottish Government, 2022)	© Crown copyright Scottish Government, SEPA and Scottish Water (2012).			✓	
Lower layer Super Output Areas (E|•|W|•)	(Office for National Statistics, 2016)	© Office for National Statistics (ONS).				✓
Main river and coastal catchments (•|S|•|•)	(SEPA, 2023a)	Licensed under the Open Government Licence v.3.0. © SEPA, 2023. Some features of this information are based on digital spatial data licensed from the Centre for Ecology and Hydrology © NERC (CEH). Contains OS data © Crown copyright and database right.	✓			
Main Rivers (•|•|W|•)	(Natural Resources Wales, 2023f)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.		✓		
Marine Article 17 Habitats Features (•|•|W|•)	(Natural Resources Wales, 2018b)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right. Derived in part from data provided under licence by the British Geological Survey © NERC			✓	
Millennium Greens	(Natural England, 2024e)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2023.				✓
Modelling of Habitat Networks for Welsh Woodlands, Grasslands, Heathlands, Bogs and Fens (•|•|W|•)	(Natural Resources Wales, 2023c)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.	✓	✓		
NASA Shuttle Radar Topography Mission (SRTM) Global 1 arc second DEM (•|S|•|NI)	(NASA JPL, 2013)	© NASA.			✓	
National Cycle Network (E|S|W|NI)	(Sustrans, 2020)	© Sustrans.				✓

Dataset (including country[21])	Reference	Copyright statement	Wetland theme			
			Water quality	Flood resilience	Carbon storage	Urban wellbeing
National Flood Risk Maps (•|•|W|•)	(Natural Resources Wales, 2020)	Contains Natural Resources Wales information © Natural Resources Wales and database right. All rights reserved. Some features of this information are based on digital spatial data licensed from the UK Centre for Ecology & Hydrology © UKCEH, the Environment Agency © EA and Getmapping Plc and Bluesky International Limited [2015]. Defra, Met Office and DARD Rivers Agency © Crown copyright. © Cranfield University. © James Hutton Institute. Contains OS data © Crown copyright and database right. Land & Property Services © Crown copyright and database right.		✓		
National Forest Estate Recreation Routes GB (E|S|W|•)	(Scottish Government, 2024b)	© Forestry Commission.				✓
National Forest Inventory Woodland GB 2020 (E|S|W|•)	(Forestry Commission, 2020b)	Contains, or is based on, information supplied by the Forestry Commission. © Crown copyright and database right 2020 Ordnance Survey [100021242].		✓		✓
National Nature Reserves (NNR) (•|•|W|•)	(Natural Resources Wales, 2022c)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right.				✓
National Nature Reserves (Scotland) (•|S|•|•)	(NatureScot, 2022)	© NatureScot, Contains Ordnance Survey data © Crown copyright and database right (2024)				✓
National Trails (E|•|•|•)	(Natural England, 2024h)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2024.				✓
National Trails (•|•|W|•)	(Natural Resources Wales, 2022d)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right.				✓
NATMAP vector England and Wales (E|•|W|•)	(Farewell, Truckell, Keay, & Hallett, 2024)	Soils Data © Cranfield University (NSRI) and for the Controller of HMSO 2023.	✓	✓		

Dataset (including country[21])	Reference	Copyright statement	Wetland theme			
			Water quality	Flood resilience	Carbon storage	Urban wellbeing
Neighbourhood Flood Vulnerability Index (E|S|W|•)	(Sayers, Horritt, Penning Rowsell, & Fieth, 2017)	Contains derived data from the Office for National Statistics licensed under the Open Government Licence. © Crown copyright and database right 2012. Sayers, P.B., Horritt, M., Penning Rowsell, E., and Fieth, J. (2017). Present and future flood vulnerability, risk and disadvantage: A UK scale assessment. A report for the Joseph Rowntree Foundation published by Sayers and Partners LLP.				✓
Neptune Coastline Campaign Open Data: Land Use 2014 (•|•|W|NI)	(Comber, et al., 2016)	Licensed under the Open Government Licence v.3.0.			✓	
Northern Ireland Household Projections (2016 based) (•|•|•|NI)	(NISRA, 2018)	© NISRA, 2020. Licensed under the Open Government Licence v.3.0.	✓			
Open Access - Dedicated Forests (•|•|W|•)	(Natural Resources Wales, 2016b)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right.				✓
Open Access – Open Country (•|•|W|•)	(Natural resources Wales, 2016c)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right.				✓
Open Access - Other Dedicated Land (•|•|W|•)	(Natural Resources Wales, 2017b)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right.				✓
Open Access - Other Statutory Access Land (•|•|W|•)	(Natural Resources Wales, 2016d)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right.				✓
Open Access – Registered Common Land (•|•|W|•)	(Natural Resources Wales, 2017c)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right.				✓

WWT

Dataset (including country[21])	Reference	Copyright statement	Wetland theme			
			Water quality	Flood resilience	Carbon storage	Urban wellbeing
OSNI Open Data - Largescale Boundaries - NI Outline (•|•|•|NI)	(OpenDataNI, 2023b)	Licensed under the Open Government Licence v.3.0.			✓	
OSNI Open Data – 50K Transport – Transport lines (•|•|•|NI)	(OpenDataNI, 2023a)	Licensed under the Open Government Licence v.3.0.			✓	
OS Open Built Up Areas (E|S|W|•)	(Ordnance Survey, 2024b)	© Ordnance Survey Limited 2023. All rights reserved.	✓			
OS Open Greenspace (E|S|W|•)	(Ordnance Survey, 2024c)	© Ordnance Survey Limited 2023. All rights reserved.				✓
OS OpenMap – Local (E|S|W|•)	(Ordnance Survey, 2023a)	© Ordnance Survey Limited 2023. All rights reserved.	✓	✓		✓
OS Open Rivers (E|S|W|•)	(Ordnance Survey, 2023b)	© Ordnance Survey Limited 2023. All rights reserved.	✓	✓		
OS Open Roads (•|S|W|•)	(Ordnance Survey, 2022a)	© Ordnance Survey Limited 2023. All rights reserved.			✓	
OS VectorMap District (•|S|W|•)	(Ordnance Survey, 2022b)	© Ordnance Survey Limited 2023. All rights reserved.			✓	
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Predictive Agricultural Land Classification (ALC) Map 2 (•|•|W|•)	(Welsh Government, 2017)	© Welsh Government 2019; this product is licenced under the Open Government Licence 3.0.	✓	✓		

Dataset (including country[21])	Reference	Copyright statement	Wetland theme			
			Water quality	Flood resilience	Carbon storage	Urban wellbeing
Potential habitat creation sites within the current floodplain (E|•|•|•)	(MMO, 2019)	© Marine Management Organisation (MMO) copyright and/or database right 2020. All rights reserved.			✓	
Priority Habitats Inventory (England) (E|•|•|•)	(Natural England, 2023e)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2023.	✓	✓		
Priority River Habitat – Rivers (E|•|•|•)	(Natural England, 2023c)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2023.	✓	✓		
Protected Area Register (•|•|W|•)	(Natural Resources Wales, 2015b)	© NRW, 2015.	✓			
Provisional Agricultural Land Classification (ALC) (England) (E|•|•|•)	(Defra, 1988)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2023.	✓	✓		
Risk of Flooding from Rivers and Sea (E|•|•|•)	(Environment Agency, 2023d)	© Environment Agency copyright and/or database right 2018. All rights reserved. Some features of this map are based on digital spatial data from the Centre for Ecology & Hydrology, © NERC (CEH) © Crown copyright and database rights 2018 Ordnance Survey 100024198.		✓		
Risk of Flooding from Surface Water (E|•|•|•)	(Environment Agency, 2023e)	© Environment Agency copyright and/or database right 2015. All rights reserved. Some features of this information are based on digital spatial data licensed from the Centre for Ecology & Hydrology © NERC (CEH). Defra, Met Office and DARD Rivers Agency © Crown copyright. © Cranfield University. © James Hutton Institute. Contains OS data © Crown copyright and database right 2015. Land & Property Services © Crown copyright and database right.		✓		
River Classifications	(SEPA, 2023d)	Licensed under the Open Government Licence v.3.0. © SEPA, 2023.	✓			

Dataset (including country[21])	Reference	Copyright statement	Wetland theme			
			Water quality	Flood resilience	Carbon storage	Urban wellbeing
River Flood Maps (•|S|•|•)	(SEPA, 2023e)	© SEPA 2022; this SEPA product is licenced under the Open Government Licence 3.0. ©Aberdeen Harbour Board (2014). Aberdeenshire Council, Aberdeen City Council, James Hutton Institute, Scottish Environment Protection Agency (2016). IR Aerial Photography ©GeoPerspectives. • Digital Terrain/Surface Model- ©GeoPerspectives. • Lidar Digital Terrain Models and Digital Surface Models- ©Infoterra Ltd. Some features of this map are based on digital spatial data licensed from the UK Centre for Ecology & Hydrology © UKCEH. Defra, Met Office and Department for Infrastructure © Crown copyright © Cranfield University. © James Hutton Institute. Ordnance Survey data © Crown copyright and database right 2022. Environment Agency copyright and/or database right 2016. All rights reserved. This study uses data from Environment Agency provided by the British Oceanographic Data Centre and funded by UKCFF. Contains Scottish Forestry information licensed under the Open Government Licence v3.0. © Cities Revealed Lidar copyright, the Geoinformation Group. © Bluesky International LTD and Getmapping Plc 2022. Nextmap © Intermap. Data from the UK National River Flow Archive. © Crown copyright and database rights 2020 OS PSGA Member Licence. Crown Copyright Scottish Government, SEPA and Scottish Water (2012). Crown Copyright Scottish Government and SEPA (2014). This information is published under an OGL licence. Some data is derived from information provided by Transport Scotland under an OGL. Tidal data provided by the UKHO has been used under licence. ©Crown Copyright 2021, UKHO and the Keeper of Public Records.		✓	✓	
Saltmarsh Extents (•|•|W|•)	(Natural Resources Wales, 2017a)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved.	✓	✓	✓	
Saltmarsh Extents And Zonation (EA) (E|•|•|•)	(Defra, 2023f)	© Environment Agency copyright and/or database right 2015. All rights reserved.	✓	✓	✓	
Saltmarsh Survey of Scotland (•|S|•|•)	(NatureScot, 2016a)	Contains NatureScot information licensed under the Open Government Licence v3.0.	✓	✓	✓	

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Dataset (including country[21])	Reference	Copyright statement	Wetland theme			
			Water quality	Flood resilience	Carbon storage	Urban wellbeing
Scottish Index of Multiple Deprivation 2020 (•|S|•|•)	(Scottish Government, 2020b)	© Scottish Government.				✓
Scotland Habitat and Land cover map – 2020 (•|S|•|•)	(NatureScot, 2020a)	Maps and data created by Space Intelligence with input and support from NatureScot, © SNH.	✓	✓		
Settlement Development Limits (2015) (•|•|•|NI)	(NISRA, 2015)	© NISRA. Licensed under the Open Government Licence v3.0.			✓	
Settlements – Scotland (•|S|•|•)	(Scottish Government, 2023c)	© National Records of Scotland, Scottish Government.			✓	✓
Shoreline Management Plan Policies (•|•|W|•)	(Natural Resources Wales, 2023e)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved.			✓	
Site of Special Scientific Interest (Scotland) (•|S|•|•)	(Scottish Government, 2024a)	Contains SNH information licensed under the Open Government Licence v3.0.			✓	
Sites of Special Scientific Interest (England) (E|•|•|•)	(Natural England, 2024a)	© Natural England copyright. Contains Ordnance Survey data © Crown copyright and database right 2024.			✓	
Sites of Special Scientific Interest (SSSI) (•|•|W|•)	(Natural Resources Wales, 2024a)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right.			✓	
Small Area Mental Health Index (E|•|•|•)	(Daras & Barr, 2021)	Daras K, Barr B (2021), Small Area Mental Health Index (SAMHI) version 4.00 [Open Dataset], Place-based Logitudinal Data Resource, DOI: 10.17638/datacat.liverpool.ac.uk/1188				✓
Social Flood Risk Index (E|S|W|•)	(Sayers, Horritt, Penning Rowsell, & Fieth, 2017)	Contains derived data from the Office for National Statistics licensed under the Open Government Licence. © Crown copyright and database right 2012. Sayers, P.B., Horritt, M., Penning Rowsell, E., and Fieth, J. (2017). Present and future flood vulnerability, risk and disadvantage: A UK scale assessment. A report for the Joseph Rowntree Foundation published by Sayers and Partners LLP.		✓		✓
Statutory Main River Map (E|•|•|•)	(Environment Agency, 2023f)	© Environment Agency copyright and/or database right. Contains OS data © Crown copyright and database right (2023).		✓		

Dataset (including country[21])	Reference	Copyright statement	Wetland theme			
			Water quality	Flood resilience	Carbon storage	Urban wellbeing
Subnational household projections (local authority): 2018 to 2043 (•|•|•|NI)	(National Records of Scotland, 2018)	© National Records of Scotland, 2018. Licensed under the Open Government Licence v.3.0.	✓			
Surface Drinking Water Protected Areas (•|•|•|NI)	(DAERA, 2023)	© DAERA, 2023. Licensed under the Open Government Licence v3.0.	✓			
Surface Water Bodies Status 2015 (•|•|•|NI)	(DAERA, 2022b)	© DAERA NIEA, contains OSNI information licensed under OGL v3.0	✓			
Surface Water Flood Maps (•|S|•|•)	(SEPA, 2023f)	© SEPA 2022; this SEPA product is licenced under the Open Government Licence 3.0. IR Aerial Photography- ©GeoPerspectives. • Digital Terrain/Surface Model- ©GeoPerspectives. • Lidar Digital Terrain Models and Digital Surface Models- ©Infoterra Ltd. Some features of this map are based on digital spatial data licenced from the UK Centre for Ecology and Hydrology ©UKCEH. Based upon LCM2007 ©UKCEH 2011. Contains Ordnance Survey data ©Crown Copyright 2007. © third party licensors. Contains OS data ©Crown copyright and database right 2022. ©Crown copyright Defra March 2006. Environment Agency copyright and/or database right 2016. All rights reserved. © Cities Revealed Lidar copyright, the Geoinformation Group. Nextmap © Intermap. © Crown copyright and database rights 2020 OS PSGA Member Licence. Crown Copyright Scottish Government, SEPA and Scottish Water (2012).		✓		
Traditional Orchards (•|•|W|•)	(Natural Resources Wales, 2016a)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved.	✓	✓		
UK Lakes - Lakes Portal (UKCEH) (E|S|W|NI)	(Hughes, et al., 2004)	© Taylor, P.J. (2021). © UKCEH.	✓	✓		
UK Managed Realignment and Regulated Tidal Exchange Schemes (ABPmer) (•|S|W|NI)	(ABPmer, 2019)	© APBmer. Permission to use dataset granted by ABPmer.		✓	✓	✓
UK Pollutant Release and Transfer Register (PRTR) datasets (E|S|W|NI)	(Defra, 2012b)	© DEFRA, 2012. Licensed under the Open Government Licence v.3.0.	✓			
UKCEH Land Cover Maps (E|S|W|NI)	(Marston, Rowland, O'Neil, & Morton, 2021)	© Marston, C. *et al.* (2021). © UKCEH.	✓			

Dataset (including country[21])	Reference	Copyright statement	Wetland theme			
			Water quality	Flood resilience	Carbon storage	Urban wellbeing
UK Roads (OpenStreetMap Export) (E|S|W|NI)	(OpenStreetMap contributers, 2020)	© OpenStreetMap.				✓
Unified peat map for Wales (•|•|W|•)	(Evans, et al., 2020)	© Evans, C.D. *et al.* (2021). © UKCEH.		✓		
Wales Coast Path (•|•|W|•)	(Natural Resources Wales, 2024d)	© Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number AC0000849444. Crown Copyright and Database Right.				✓
Water Framework Directive (WFD) Coastal Waterbodies Cycle 2 (•|•|W|•)	(Natural Resources Wales, 2015a)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.	✓		✓	
Water Framework Directive (WFD) River Waterbodies Cycle 2 (•|•|W|•)	(Natural Resources Wales, 2023b)	Contains Natural Resources Wales information © Natural Resources Wales and Database Right. All rights Reserved. Contains Ordnance Survey Data. Ordnance Survey Licence number 100019741. Crown Copyright and Database Right.	✓	✓		
WFD RBMP2 Reason for Not Achieving Good Status (RNAGS) (E|•|•|•)	(Environment Agency, 2015)	© Environment Agency copyright and/or database right 2015. All rights reserved.	✓			
Welsh Index of Multiple Deprivation (•|•|W|•)	(Welsh Government, 2022)	© Statistics for Wales.				✓
Westminster Parliamentary Constituencies (E|S|W|NI)	(Office for National Statistics, 2024)	Contains both Ordnance Survey and ONS Intellectual Property Rights.	✓	✓	✓	✓
WFD River Water Body Catchments Cycle 2 Classification 2019 (E|•|•|•)	(Environment Agency, 2019a)	© Environment Agency copyright and/or database right 2015. All rights reserved.	✓	✓		
WFD River Water Bodies 2nd Cycle (•|•|•|NI)	(DAERA, 2021)	© DAERA NIEA, contains OSNI information licensed under OGL v3.0	✓	✓		
WFD Transitional and Coastal Waterbody Classifications 2019 (E|•|•|•)	(Environment Agency, 2019b)	© Environment Agency copyright and/or database right 2015. All rights reserved.	✓		✓	

Dataset (including country[21])	Reference	Copyright statement	Wetland theme			
			Water quality	Flood resilience	Carbon storage	Urban wellbeing
World Imagery (Esri) (•|S|W|NI)	(Esri, Maxar, Earthstar Geographics, & GIS User Community, 2024)	Esri; Maxar; Earthstar Geographics and the GIS User Community			✓	

Appendix V. Combined monetised benefits and liabilities.

Table A10. Combined monetised benefits and liabilities estimated for 100,000 hectares of wetland creation split between the four wetland themes (assessed over 60 years in present value terms). Red figures in brackets represent negative values (costs). All figures are in £m.

			Constant baseline* (PV60 £m) 2024 prices		
Wetland 'theme'	**Benefit type**	**Valuation metric**	**Value to Businesses (£m)**	**Value to the rest of society (£m)**	**Total (£m)**
Asset values (monetised)					
Wetlands for carbon storage (saltmarsh creation)	Food provision	Total income from livestock	47	-	47
	Carbon sequestration	Value of CO2e sequestered by saltmarshes	-	2,152	2,152
	Carbon sequestration	Cost of CO2e emitted by livestock	-	(252)	(252)
	Flood risk management	Value of additional coastal wetland area for flood control	-	553	553
	Recreation	Welfare value uplift for created saltmarsh	-	235	235
	Water quality	Value of nitrogen and phosphorus removal	-	66	66
Urban wetlands for wellbeing	Carbon sequestration	Value of CO2e sequestered by wetlands	-	632	632
	Recreation	Welfare value for created wetland	-	2,808	2,808
	Mental health	Avoided medical treatment costs of MHC cases	-	37	37
	Mental health	Avoided productivity loss costs of MHC cases	32	-	32
	Physical health	Avoided medical treatment costs	-	1,117	1,117
	Urban cooling	Costs avoided from temperature regulation	1,074	-	1,074
Wetlands for flood resilience	Food provision	Avoided loss of farming income	2	-	2
	Food provision	Opportunity cost of agricultural land changed to NFM wetlands	(248)	-	(248)
	Food provision	Value of livestock conservation grazing	14	-	14
	Carbon sequestration	Total CO2e sequestered by flood management wetlands	-	617	617
	Air quality regulation	Value of PM2.5 removal by woodland	-	113	113
	Flood risk management	Avoided damage costs to buildings	99	37	136
	Recreation	Welfare value for created wetland	-	401	401
	Physical health	Avoided medical treatment costs	-	158	158

Wetland 'theme'	Benefit type	Valuation metric	Constant baseline* (PV60 £m) 2024 prices: Value to Businesses (£m)	Constant baseline* (PV60 £m) 2024 prices: Value to the rest of society (£m)	Constant baseline* (PV60 £m) 2024 prices: Total (£m)
Wetlands for water quality	Food provision	Opportunity cost of agricultural land changed to water quality wetlands	(400)	-	(400)
	Water quality	Value of improvement in WFD status of rivers	-	546	546
	Water quality	Avoided wastewater treatment costs	-	1,115	1,115
	Recreation	Welfare value for created wetland	-	59	59
Total gross asset value		**Mix of values**	**620**	**10,393**	**11,012**
Asset values (non-monetised)					
Other material unquantified benefits					
Wetlands for carbon storage (saltmarsh creation)	Fishing (commercial); Water supply; Education; Volunteering; Property value; Biodiversity; Mental health				
Urban wetlands	Water supply; Flood risk management; Water quality; Property value				
Natural flood management (NFM) wetlands	Water supply, mental health, tourism, volunteering, education, amenity, landscape, water quality, biodiversity				
Water quality (WQ) wetlands	Avoided carbon emissions from traditional wastewater treatment plants, avoided investment in traditional wastewater treatment capacity, habitat benefits				
Liabilities					
Wetlands for carbon storage (saltmarsh creation)		Creation and operational costs	(1,081)	-	(1,081)
Urban wetlands		Creation costs	(272)	-	(272)
		Operational costs	(74)	-	(74)
Natural flood management (NFM) wetlands		Creation costs	(318)	-	(318)
		Operational costs	(74)	-	(74)
Water quality (WQ) wetlands		Creation costs	(287)	-	(287)
		Operational costs	(78)	-	(78)
Total gross asset maintenance costs			**(2,184)**	**-**	**(2,184)**

			Constant baseline* (PV60 £m) 2024 prices		
Wetland 'theme'	**Benefit type**	**Valuation metric**	**Value to Businesses (£m)**	**Value to the rest of society (£m)**	**Total (£m)**
Total net asset value (monetised)			**(1,564)**	**10,393**	**8,828**

* PV estimates for air quality regulation, carbon sequestration and agriculture have trend assumptions included as part of valuation process.

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