Report No. 494

epa Research

Peat Hub Ireland

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Lead organisation: University College Dublin

www.epa.ie

Rialtas na hÉireann
Government of Ireland

Environmental Protection Agency

The EPA is responsible for protecting and improving the environment as a valuable asset for the people of Ireland. We are committed to protecting people and the environment from the harmful effects of radiation and pollution.

The work of the EPA can be divided into three main areas:

Regulation: Implementing regulation and environmental compliance systems to deliver good environmental outcomes and target those who don't comply.

Knowledge: Providing high quality, targeted and timely environmental data, information and assessment to inform decision making.

Advocacy: Working with others to advocate for a clean, productive and well protected environment and for sustainable environmental practices.

Our Responsibilities Include:

Licensing

- Large-scale industrial, waste and petrol storage activities;
- Urban waste water discharges;
- The contained use and controlled release of Genetically Modified Organisms;
- Sources of ionising radiation;
- Greenhouse gas emissions from industry and aviation through the EU Emissions Trading Scheme.

National Environmental Enforcement

- Audit and inspection of EPA licensed facilities;
- Drive the implementation of best practice in regulated activities and facilities;
- Oversee local authority responsibilities for environmental protection;
- Regulate the quality of public drinking water and enforce urban waste water discharge authorisations;
- Assess and report on public and private drinking water quality;
- Coordinate a network of public service organisations to support action against environmental crime;
- Prosecute those who flout environmental law and damage the environment.

Waste Management and Chemicals in the Environment

- Implement and enforce waste regulations including national enforcement issues;
- Prepare and publish national waste statistics and the National Hazardous Waste Management Plan;
- Develop and implement the National Waste Prevention Programme;
- Implement and report on legislation on the control of chemicals in the environment.

Water Management

- Engage with national and regional governance and operational structures to implement the Water Framework Directive;
- Monitor, assess and report on the quality of rivers, lakes, transitional and coastal waters, bathing waters and groundwaters, and measurement of water levels and river flows.

Climate Science & Climate Change

- Publish Ireland's greenhouse gas emission inventories and projections;
- Provide the Secretariat to the Climate Change Advisory Council and support to the National Dialogue on Climate Action;
- Support National, EU and UN Climate Science and Policy development activities.

Environmental Monitoring & Assessment

- Design and implement national environmental monitoring systems: technology, data management, analysis and forecasting;
- Produce the State of Ireland's Environment and Indicator Reports;
- Monitor air quality and implement the EU Clean Air for Europe Directive, the Convention on Long Range Transboundary Air Pollution, and the National Emissions Ceiling Directive;
- Oversee the implementation of the Environmental Noise Directive;
- Assess the impact of proposed plans and programmes on the Irish environment.

Environmental Research and Development

- Coordinate and fund national environmental research activity to identify pressures, inform policy and provide solutions;
- Collaborate with national and EU environmental research activity.

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- Monitoring radiation levels and assess public exposure to ionising radiation and electromagnetic fields;
- Assist in developing national plans for emergencies arising from nuclear accidents;
- Monitor developments abroad relating to nuclear installations and radiological safety;
- Provide, or oversee the provision of, specialist radiation protection services.

Guidance, Awareness Raising, and Accessible Information

- Provide independent evidence-based reporting, advice and guidance to Government, industry and the public on environmental and radiological protection topics;
- Promote the link between health and wellbeing, the economy and a clean environment;
- Promote environmental awareness including supporting behaviours for resource efficiency and climate transition;
- Promote radon testing in homes and workplaces and encourage remediation where necessary.

Partnership and Networking

- Work with international and national agencies, regional and local authorities, non-governmental organisations, representative bodies and government departments to deliver environmental and radiological protection, research coordination and science-based decision making.

Management and Structure of the EPA

The EPA is managed by a full time Board, consisting of a Director General and five Directors. The work is carried out across five Offices:

1. Office of Environmental Sustainability
2. Office of Environmental Enforcement
3. Office of Evidence and Assessment
4. Office of Radiation Protection and Environmental Monitoring
5. Office of Communications and Corporate Services

The EPA is assisted by advisory committees who meet regularly to discuss issues of concern and provide advice to the Board.

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What did this research aim to address?

Healthy peatlands provide a range of benefits for human health and well-being, including improved air and water quality, water regulation, lower carbon emissions and access to natural and cultural heritage. Research and policy across Europe highlight the need for protection of undrained peatlands, rewetting of drained peatlands and restoration of degraded peatlands. This is essential to achieve global and EU goals on climate, soil, water and biodiversity. In Ireland and in other regions, peatland research has expanded rapidly in the last two decades, encompassing a diverse, multidisciplinary evidence base. In this context, it is important to synthesise existing knowledge, understand knowledge gaps and uncertainties, and provide a roadmap for the future sustainable management of Irish peatlands. The Peat Hub Ireland (PHI) project synthesised Irish peatland research from 2000 to 2023 to identify key trends, risks and knowledge gaps, providing researchers, policymakers and civil society with reliable evidence to guide future peatlands research, sustainable peatland management and informed decision-making for Irish peatlands, a critical national resource.

What did this research find?

The PHI project synthesised over two decades of peatland research to provide actionable insights for sustainable peatland management, identifying 71 research gaps and 96 priority actions across biodiversity, climate, policy and other key themes. The project incorporated expert and stakeholder knowledge with peer-reviewed and grey literature to represent the wide knowledge base needed for sustainable peatland management. The project's findings support evidence-based decision-making through four strategic recommendations, each serving as a foundational pillar to achieve sustainable peatland management: (1) accountability in the area of policy, regulations and governance; (2) long-term funding mechanisms for monitoring and financial schemes; (3) equity, especially in training and supporting community-led peatland management; and (4) holistic knowledge: a new paradigm for participatory and open research on peatlands. The project developed a peatland glossary, an open-source database and 10 factsheets that provide accessible summaries of each thematic area. A policy brief was also produced with a suite of recommendations to support policymakers in implementing the global and national policies required to drive sustainable peatland management.

How can the research findings be used?

The findings provide researchers, policymakers and civil society with accessible, reliable and up-to-date evidence for sustainable peatland management in Ireland. The evidence synthesis process, incorporating expert and stakeholder knowledge and evidence from multiple resources, produced several outputs for all stakeholders.

For policymakers, the 96 actions identified, along with the recommendations, offer a policy roadmap – including enforcing regulations, securing long-term funding and fostering cross-sectoral collaboration – for meeting Ireland's climate and biodiversity targets through sustainable peatland management.

For researchers, the study identifies 71 critical research gaps (of which 50% are high priority) and advocates for open science, interdisciplinary collaboration, participatory methodologies and the use of emerging technologies to advance peatland science.

For communities/non-governmental organisations, the report provides an accessible and reliable knowledge base for those seeking to protect, manage or restore local peatlands, and tools for engagement and advocacy, ensuring that local voices shape peatland management.

Project code: 2022-NE-1129

EPA RESEARCH PROGRAMME 2021–2030

Peat Hub Ireland

(2022-NE-1129)

EPA Research Report

Prepared for the Environmental Protection Agency

by

University College Dublin

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ACKNOWLEDGEMENTS

This report is published as part of the EPA Research Programme 2021–2030. The EPA Research Programme is a Government of Ireland initiative funded by the Department of Climate, Energy and the Environment. It is administered by the Environmental Protection Agency, which has the statutory function of co-ordinating and promoting environmental research. This project is co-funded by the Environmental Protection Agency and the Department of Agriculture, Food and the Marine.

The authors would like to acknowledge the members of the project steering committee, namely Phillip Blackwell, Department of Agriculture, Food and the Marine (DAFM); Örjan Berglund, Swedish University of Agricultural Sciences; Niamh Gibbons, Department of Climate, Energy and the Environment (DCEE); Laura Broomfield, DCEE; Mícheál Callaghan, DCEE; Tadhg O'Mahony, Environmental Protection Agency (EPA); Anthony Mannix, EPA; Sinéad Barrett, EPA; Ian Brunswick, EPA; Caroline Wynne, EPA; and Siobhán Murphy (Research Project Manager on behalf of the EPA).

Special thanks go to Dr Matt Finch for his guidance on scenario planning and for expertly facilitating the Peat Hub Ireland scenarios workshop. Thanks also go to Dr Elizabeth Bruton and Elena Aitova for supporting the team to deliver the online scenarios workshop and Eugene Dunbar (Everything Tyrrellspass Has On Show (ETHOS)) for a guided walk around Cloncrow Bog.

We also wish to acknowledge the input of the researchers who reviewed the Peat Hub Ireland factsheets and provided feedback and photographs.

We are also grateful to the peatland researchers and stakeholders who responded to our surveys and whose input greatly enriched the research.

DISCLAIMER

This report is based on research carried out/data from 1 April 2023 to 30 June 2024. More recent data may have become available since the research was completed.

The EPA Research Programme addresses the need for research in Ireland to inform policymakers and other stakeholders on a range of questions in relation to environmental protection. These reports are intended as contributions to the necessary debate on the protection of the environment.

EPA RESEARCH PROGRAMME 2021–2030
Published by the Environmental Protection Agency, Ireland

ISBN: 978-1-80009-308-9 October 2025

Price: Free Online version

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Executive Summary

Peatland research has expanded rapidly in the last two decades, encompassing a diverse, multidisciplinary evidence base, as countries seek to manage this resource sustainably in conjunction with meeting climate and biodiversity targets. There has been growing global interest in the role of peatlands in carbon and water cycles, leading to more interdisciplinary research that applies ecosystem services and other integrative frameworks to generate new knowledge and provide guidance for societal action. These trends have been replicated in Ireland, with increasing research in peatland science, more applied work on degraded ecosystems through European and national funding, and a growing interest from civil society, landowners and communities in the stewardship of Ireland's peatland resource. In this context, it is important to synthesise existing knowledge, understand knowledge gaps and uncertainties, and provide a roadmap for the future.

The Peat Hub Ireland (PHI) project has assessed research carried out on Irish peatlands since 2000, building evidence from peer-reviewed literature, specialist expertise and stakeholder knowledge to identify trends, risks, opportunities and knowledge gaps in peatland research in Ireland. Drawing on insights from sustainability science and other integrative frameworks, the results of this work are presented under a range of themes to provide research-based knowledge for sustainable action and to support integrated decision-making across sectors. This provides researchers, civil society and policymakers with accessible, reliable and up-to-date evidence for sustainable management and planning around this major national resource.

Chapter 1 introduces the current context and need for sustainable peatland management (SPM) in Ireland, as well as outlining the aims and objectives of the PHI project. Chapter 2 presents an overview of the approach to evidence synthesis, detailing the methods employed to incorporate expert and stakeholder knowledge and evidence from multiple sources, including through the creation of a living glossary and an accessible database of literature (2000–2023). Chapter 3 summarises the project findings, providing evidence-based synopses of the knowledge and outlining the main recommendations under each of the 10 review themes: biodiversity, soil, climate change, water, archaeology and the palaeo-environment, technology and mapping, society and culture, management, growing media/substrate, and policy and law. In total, 71 research gaps (50% of which are considered to be of high priority) were identified and 96 key actions (60% of which are considered to be of high priority) have been provided for policymakers, researchers and civil society. Factsheets have been created that summarise the state of knowledge of peatland research. Chapter 4 provides a series of broad and cross-cutting recommendations of relevance to all disciplines and sectors, along with proposals to build on the foundation of the PHI project in the future, to ensure that all who have a stake in Irish peatlands can access reliable knowledge and evidence to inform action. The various outputs from the project provide key insights that fall into one of four strategic recommendations, each serving as a foundational pillar to achieve SPM in Ireland:

1. Accountability: SPM requires policy compliance, regulation enforcement, policy coherence (peatland mainstreaming) and collaborative governance.
2. Longevity: mechanisms for the long-term funding of SPM activities and their long-term monitoring are critical and should include financial frameworks, subsidies (promotion of positive and removal of negative), private finance and community engagement support.
3. Equity: to foster SPM, there is a need for education, knowledge exchange and capacity building, with a need for institutions that promote inclusive participation (engaged research), empower communities to drive change and hold authorities to account for environmental stewardship.
4. Holistic knowledge: to ensure wider societal, environmental and policy impacts, a new paradigm for peatland research in Ireland is proposed that includes three visions: (i) empowering

stakeholders via participatory methodologies, engaged research and knowledge co-production; (ii) integrating the principles of “open science” and mechanisms for sharing data and knowledge, which will also enable inter- and transdisciplinary collaboration, as well as intergenerational learning; and (iii) future-proofing science through training researchers in artificial intelligence/big data/ remote-sensing tools, while tackling the ecological footprints of these technologies and encouraging open data governance.

Altogether, the re-imagination of peatland management will involve taking into account a diversity of values and perspectives to manage trade-offs, create synergies and develop multifunctional landscapes that will safeguard the ecosystem services and communal benefits that peatlands provide for current and future generations.

1 Introduction

1.1 Context

Globally, Ireland has experienced the highest rate of wetland loss (primarily peatlands) since the 1700s (Fluet-Chouinard *et al*., 2023). Reversing centuries of unsustainable peatland management will demand significant efforts from all stakeholders. Sustainability is a well-established goal in global and national governance and a key concept in peatland management, given the need to sustain the diverse range of ecological, social and economic values associated with peatlands (Renou-Wilson *et al*., 2011). As with any concept or framework, sustainable peatland management (SPM) has different meanings in different disciplines, sectors and stakeholder groups, as its focus has changed over time. We now know that peatlands are a finite resource that provide many functions and benefits for society other than economic services, such as burning peat for fuel or as a raw material for horticultural products. Although the concept of "sustainability" is sometimes considered vague and problematic, the idea of meeting human needs while preserving the life-support system of our planet continues to be a pressing concern. Yet, improving sustainability across all the ecosystem services provided by peatlands in Ireland has presented a significant challenge to date.

Peatlands were at the heart of the first "sustainable development" project funded by the EPA in 2006, which culminated in the BOGLAND report (Renou-Wilson *et al*., 2011), the result of a country-wide peatland assessment that delivered 58 recommendations and formed the backbone of Ireland's 2015 National Peatlands Strategy (National Parks and Wildlife Service, 2015). The BOGLAND protocol for the sustainable management of peatlands was one of the first in Ireland to recognise the importance of the relationships between people and peatlands, and it sought to understand the different types of values related to peatlands across social, ecological, cultural, economic and institutional dimensions.

SPM involves a societal responsibility to optimise the social, cultural, environmental and economic contributions that peatlands make to the health and well-being of current and future generations. At the heart of sustainability challenges lies the problem of managing ecosystems, such as peatlands, under conditions of uncertainty, and integrating the plurality of stakeholders, perspectives and values involved in sustainable management. When contemplating the future governance and sustainable management of peatlands, the wide range of actors, organisations and institutions that have a role to play in shaping those futures should be considered. They all have their own identity and culture, which are inherited from the past, and may clash or diverge from optimal strategies or policies, which are oriented towards the future. In times of unprecedented change and uncertainty, we must consider "not just what our institutions will do but what they may need to become" (Finch *et al*., 2024).

SPM may have different meanings and areas of emphasis in different research disciplines (ecology, hydrology, archaeology, social science, arts) and sectors (agriculture, forestry, industry). However, a commonality across these domains is the recognition of peatlands as valuable ecosystems in their own right, as well as their crucial role in supporting human health and well-being when they are restored and rewetted or rehabilitated. Conversely, research has shown the negative impacts that *degraded peatlands* have on water quality, air quality, flora and fauna, flood risk and climate (through greenhouse gas (GHG) emissions), and on cultural heritage and the communities that live and work in these landscapes (Pschenyckyj *et al*., 2021).

1.2 The Peat Hub Ireland Project

Since the start of the 21st century, there has been growing global interest in the role of peatlands in carbon and water cycles, with more interdisciplinary research applying the ecosystem services framework. This has been guided by the recognition that peatlands form important natural capital, and by the growing recognition that peatland degradation will lead to significant negative impacts on global climate change and human health. The same trends have also been experienced in Ireland, with increasing research in peatland science, applied work on

degraded ecosystems via European and national funding (EU LIFE projects), and also participatory public projects with peatland community groups. In the past 20 years, research on peatlands and their sustainable management has proliferated; however, simply creating and producing more knowledge does not always translate into better practice (Reed *et al*., 2014).

The amount of research that is currently produced makes it increasingly difficult for practitioners and researchers to stay updated on past and current findings within and across disciplines. Consequently, research agendas often do not build on or progress from previous work, leading to a disconnect from the broader body of evidence (Gusenbauer and Haddaway, 2020). As the volume of primary research literature increases, there is a greater need for systematic evidence syntheses and public datasets to inform policymaking and decision-making around peatland resources in Ireland. Both Irish and international research on peatlands is growing at a rapid rate, encompassing a diverse and often complex evidence base, as countries seek to manage this resource sustainably and meet climate and biodiversity targets. Therefore, it is an opportune time to provide a holistic synthesis of research on peatlands in Ireland, using evidence-based approaches to assess the research carried out since the year 2000, and to explore current and future challenges for progress on the path to sustainability (Flood *et al*., 2025).

1.2.1 Research aims and objectives

The main aim of the Peat Hub Ireland (PHI) project was to collate evidence to encourage researchers, civil society and policymakers to move towards an evidence-based position with regard to future sustainable management and to ensure better planning around this major national resource. To achieve this aim, the key objectives of the project were to:

- compile a “living” glossary of terms associated with peatlands for Irish stakeholders;
- develop a rigorous methodology (stakeholder analysis, survey and evidence synthesis) to source, compile and validate all available information;
- deliver an accessible database of evidence for researchers and stakeholders to inform policy development and support the implementation of national and EU policies and strategies;
- analyse and synthesise the data, identifying linkages and gaps, while complementing expert knowledge from emerging international research;
- make recommendations to support sustainable peatland actions in a “whole-of-society” approach, across government, academic institutions and sectors;
- generate accessible factsheets on identified research themes, to present key facts and issues, research gaps and policy recommendations.

2 Overview of the Research

2.1 Approach to Evidence Synthesis

This section summarises the evidence synthesis protocol established in this project to identify, review and critically appraise evidence from 20 years of Irish peatlands research. Systematic evidence synthesis is a general term that covers a broad spectrum of approaches and methods that can be used to synthesise and combine evidence from multiple sources more systematically than other approaches. The heterogeneous nature of current research on Irish peatlands, with the involvement of multiple disciplines, sectors and methodologies, necessitates a broader approach than that used in traditional systematic reviews, which aim to answer specific focused questions. Such reviews have also been criticised for being biased towards quantitative data and for their positivist approach to knowledge synthesis (Berrang-Ford *et al*., 2015). This study embraces a broader knowledge synthesis framework, one that incorporates expert and stakeholder knowledge with peer-reviewed and grey literature[1] to represent the wide knowledge base involved in peatland management in Ireland (Figure 2.1).

2.2 Methods

2.2.1 Stakeholder analysis

A comprehensive stakeholder analysis was carried out to identify and prioritise the network of peatland researchers and stakeholders who needed to be engaged throughout the project (Langer *et al*., 2017). This stakeholder analysis informed all phases of the project, with stakeholders involved in piloting survey instruments, contributing knowledge and literature via the surveys, and providing input to specific research themes and attending the end-of-project workshop.

2.2.2 Peatland glossary: building consensus around peatland terminology

Terminology related to peatlands is an ongoing area of scientific discussion, and so an initial clarification of terminology was necessary to ensure that all stakeholders could access up-to-date information and definitions. A list of critical terms and concepts was drawn up by the project team, drawing on national, European and international research and policy documents (IPCC, 2023; National Parks and Wildlife Service, 2015; Renou-Wilson *et al*., 2011).

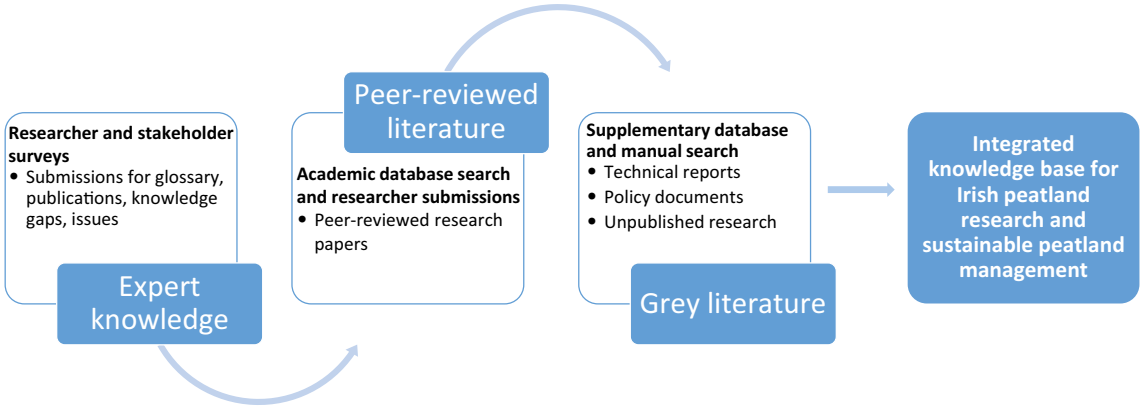

Figure 2.1. Knowledge base for evidence synthesis.

1 The term "grey literature" is used to describe a wide range of information that is produced outside traditional publishing and distribution channels and that is often not well represented in indexing databases.

Definitions were also collated from submissions to the survey by Irish peatland researchers (see section 2.2.3). The glossary currently comprises over 125 terms from over 25 sources, listed alphabetically. The peatland glossary can be accessed on the PHI website,[2] where users can suggest terms or propose changes or updates to existing terms. It is also accessible on the PeatSense platform,[3] where users can search by term or by theme.

2.2.3 Surveys with peatland researchers and stakeholders

Two online survey questionnaires were conducted to elicit expert knowledge and stakeholder views on current knowledge gaps and issues in Irish peatland research. The first survey was targeted at researchers and the second survey at the broader network of stakeholders in Ireland who are involved with different aspects of peatlands and their management. A total of 98 researchers were identified through the project team's professional networks, including an Irish network of early-career peatland researchers. The survey questionnaire included 10 questions and collected a range of data, including on the disciplines represented, issues and knowledge gaps in each researcher's field of study and each researcher's understanding of SPM (Appendix 1). The survey also provided an opportunity for researchers to suggest key sources of peer-reviewed literature in their field and to identify terminology for the project's peatlands glossary. A total of 40 researchers responded to the survey (an approximately 41% response rate). Respondents represented a variety of disciplines, with contributions from the natural sciences dominating.

The stakeholder survey, titled "Help Identify Knowledge Gaps in Irish Peatland Research", was conducted over a 10-week period from August to mid-October 2023. Distribution was broadly targeted at anyone with an interest in peatlands in Ireland, including government agencies, non-governmental organisations, the private sector and civil society. The survey questionnaire included 10 questions and collected a range of data relating to respondent demographics, perceived knowledge gaps, and barriers to and enablers of the uptake of research (Appendix 1). Respondents could also suggest terms to be included in the peatlands glossary. A total of 98 responses were received, representing a variety of sectors and peatland projects in Ireland.

2.2.4 Evidence synthesis search strategy

This research has generated an accessible evidence base to support SPM in Ireland through a comprehensive review of Irish peatland research, focusing on literature from 2000 to 2023. The review draws on three categories of data (peer-reviewed literature, grey literature and recommendations from researchers who are experts in their field), as outlined in Figure 2.1. The scope of the literature search encompassed key thematic areas related to soil, water quality, management, biodiversity, climate change, archaeology, the palaeo-environment, society and culture, policy and law, and technology. All study designs were considered, including qualitative and quantitative methods. No Irish-language research was included in this study. Studies were excluded if they did not provide information on SPM, if they were conducted before 2000 or if the research was not based in Ireland or related to Irish peatlands. Web of Science and Scopus were searched on 10 October 2023 using the keyword search string "(irish OR ireland) AND (peatland OR bog OR fen OR mire OR bogland)" (see full methodology in Appendix 2). Google Scholar and specific governmental websites were manually searched using the same search string and provided an important source of grey literature (policy documents, technical reports and unpublished academic studies). This countered publication bias, which can occur when journals do not publish studies that are not considered significant or authors do not submit papers that have negative results (Toronto and Remington, 2020). These searches were combined using the bibliometrix packages (Aria and Cuccurullo, 2017) in R (R Core Team, 2023). The evidence synthesis process included further screening of the articles according to several criteria: articles were excluded if they were not based on Irish research or based in Ireland (criterion 1) or if they were not relevant to Irish peatlands and their sustainable management (criterion 2). This led to the creation of a separate "history and literature" database that is

2 https://www.ucd.ie/peat-hub-ireland/researchonirishpeatlands/peatlandglossary/ (accessed 12 June 2025).

3 https://peatsense.org/glossary (accessed 12 June 2025).

not directly related to peatland management, but is of value to researchers in arts and humanities disciplines (criterion 3). Conference abstracts, inaccessible full papers and self-published web documents were removed (criterion 4), leaving 900 unique records (Figure 2.2).

Each entry was coded based on the themes identified for analysis and subtopics, which were created to identify specific areas of interest, for example peat slides, wildfire management and habitat types. Content analysis was also performed on the database to identify trends in publications by year and highlight the distribution of themes. The analytical framework for content analysis was operationalised by creating a review matrix in Excel for each theme to extract key information from the literature. The review matrix included the following categories: aims/purpose of research; key findings relating to the review question; key messages; policy recommendations; and research gaps. Not all papers included policy recommendations or research gaps. The review work was divided between the project team according to their areas of expertise. After screening the abstract and filling out aims and key messages, the papers were searched for keywords, including "sustainable", "policy", "gap", "further research" and "recommendations". Full screening of the text was performed on articles where the abstract and keyword searches did not provide sufficient information. After the review process, briefing notes and long-form factsheets were produced for each theme and subtopic, including ID numbers to track the source of the data. This process provided a systematic catalogue of evidence that enabled an integrative narrative synthesis of the findings to be conducted to identify patterns and trends across the research themes and provide discipline- and sector-specific recommendations. To ensure the accessibility and wide dissemination of the findings, factsheets for each theme were created to provide a plain-language

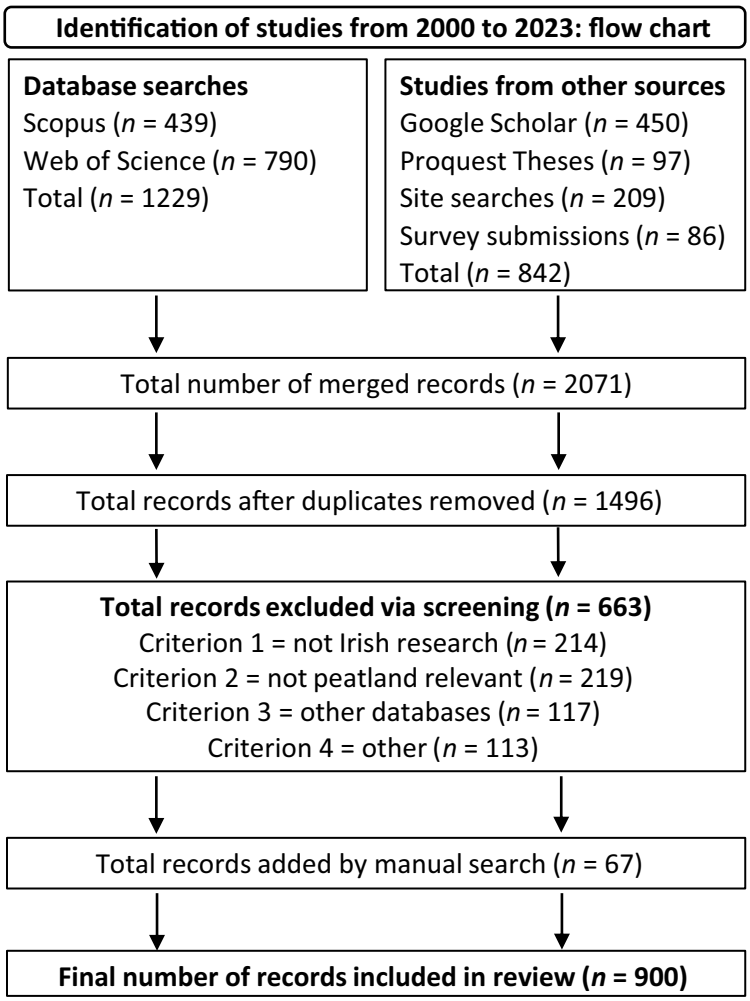

Figure 2.2. Flow chart indicating each phase in the evidence synthesis process.

summary and recommendations for a general audience. These are available on the project website.[4]

2.2.5 Peatland scenarios for 2050 workshop

The PHI team held a workshop to communicate the outcomes of the PHI project to and enable dialogue and networking among project members, research partners and stakeholders. The second part of the workshop used scenarios to better understand how future social, economic and environmental worlds will be served by the choices that are made for peatlands today. Scenarios can inform strategy and policy by helping us to re-perceive the current contexts in which we operate. Workshop participants explored peatland scenarios for 2050 with Dr Matt Finch, a strategy and foresight practitioner who works with communities and institutions around the world on scenario planning, strategy and policy. The scenarios explored were “peatlands for profit”, “politics of peatlands” and “peatlands for people and planet”. An overview of outcomes from the workshop, including the peatland scenario scripts, key takeaways and workshop feedback, is available in Appendix 3.

4 https://www.ucd.ie/peat-hub-ireland/researchonirishpeatlands/factsheets/ (accessed 12 June 2025).

3 Findings by Theme

The PHI database provides a searchable, updatable and comprehensive evidence base for sustainable management of peatlands in Ireland. The database contains a total of 900 records organised by theme and is available on the project website and to download on Zenodo,[5] an open-source data repository platform. Since 2000, there has been a steady but intermittent increase in peatland research (Figure 3.1). The distribution of research based on the themes identified provides a broad overview of where gaps in knowledge exist (Figure 3.2). Publications relating to biodiversity, management, the palaeo-environment, climate, water and soil were most prevalent, accounting for over 78% of database records, while research on the cultural, societal, policy and legal dimensions of peatland conservation and management was less well established (8.8% of records). Archaeology constituted a relatively minor proportion of the overall research, at just 6.2% of the studies reviewed, while research on new technology for and mapping of peatlands is in the early stages but growing rapidly (4.7%). Finally, research on growing media was the most limited (0.9% of records).

Each of the following sections present a synopsis of evidence for each theme identified in the project, followed by key actions (A1, A2, etc.) and research gaps (G1, G2, etc.). Each record in the database is given a unique ID number (referenced in brackets after the recommended actions and research gaps) to enable readers to refer back to the original source of evidence. Although outlined as separate themes, there are clear complementarities and interdependencies in the actions and research recommendations provided. Taken as a whole, these themes and the associated actions provide a comprehensive, focused research and action framework for the sustainable management of Ireland's peatlands.

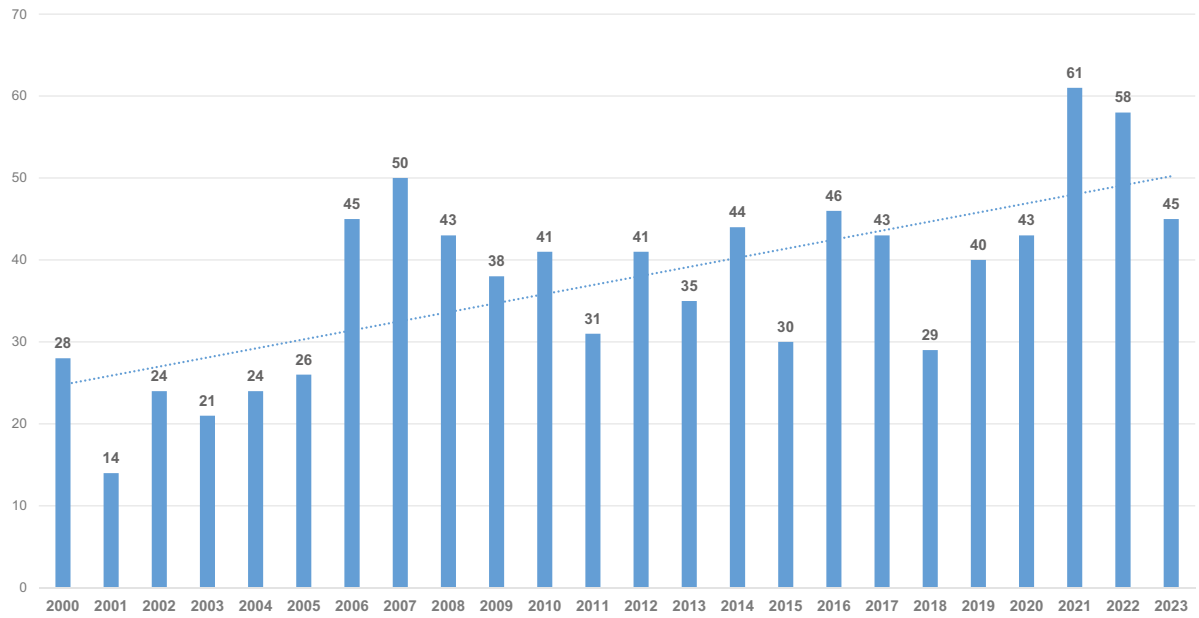

Figure 3.1. Number of publications by year of publication (ending October 2023).

5 https://zenodo.org/records/13908703 (accessed 12 June 2025).

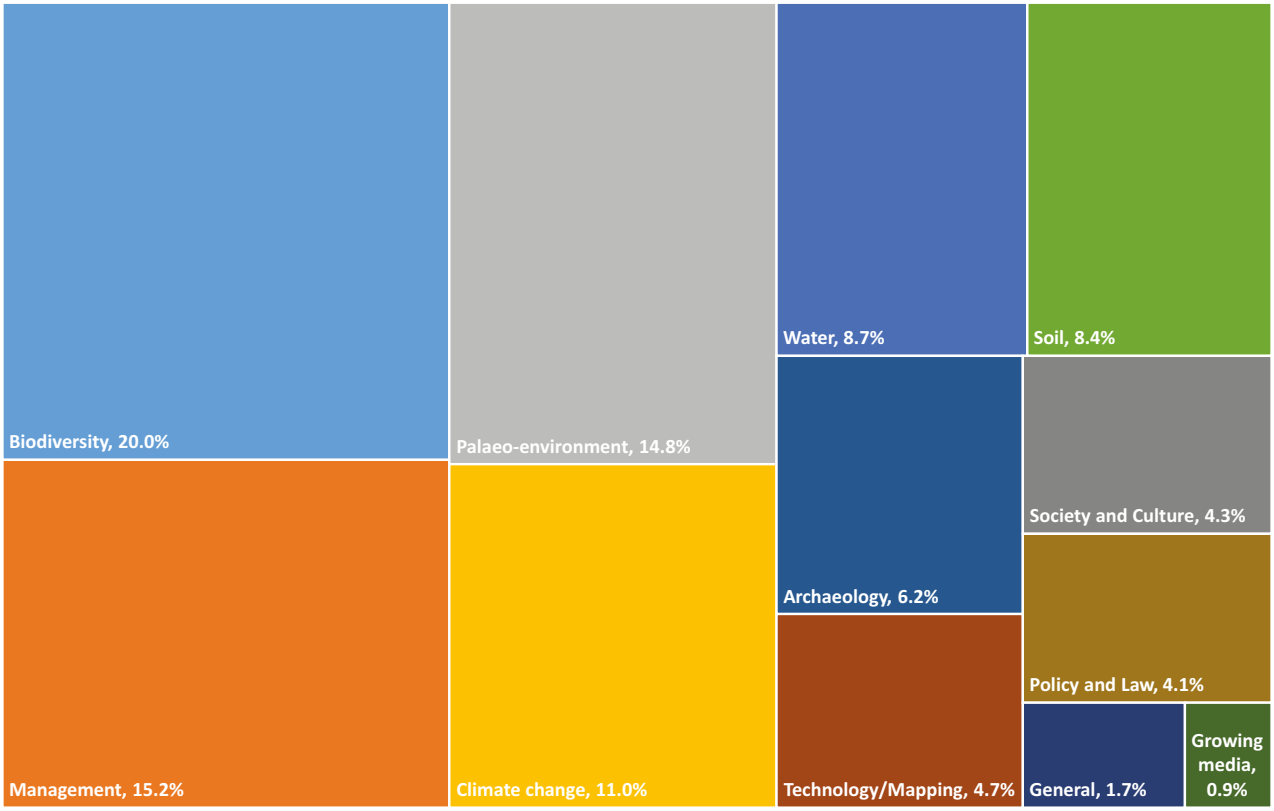

Figure 3.2. Distribution of database records by theme.

3.1 Biodiversity

3.1.1 Synopsis of evidence

Peatlands are exceptional natural entities and can form a variety of landscapes containing a range of ecosystems and unique biodiversity (i.e. the variety and variability of living species, including plants, animals, bacteria, fungi and genetic material). Peatland biodiversity is so rich that species have yet to be discovered (732), but many species are threatened by unsustainable human activities. Peatlands are refugia of rare and threatened species that are in sharp decline not only in Ireland but on a global scale. The ecosystem services provided by natural peatlands depend ultimately on living organisms. Biodiversity is directly responsible for the creation of the diversity of landscape, habitats and various peat types, and helps to underpin a sustainable rural community, as well as providing services for society. To reverse biodiversity loss, it is essential to manage the water table effectively and protect and restore peatlands. This is vital not only for the biodiversity that peatlands support or should support, but for peatlands' roles as habitat connectors and their significant contribution to global climatic and hydrological processes. Key actions and research gaps related to biodiversity are listed in Tables 3.1 and 3.2.

3.1.2 Actions

Table 3.1. Biodiversity – key actions and priority levels

Action	Priority level
A.1. A national protected blanket bog (SAC and SPA) management and restoration plan is overdue. Associated long-term monitoring of rewetting projects will go a long way towards achieving Ireland's biodiversity goals given the rare species present in these ecosystems (732).	High
A.2. A new national peatlands strategy remit should include an analysis of the incompatibility of measures to protect biodiversity in the face of more general policies and subsidies that are harmful to biodiversity (578).	High
A.3. The most damaging effects of peatland afforestation can be avoided by effective implementation of published guidelines to reduce the likelihood of afforesting habitats that have a high conservation value. Forest management should aim to avoid siting future plantations on peatlands under low-intensity management or on slightly modified peatland habitats that typically support bird communities of high conservation value (100, 511, 346).	High

Action	Priority level
A.4. Virtual fencing technology has the potential to be transformative for continued grazing in uplands that contain blanket bogs, but its implementation should be approached with thorough and detailed planning, and with a comprehensive understanding of the technology's weaknesses and limitations in relation to the specific use or site. In addition, training, mentorship and the establishment of national standards for its use are considered essential (1020).	High
A.5. Given that the expansion of new and existing wind farms on unprotected peatlands is likely to increase, mitigation of potential impacts on birds, such as through the creation of Habitat Enhancement Areas adjacent to wind farms, should be considered (550).	High
A.6. Conservation policy and practice must be revised in the face of climate change (39). It has already been ascertained that climate change will negatively affect raised bogs due to their limited adaptation capacity during summer drought (38), and water management at a few sites of high conservation importance should be addressed and planned now as a matter of urgency. Given that environmental change is expected to continue or even intensify, bog plant communities will change as species migrate to areas where environmental conditions are suitable. Studies have shown that this requires the conservation of the collection of bog species, and that investment in improving the connectivity of natural peatlands should have highest priority (743).	High
A.7. Wildfire management should be integrated into the conservation objectives of designated upland bog SACs and SPAs (717).	High
A.8. It is recommended that hydrological indicators be used to assess improvements in biodiversity in results-based payment schemes (672). Given that landscape-scale microforms are a strong ecological indicator of a peatland ecosystem's hydrological conditions and resilience, monitoring vegetation and microform dynamics with drones can be invaluable for assessing the progress of restoration and rewetting efforts (805).	Medium
A.9. In addressing the demise of emblematic birds (e.g. curlew), lessons should be learned from positive outcomes of innovative workshops seeking to formulate ideas and implement actions from stakeholders themselves within the current legislative framework (941).	Medium
A.10. Extending protection or Habitat Enhancement Areas outside the strict boundary of protected peatlands will help efforts to conserve threatened species, including rare bryophytes and moths (99, 303). The lagg zone (surrounding raised bogs) should also be a key element in bog restoration (179).	Medium
A.11. Rewetted cutover and cutaway bogs as well as the new ecosystems associated with them (created cutaway peatland lakes) are more vulnerable to future climate change and need monitoring (376, 377, 738).	Medium
A.12. The Critical Criteria Approach is a screening tool designed to prevent the development of new agricultural facilities that would lead to new sources of ammonia emissions, which could have a significant adverse impact on SACs/SPAs. However, this precautionary tool requires supplementation with more sophisticated modelling to ensure accurate and comprehensive impact assessments (1019).	Low
A.13. Landscape biodiversity is an important indicator to consider using for SPM; it is suggested that legal protection be attached to enigmatic mushroom stones, as these are valuable indicators of our past landscape (247).	Low

SAC, Special Area of Conservation; SPA, Special Protection Area.

3.1.3 Research gaps

Table 3.2. Biodiversity – research gaps and priority levels

Research gap	Priority level
G.1. The contribution of Irish peatlands to biodiversity is not yet fully understood and it is likely that many species of invertebrates, plants, mosses, fungi, algae and microbes remain unrecorded because very few studies have been carried out on peatlands in Ireland (732). Addressing this requires not only ongoing academic research but also the integration of the data collected through academic research with data collected through publicly funded environmental assessments and citizen science efforts across Ireland.	High
G.2. Either the impact of restoration and rewetting on a range of biodiversity indicators (birds, invertebrates, microbiota) has been wholly lacking or monitoring of the impact has been over too short a period to see change. Long-term monitoring (*c.*15 years) of newly restored/rewetted habitats with appropriate controls for comparison is necessary (844). For this purpose, further topographical and hydrological studies are needed to set site-specific favourable reference values (876) and to determine the overall effects of any rewetting or restoration plan on biodiversity (both aquatic and terrestrial) and especially on vulnerable or rare species (birds).	High
G.3. Research into multi-taxa bioindicator information in peatlands and peatland catchments would help to develop more useful ecological assessment and refine the calibration of assessment protocols (642). These should be scientifically monitored to support robust results-based payment schemes and other agri-environmental measures. Integration of all biodiversity elements (from landscape to microbiota) into all peatland land use projects is needed.	High

Research gap	Priority level
G.4. Virtual fencing research must be conducted to help restore and protect the biodiversity in the uplands and inform further the sustainable management of agricultural peatlands (1020).	High
G.5. Studies are needed on the maximum area of forestry that could be tolerated in peat soil-dominated catchments with depleted freshwater pearl mussel populations (467).	High
G.6. Further research into the eco-hydrological functioning of blanket bogs is required given their heterogeneous profile, to help develop appropriate restoration strategies. Inventories of fens, heaths and cutover and cutaway bogs need to be compiled so that valuable unprotected sites are designated for conservation or biodiversity (303, 876).	Medium
G.7. Capacity building is required to support peatlands, especially fen surveys, including bryophyte training, species nomenclature, recording of nutrient enrichment and the potential use of unmanned aerial vehicle surveys (1016).	Low

3.2 Soil

3.2.1 Synopsis of evidence

Peat consists of partly decomposed plant remains that have accumulated where they have been produced (*in situ*). More precisely, peat is defined as "sedentarily accumulated material consisting of at least 30% (dry mass) of dead organic material" (Rydin and Jeglum, 2006). Peat belongs to the larger family of "organic soils" or "histic soils" that includes a wider range of managed soils containing at least 20% organic matter. According to the Global Peatland Assessment Report (872), land with any thickness of *in situ* peat is a peatland (UNEP, 2022, p. 22). However, for mapping and statistical purposes (e.g. reporting to the United Nations Framework Convention on Climate Change (UNFCCC)), each country has its own definition based on a minimal peat depth. In Ireland, a group of experts from various institutions met during the BOGLAND project (732) and defined peat soils as "soil that contains peat over a depth of at least 30 cm; the depth requirement does not apply in the event that the peat layer is directly over bedrock" (Renou-Wilson *et al.*, 2011). For the purpose of reporting to the UNFCCC, the EPA uses the depth sensu *stricto*, and if the peat layer is less than 30 cm then the soil is classified as organo-mineral (or peaty-mineral) (EPA, 2024). Peat soils store an enormous amount of carbon because of the high organic matter content and depth of the peat. Most recent estimates put the total carbon store at 2216 Mt, with *c.*42% stored in raised bogs, *c.*42% in lowland blanket bogs and *c.*15% in mountain blanket bogs (733). Peat soils have a low level of available nutrients; most of the nitrogen is bound to the organic matter but peat soils remain a significant store of nitrogen, with total nitrogen stock in Irish peat soils estimated at 73 Mt (892). Peat soils are currently under threat from unsustainable practices in Ireland and all over Europe (421). Anthropogenic disturbances (land use change) (739) and also natural erosion of peatlands (268) significantly affect their functions and the ecosystem services that they provide. Key actions and research gaps related to soil are listed in Tables 3.3 and 3.4.

3.2.2 Actions

Table 3.3. Soil – key actions and priority levels

Action	Priority level
A.14. Field assessments are needed to identify the best combinations of soil type and management practices to determine the risks to the peatland carbon store. This requires standardisation of carbon store definitions (FAO, 2017), sampling and analysis, and data reporting is key for the expansion of such databases (733, 413).	High
A.15. Given the increased occurrences of peat slides and climate-related risks, an approved method of analysis of the risk of peat movements needs to be developed, deployed and used by industry and required within regulatory frameworks such as EIAs and WFD assessments (249, 258). This would require (i) an awareness of the correct terminology of these events and (ii) careful characterisation of both the peat (macro-fossil and fibre content) and underlying mineral soils and the prevailing groundwater and drainage conditions (57, 929, 521, 410).	High
A.16. Soil monitoring and shareable data collection must be supported by governmental initiatives to improve understanding of peat soil conditions and support GHG inventorying and SPM across Ireland (733, 83).	High
A.17. Unlike mineral soils, peat soils have little or no phosphorus sorption or storage capacities, and hence applied fertiliser phosphorus is highly mobile and there is a high risk of incidental losses, requiring awareness (from farmers) and strict regulations for its application (including in forestry) (256, 722, 203).	Medium

EIA, environmental impact assessment; WFD, Water Framework Directive.

3.2.3 Research gaps

Table 3.4. Soil – research gaps and priority levels

Research gap	Priority level
G.8. While the EU is moving towards a more robust and comprehensive soil policy framework, Ireland has not demonstrated sufficient leadership, given that it is a country with extensive peat soil coverage. There is a noticeable gap in research to support on-the-ground initiatives, climate change experiments and legislative efforts aimed at ensuring the sustainable management and restoration of peat soils, as set out in the EU Soil Strategy for 2030. This gap must be filled in view of the expected introduction of an EU soil health law, which will establish a comprehensive legal framework for soil protection and restoration.	High
G.9. Given their extent, further investigations of blanket bog peat soils to assess the combinations of soil type and management practices that risk soil carbon stock depletion are required (413, 733).	High
G.10. The impact of climate change on peat soil properties needs to be investigated in long-term experimental settings (e.g. SPRUCE or FACE experiments) (733).	High
G.11. Attention should be focused on reviewing the susceptibility to failure of natural blanket bogs outside the downslope edges of forest plantations (249), while also reviewing the potential influence of various peat properties (including botanical composition) (521).	High
G.12. Airborne soil-classified radiometric data can provide a framework for further ground-based studies of soil moisture (31). The degree to which areas covered by peat can be distinguished by radiometric data needs to be further explored with ground investigations (see section 3.6).	Medium
G.13. Additional studies on peat nitrogen cycling are needed to address the fate of the large peat nitrogen stocks under recent and projected warming. No suitable models have yet been found to estimate nitrogen content and stocks, so further research may be required to better understand nitrogen dynamics and storage in Irish peatlands (892).	Medium
G.14. A more realistic understanding of the mechanisms that govern carbon stability should incorporate three axes – climate, soil nutrient stoichiometry (ratios) and biology – and their complex interactions (68).	Low

FACE, free-air carbon dioxide enrichment; SPRUCE, spruce and peatland responses under changing environments.

3.3 Climate Change

3.3.1 Synopsis of evidence

Peatlands play a vital role in regulating the global climate by acting as long-term carbon sinks, with carbon accumulating when the amount of carbon dioxide (CO_2) fixed by the peatland vegetation during photosynthesis is greater than that released as a result of (i) respiration by the plants and the microbial communities, (ii) methane emissions and (iii) the leaching and surface run-off of fluvial carbon (dissolved organic carbon). Peatlands are likely to be severely affected by climate change, with effects including changes in decomposition rates, leading to a loss of the stored carbon; increased fire risk; and reduced peatland area. Crucially, the rising temperatures associated with climate change are thought to enhance peatland decomposition and dissolved organic carbon release to inland waters. Degraded peatlands are also expected to be more vulnerable to climatic changes, and, importantly, the longer that a rewetted peatland has been established for, the more resilient it will be to climate change. Key actions and research gaps related to climate change are listed in Tables 3.5 and 3.6.

3.3.2 Actions

Table 3.5. Climate change – key actions and priority levels

Action	Priority level
A.18. Recognition of the heterogeneity found across Irish peat soils, together with an understanding of the relationships between key soil properties, is critical to developing effective strategies for remedial management of these degraded ecosystems (733).	High
A.19. Peatland rewetting should be given high priority in countries where degraded and/or drained peatlands are a key land use category (917, 918). This is because climatic change may make restoration of the carbon sink function in degraded peatlands a considerable challenge in the years ahead (920, 738).	High
A.20. A site-by-site approach for future rewetting management schemes is required, as each peatland exhibits unique properties with far-reaching implications for GHG production, cycling of carbon and nutrients, local and regional hydrology and water quality, and biodiversity (733).	High
A.21. Peatland carbon stocks must remain in the ground and the development of carbon sinks in all types of land use must be promoted (733).	High
A.22. In light of Ireland's Climate Action Plan targets, it is imperative to establish a national-level coordinated approach to the future management of all Irish peatlands, encompassing all land use categories and ownership types. A coordinated approach is essential, to ensure that adequate extents of both natural and rewetted peatlands are effectively managed. Such management must maintain water table levels to preserve as many ecosystem services as possible, particularly in the context of future climate scenarios. Achieving this will require the sustained, long-term monitoring of rewetted peatland sites (738).	High

Action	Priority level
A.23. Nutrient-poor organic soils that are poorly drained should be targeted to ensure that they remain wet (water table depth higher than –25 cm) with a continued low-input/output system. Nutrient-rich organic soils should be targeted for rewetting as a strategy to mitigate GHG emissions (734).	High
A.24. Based on scientific evidence that the afforestation of blanket peats, with necessary installation of drains, is unsuitable as a strategy for fixing atmospheric carbon (425), forestry policy must be updated to prioritise the protection and rewetting/restoration of peat soils as an adaptive land use strategy.	High
A.25. Reducing the water table depth in all drained agricultural peatlands by 50% could reduce emissions by the equivalent of over 1% of global anthropogenic emissions (266).	High
A.26. To align with climate change mitigation objectives, the drainage of peatlands for any land use, including peat extraction, must cease immediately. Priority should be given to identifying and rewetting drained peatlands, particularly those managed for peat extraction, as they represent significant CO_2 emission hotspots and exacerbate climate change through positive feedback effects. This effort must be supported by the development of targeted land management programmes and a comprehensive review of existing incentives and schemes to ensure policy coherence and eliminate conflicts with GHG mitigation goals. Rewetting these areas should be a cornerstone of national climate action strategies, as it offers a critical pathway to reducing emissions and enhancing carbon sequestration (263, 737).	High
A.27. Nutrient-poor organic soils (under either peat extraction or grassland) have been identified as priority sites that can provide the greatest benefits in terms of both reducing GHG emissions relative to the drained state and having the potential to sequester carbon in the long term (737).	High
A.28. Land management that lowers the water table level in peat soils could significantly increase anthropogenic CO_2 emissions and should be avoided (2).	High
A.29. High-resolution maps of Irish peatlands under various management/land use and disturbance regimes, showing their current characteristics and rewetting/restoration potential, should be developed, to target priority sites for biodiversity and/or climate benefits (737). A database of all rewetted/restored peatlands and organic soils in the State should be established and include data on the location, the area rewetted and restored, and methods, and information on GHG trajectory and biodiversity (6).	High
A.30. More accurate areal and GHG flux data from cutover bogs (private turbary) are required (733).	Medium
A.31. There is a critical need to continue the monitoring of GHG fluxes and associated environmental variables (water table levels and vegetation), given the diversity of conditions encountered in Ireland (733).	Medium
A.32. The Irish government needs to urgently remedy the lack of repository geographical information on both public and private peatland rewetting projects (6).	Medium
A.33. Given both the national and international importance of climate change, it is critical to maintain the level of investment in infrastructure, analytical systems and associated measurements needed to ensure that Ireland is at the forefront of this critical area (527).	Medium
A.34. It is critical to develop strategies to reduce GHG emissions that are tailored to local grassland types (734).	Medium
A.35. A cross-government climate change vision for Ireland is needed to mainstream actions to progress medium- and long-term mitigation goals into sectoral and national development goals. This needs to be coupled with strategies for green enterprise and development, and linked to the key international processes for the development of global actions (624).	Medium
A.36. Restoring and preserving peatlands necessitates a broader perspective that extends beyond peatland-specific processes to include wider landscape-scale interactions and feedback. In addition, it is crucial to consider longer time frames, as peatland sites undergoing restoration may take up to 10 years or more to reach equilibrium and achieve a carbon sequestration potential comparable to near-natural bog sites (486). Multi-annual measurements of carbon balances from individual peatland sites are important for elucidating their current role in carbon sequestration, which is currently uncertain. Furthermore, the continuity of these measurements is essential if progress is to be made in modelling carbon balances for future climate change scenarios (462). This underscores the importance of long-term research to monitor and understand the dynamics of peatland recovery, ensuring that restoration efforts are effective and aligned with climate mitigation goals (486).	Medium

3.3.3 Research gaps

Table 3.6. Climate change – research gaps and priority levels

Research gap	Priority level
G.15. There is an urgent need for capacity building in remote sensing to upscale site results to regional and national scales (452).	High
G.16. Studies are needed on restored peatlands to identify the most effective restoration approaches for different ecosystem types, conditions, climates and land use histories (943).	Medium

Research gap	Priority level
G.17. Further studies are necessary to reduce the uncertainty associated with below-ground carbon allocation and interannual variation in afforested peatlands over several years. In addition, studies should be extended to include regional differences in forested blanket peatland, different peat (nutrient poor vs nutrient rich) and forest types, as well the soil carbon balance in second and subsequent rotation sites. Studies are also required to assess the feasibility and carbon balance of alternative management systems (rewetting and low-impact silvicultural systems) and consider their impact on ecosystem services (425).	Medium
G.18. More field data are needed to thoroughly characterise the wide range of peatlands and drivers of peatland GHG emissions. The types of data collected, methods used and format used for reporting these data need to be streamlined across the scientific community. In addition, data from the growing number of studies focused on peatland GHG emissions need to be compiled in a format that is accessible to both the scientific community and policy managers, and that can inform, in a timely manner as appropriate, the preparation of national GHG inventory reports (730, 813, 854, 916, 926).	Medium
G.19. An expanded framework that would allow the identification of adaptation strategies that are robust (i.e. insensitive) to climate change uncertainties and would allow more confidence in identifying and targeting vulnerable areas of blanket bog for priority conservation management measures (144) should be developed.	Medium
G.20. There is a paucity of studies on some peatland types (particularly cutover peatlands) (919). Further studies are needed to address this.	Medium
G.21. Research on improving the water component in ECOSSE is essential, as is continuous empirical data collection, especially from rewetted sites. This is critical for supporting any SPM schemes (733).	Low
G.22. Many data remain hidden from scientific scrutiny on paper records, and therefore supporting the digitisation, quality assurance and analysis of these data should be a priority (590).	Low
G.23. There is a huge degree of uncertainty in relation to particulate organic carbon calculations, which are based on a combination of small-scale studies at individual peatland sites and global budget calculations that are not peat specific (267).	Low

ECOSSE, Model to Estimate Carbon in Organic Soils – Sequestration and Emissions.

3.4 Water

3.4.1 Synopsis of evidence

Undisturbed peatlands provide important ecosystem services, as they buffer against acidification and eutrophication by locking up nutrients and other elements, which in turn buffer downstream surface waters and their biota. Although water from natural bogs is acidic and low in minerals, the streams that drain these bogs host an unusual variety of organisms (280). Peatland catchments are also important for drinking water supply. In Ireland and the UK, approximately 85% of all drinking water is sourced directly from peatlands, thereby highlighting the crucial role that peatlands play in the water security of these nations (934).

Drainage lowers the water table level, which leads to significant changes in hydrology (i.e. the way in which the water is stored and flows off the peat surface) and water quality within the bog and downstream waterbodies. For example, the Irish Midland region, known for its originally high coverage of raised bogs, which have been utilised for many decades, is facing a significant and widespread reduction in water quality, with high fluvial nitrogen and carbon content being present in all streams (704). Peatland drainage presents several serious challenges to aquatic life, including increased mortality, reduced richness, behavioural changes, habitat alterations and changes in community structure (235).

Peatland restoration has been highlighted for use as a tool for meeting different regulatory targets with regard to water regulation (Water Framework Directive (i.e. Directive 2000/60/EC)). To date, there has been a dearth of Irish data and published studies to support this management practice, despite several governmental restoration projects. Since industrial cutaway peatlands are extremely heterogeneous, their rehabilitation will include a mosaic of habitats, such as lakes of variable hydro-chemical stability (375), planted or naturally regenerated wooded areas (723) and rewetted areas (726) that may also affect water quality within the larger river basin (704). The restoration of blanket bogs and sustainable management techniques and practices carried out by local farmers and forest owners have helped to restore suitable eco-hydrological conditions (307), including for the rare and protected freshwater pearl mussel (672). Key actions and research gaps related to water are listed in Tables 3.7 and 3.8.

3.4.2 Actions

Table 3.7. Water – key actions and priority levels

Action	Priority level
A.37. A call for SPM is synergistic with a call for sustainable water resource management in Ireland. This necessitates (i) the development of management tools at both the site (water treatment) and (rewetting) landscape levels to help meet regional water quality standards; and (ii) regular monitoring of water chemistry as an integral part of current and future peatland management practices (704, 705).	High
A.38. A long-term water chemistry monitoring programme is an essential supplementary tool for SPM. Blanket or raised bog-dominated catchments possess distinct hydrological characteristics that necessitate long-term monitoring programmes (of at least 10 years) to accurately capture their inherent environmental variability (240, 304, 360, 524). The findings of such monitoring programmes are essential for guiding local authorities in applying water and climate policy objectives to various catchment types and mobilising communities to identify solutions for critical pressure points.	High
A.39. Compliance with existing water regulations together with the eradication of deficiencies or conflicts in this legislation must be enhanced as a first approach to integrated SPM. The degradation status of peatlands must be fully acknowledged in river basin management plans and closely monitored across all catchments, with particular attention to dissolved organic carbon and ammonia emissions in each area (704, 705).	High
A.40. While drinking water quality standards are well regulated, compliance with these standards alone is insufficient to prevent further water quality decline (649). Monitoring raw water for organic matter precursors provides valuable insights into trends and links contaminants to specific land users in the catchment. In Ireland, the focus has primarily been on treated drinking water, with limited attention having been paid to source protection.	High

3.4.3 Research gaps

Table 3.8. Water – research gaps and priority levels

Research gap	Priority level
G.24. There is ample evidence that drained peatlands can have a detrimental impact on the provision of water-related ecosystem services, not least rare species. However, further research is needed for Ireland to develop practical, sustainable and context-specific solutions that meet international obligations under EU water-related directives and that also tackle climate change and sustainability goals (705).	High
G.25. Measures and tools to prevent water degradation from peat catchments that have been investigated thus far need to be tested further in long-term field-scale experiments (17) and for monitoring multiple catchments and deploying a range of indicators (e.g. zooplankton communities) (108).	High
G.26. Enhancing our understanding of the biogeochemistry of peatland-associated waterbodies is required to improve our ability to predict the future of climate-sensitive peatlands (15, 305).	Medium
G.27. Increasing our knowledge of spatial and seasonal variations in dissolved organic carbon and nitrogen concentrations in streams, and the drivers of these variations, will be essential for optimising riverine water resource management (498, 704).	Medium

3.5 Archaeology and the Palaeo-environment

3.5.1 Synopsis of evidence

Ireland's peatland and wetland archaeology has been the subject of archaeological fieldwork and research for decades (101, 1000). Artefacts and archaeological sites preserved in peatland deposits have provided an exceptionally rich repository of knowledge about communities who have lived and interacted with the bogs throughout all periods (669). The waterlogged conditions of peatlands preserve a wide range of archaeological and palaeo-environmental evidence, collectively known as the archaeo-environmental record (328). The preservative qualities of peatlands arise from their acidic and anoxic environment (i.e. deficiency of oxygen) (1000) and have contributed to the preservation of human and animal tissue (713). The value of bogs for understanding human history and the past over millennia through palaeo-environmental studies is also evident in research. Interpreting the archaeological record requires understanding the context of the site or the artefact found, which can inform interpretation and feed into theory building (327, 1000). Pollen sampled from cores extracted from peat bogs provide a means to reconstruct local vegetation and identify human impact and abandonment in various historical periods (541). Key actions and research gaps related to archaeology and the palaeo-environment are listed in Tables 3.9 and 3.10.

3.5.2 Actions

Table 3.9. Archaeology and the palaeo-environment – key actions and priority levels

Action	Priority level
A.41. It is crucial that archaeological remains are protected and that appropriate mitigation actions are taken early in the process of planning restoration and rehabilitation work (330). While peatland restoration initiatives broadly align with heritage management, they should include input from archaeologists, to ensure an understanding of landscape character and the vulnerability of the archaeological record, and provide guidance for mitigation (328, 330). Such guidance could build on and adapt best practice approaches for protecting archaeological remains during peatland restoration (330).	High
A.42. With the cessation of Bord na Móna's peat extraction in 2020 and completion of the final excavation reports generated by this programme, archival management of these records is a key priority to ensure the accessibility of this resource for future generations. Research suggests that this information should be urgently and extensively collated, analysed, synthesised and published, as most of the excavation reports remain unpublished (1001).	High
A.43. Attention should turn to the horticulture industry, farmers/landowners and communities to ensure the future protection of the diversity of archaeological sites in peatland environments. This requires stakeholder engagement, research and the development of guidelines to ensure that best practice is followed (1000).	High
A.44. Building closer links between archaeology, heritage and nature conservation should also be a key action (1000). The ecosystem services framework presents opportunities in this regard, by including archaeological and palaeo-environmental value alongside biodiversity, water regulation and climate regulation. The importance of these cultural services has not yet been well recognised in management and planning agendas, and their inclusion in ecosystem services frameworks could provide resources to fund archaeological components of peatland restoration work (328).	High
A.45. Increasing public participation in and enjoyment of Ireland's archaeological heritage is a key priority. Greater public involvement in and awareness of archaeology has the potential to increase the audience for information and could also influence how archaeologists think and conduct projects by involving the community as stakeholders (1011). A variety of interpretive approaches are also needed to convey the significance of archaeological landscapes to the public and local communities (632).	High
A.46. Collaboration between academic, curatorial, conservation and restoration communities is vital to ensure knowledge transfer and protection and survival of archaeological and palaeo-environmental archives (1011). Collaboration between government, archaeological consultancies and university sectors can enhance the quality and range of evidence and ensure that the highest standards of investigation and protection prevail (669).	High
A.47. Regular repeat surveys and excavation of these sites can offer significant potential for discovery, yielding new archaeological sites in both old and new localities (37).	Medium

3.5.3 Research gaps

Table 3.10. Archaeology and the palaeo-environment – research gaps and priority levels

Research gap	Priority level
G.28. There is need to increase understanding of the impact of different land management practices on the archaeological record of peatlands (1000).	High
G.29. Understanding the factors that control the preservation of remains, particularly with regard to hydrogeological processes and the impact of management practices on archaeological and palaeo-environmental records, is essential for making informed decisions on preserving the archaeological record in bogs (1000). To best manage the archaeological resource, more data are needed on the condition of archaeological sites and more assessments are needed of how water quality, water table stability and associated processes of revegetation can affect long-term *in situ* preservation of archaeological and palaeo-ecological material (330).	High
G.30. One of the main impediments to enhancing the impact of archaeological and palaeo-environmental work on the wider archaeological community and the public is the lack of the regular publication of findings, coupled with delays in output. Engaged research approaches would benefit communication and dissemination to a wider audience (329).	High
G.31. The integration of further datasets may be beneficial, including emerging data from approaches such as ancient DNA and sedimentary ancient DNA analyses (537). Ecosystem services research could also serve as an integrating mechanism for such collaboration (328).	Medium
G.32. There is limited understanding of the spatial distribution and density of archaeological sites in peatlands (1000). The state and extent of the peatland archaeo-environmental record should be fully identified and assessed in all locations, and methods for assessing its value should be developed in alignment with the ecosystem services framework (330).	Medium

Research gap	Priority level
G.33. Research is needed on public engagement with archaeological heritage and its position in informing a sense of place and identity for Irish citizens, alongside research into the care and management of the archaeological resource (1011).	Medium

3.6 Technology and Mapping

3.6.1 *Synopsis of evidence*

Interest in mapping peatland information derived from digital data, be it remotely sensed data (e.g. satellite imagery, radiometric data[6]) or data from other digital mapping (historical maps) and artificial intelligence (AI) technologies (machine learning), has grown exponentially in the last two decades. There are now multiple means of remotely monitoring peatland areas, their status and the effects of management (especially rewetting and restoration), ranging from space-based satellite measurements (optical and radar) to airborne geophysical measurements (electromagnetic and radiometric). The analysis and classification of land cover, land use, peat depth and three-dimensional terrain modelling have been principal applications of these methodologies, although they are also increasingly being deployed to monitor the environmental conditions of peatlands, vegetation and disturbances, such as drainage systems.

A variety of data sources are now available, such as Earth observation (EO) data (imagery) from satellites operated either by the National Aeronautics and Space Administration (Landsat) or by the European Space Station (Sentinel-2), airborne radiometric surveys (e.g. Tellus project) or light detection and ranging (LIDAR) surveys. This review underscores the need for enhanced upscaling techniques and the integration of multi-sensor data (e.g. satellite and drone imagery and LIDAR products), combined with machine learning algorithms, to enrich our understanding and sustainable management of peatlands by providing more accurate maps, and tools for efficiently monitoring the status of peatlands. Key actions and research gaps related to technology and mapping are listed in Tables 3.11 and 3.12.

3.6.2 *Actions*

Table 3.11. Technology and mapping – key actions and priority levels

Action	Priority level
A.48. The advent of internet of things[7] technology has enhanced ecological sensing, but its high cost and the lack of networks in remote areas make widespread deployment for comprehensive monitoring challenging. Therefore, national funding is required to support investigation where bogs are located (119).	High
A.49. Numerous studies leveraging advanced EO technologies, including satellite-based imagery, have focused on predictive modelling, but they often lack robust validation and uncertainty assessments. To enhance their reliability and applicability, these studies should be more closely integrated with interdisciplinary fields, such as field ecology, catchment hydrology and watershed management. Such collaboration would facilitate ground-truthing efforts, ensuring more accurate and actionable insights for peatland research and management (437).	High

3.6.3 *Research gaps*

Table 3.12. Technology and mapping – research gaps and priority levels

Research gap	Priority level
G.34. Future studies should utilise higher-resolution imagery, particularly for the marginal peatland class (revegetated cutaway and cutover areas) where potential impact of rewetting/restoration may remain undetectable with satellite data (352). In tandem, drone studies, which have generally focused on raised bogs, should be tested on blanket bogs and combined with satellite data to assist in mapping vegetation.	High
G.35. Further studies on interferometric synthetic aperture radar coherence (which captures peatland surface motion directly linked to soil moisture) should be conducted on blanket bogs to assist with the monitoring of rewetted/restored sites, especially sites affected by wildfires. This is particularly relevant, as the frequency and intensity of wildfires are expected to rise due to global warming (291, 395).	Medium

6 Radiometric data provide a passive measure of naturally occurring radiation. These data can be derived from a crystal pack onboard an aircraft reacting to the gamma rays produced by radionuclides present in geological material.

7 Internet of things refers to the network of physical devices, vehicles, appliances and other objects that are embedded with sensors or software and have connectivity that enable them to collect, exchange and act on data.

Research gap	Priority level
G.36. Peatland enterprises associated with paludiculture and aquaculture will benefit from digital technologies, but guidance is required as to how to make use of digital innovation hubs to meet goals for community transitions to a low-carbon economy (757).	Low

3.7 Society and Culture

3.7.1 Synopsis of evidence

Research in this category is grouped into the thematic areas of "participation", "values" and "culture", which intersect and relate to each other across multiple dimensions (Figure 3.3). The evidence base demonstrates the complexity of issues relating to the human and socio-cultural dimensions of SPM (301, 705, 731). This complexity underscores the need to take integrated rather than single-value (climate/emissions) approaches to peatland management, monitoring and ecosystem services assessment that combine ecological, socio-cultural, economic and ethical value dimensions (54, 301, 705, 907).

The literature on "participation" deals with participatory processes, stakeholder engagement, inclusion of civil society and governance (top-down/bottom-up governance) (24, 79, 148, 228, 234, 300, 559, 576, 663, 664, 777). Research identifies ongoing tension between the emphasis on formal scientific knowledge and the lack of consideration of local knowledge in conservation efforts, which can undermine legitimacy (367, 663). The literature in this thematic area provides empirical evidence of the importance of local communities and knowledge systems for the conservation of peatlands, and it highlights the new values, cultures and meanings emerging around Irish peatlands that foreground equity (299, 367, 559, 705).

The "values" theme highlights the central role of human values in devising integrated SPM that combines the socio-cultural, environmental and economic values of peatlands (148, 150, 299, 663, 664, 705). Research here identifies the significance of bog landscapes for cultural values and traditions, while highlighting the historical emphasis on the economic values of peatlands (205, 663). The research also highlights that Ireland has applied a market-based approach to innovation, including peatland innovation, at the expense of grassroots innovations (559). However, community-based projects are found to reflect a diverse range of functions and values aside from monetary value, including instrumental, intrinsic and relational values and non-human communities (66, 148, 299).

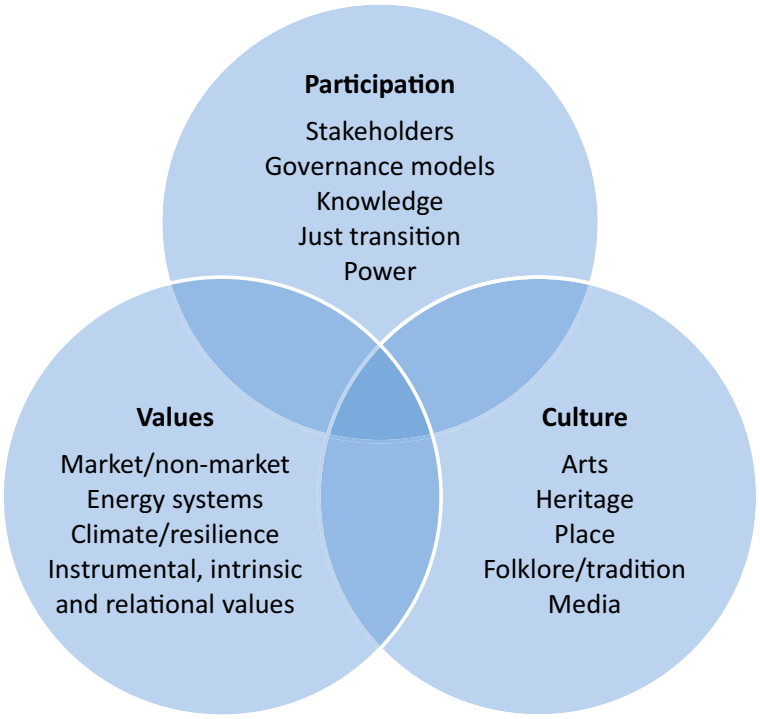

Figure 3.3. Interconnected thematic areas in the society and culture literature.

The theme of "culture" is related to the arts, heritage, tradition and folklore, and also to less-visible aspects of human cultures, including belief systems, values, ethics, shared meaning and worldviews (79, 149, 273, 298, 299, 301, 540, 661, 663). Peatlands provide important cultural ecosystem services related to sense of place, education, tangible and intangible cultural heritage history, heritage and spirituality. These experiential and symbolic values are especially important for local communities, yet are often under-represented in peatland conservation, management and decision-making (301, 328). Key actions and research gaps related to society and culture are listed in Tables 3.13 and 3.14.

3.7.2 Actions

Table 3.13. Society and culture – key actions and priority levels

Action	Priority level
A.50. Improved structures and more diverse processes for participation in peatland conservation, restoration and management are required (300, 576). More community participation in policy formulation and decision-making regarding renewable energy developments at peatland sites are also needed (599). Multifunctionality in post-industrial sites should be a stated aim in land use policy and peatland rehabilitation projects (148). Land use plans for the remaining area of Bord na Móna's cutaway peatland should be developed by a multi-agency group that includes experts from Bord na Móna, the National Parks and Wildlife Service, non-governmental organisations and local authority and community groups (262).	High
A.51. There is a need to develop a culture of early and inclusive stakeholder engagement in planning for SPM and restoration programmes, through collaborative approaches and social science methods that facilitate fair participation (24, 148, 300). Organisations involved in SPM should move beyond passive participation to the active co-management and co-production of solutions, enabling dialogue between experts, policymakers and communities (79, 148).	High
A.52. Collaboration between all stakeholders and across all sectors in society is needed. Established organisations with the power to facilitate networking and knowledge sharing should be identified through stakeholder analysis, assessing the quality of existing relationships and identifying where further support is needed (300, 705). This can help to identify existing networks and develop new networks and bridging organisations (705).	High
A.53. New partnerships with civil society organisations and cultural institutions should be sought to provide new perspectives and build visions for the evolving relationships between people and Irish peatlands.	High
A.54. A lack of trust in local authorities, agencies and semi-state companies has been identified as a barrier to SPM. This is noteworthy, as these are key intermediaries for building transition pathways at the local level and engaging citizens (24, 300, 556, 663, 664). Trust building should be included as part of communication and engagement initiatives, identifying the expertise needed to engage in such activities (556). Public sector organisations with a remit for peatland management should have dedicated community liaison departments with associated guidelines for staff on best practice (705).	High
A.55. Planners, policymakers and researchers should move from a top-down approach to the management of green and blue spaces to incorporate a systems approach that improves decision-making and creates positive feedback between policies related to ecosystem services, land use, green infrastructure, management and health promotion (300, 455, 559).	High
A.56. The use of action research, engaged research and systems thinking approaches that enable integrated solutions and foreground local needs and community concerns should be encouraged (148, 234, 455, 705). These approaches would include methodologies that facilitate participatory and collaborative approaches to restoration and management, helping to reduce conflict, manage power differentials between stakeholders and enable social learning (148, 299). Embedding researchers in local places can also support the co-creation of research and community science projects and provide resources and funding support for community groups (300, 554).	High
A.57. Considerations of equity and social justice should be integrated into climate and energy policy by examining processes of participation and allocation of funding for restoration (559). Renewable energy projects and other developments on bogs must be acceptable to local communities and could be achieved by involving the communities in the decision-making process and integrating community visions (66, 300).	Medium
A.58. The strong support among local communities for amenity and biodiversity after-uses of cutaway and undesignated peatlands should be acknowledged and prioritised, but this is currently not reflected in public policy debates (150). Greater community agency, ownership and stewardship of landscapes should be encouraged (300, 705).	Medium
A.59. Place-based approaches and incentive schemes for SPM should be encouraged to better account for local place-based knowledge, experiences and cultural contexts (299, 554, 559).	Medium

3.7.3 Research gaps

Table 3.14. Society and culture – research gaps and priority levels

Research gap	Priority level
G.37. Interdisciplinary and transdisciplinary research is required for transformative change and sustainability transitions (250, 299, 705, 732, 941). Funding calls and public tenders for peatland projects should encourage the inclusion of research from the arts, humanities and social sciences as well as from scientific disciplines when commissioning research on SPM (705). Such research also needs to be supported and facilitated in higher education and research institute structures and processes.	High
G.38. Further research is required on stakeholder attitudes to peatlands and SPM, examining local stakeholder conflicts, needs and perspectives (79, 150, 234). The benefits and challenges of implementing a just transition and the socioeconomic impact of the loss of jobs in the peat industry should be explored (24, 559). Further research on the communities affected is recommended (24, 300, 367, 369, 559).	High
G.39. Despite over 50 years of research into commercial, market-driven after-use options for cutaway peatlands, non-market options have rarely been explored (150). The shift from extractive to regenerative peatland land use requires further research on community stewardship, social enterprises, commons research and the diversity of economic and social practices that foreground the well-being of both human and non-human communities (64, 65, 66, 300).	High
G.40. Further research on the health and well-being benefits of peatland environments and the impact of increased amenity use on these ecosystems is required (150, 299, 369, 455). More data are needed on the multiple uses of green and blue spaces (455). These data should come from research on, for instance, the human impacts of living and working in degraded peatland environments and the impact of renewable energy developments (369).	High
G.41. Further research on community leadership, capacity building, multi-stakeholder partnerships and collective action is also needed (554, 300, 1006). This could include research on participatory governance, succession planning, mechanisms for collaboration, supporting volunteerism and encouraging the transition to sustainable rural livelihoods relating to peatlands (300, 367, 554).	High
G.42. Future research should examine the representation and coverage of peatlands in Irish print, visual, broadcast and online media (189), including the influence of media on public debates and attitudes to peatland restoration and management and cultural narratives around peatlands (64). Critical research on media and communications strategies to engage different groups across the human lifespan is needed (556). Little is known about the role of social media, a knowledge gap that is significant due to its increasingly dominant role as a source of news and information (189).	Medium

3.8 Management

3.8.1 Synopsis of evidence

For centuries, Irish peatlands have been utilised and managed for a wide range of uses. Historically, these uses included light grazing (by livestock) and extraction of peat for heating (by hand), but, more recently, peatlands have been subject to extensive use for forestry, grassland and peat extraction (on small and industrial scales). Over the last few decades, peatlands have also been managed as locations for wind farms and aquaculture. However, the environmental benefits offered by non-degraded peatlands are well recognised and considerable efforts have been made to protect and conserve these sites, while efforts to actively restore degraded sites have also gained significant momentum, particularly with regard to reducing GHG emissions, enhancing biodiversity and protecting water quality. Key actions and research gaps related to management are listed in Tables 3.15 and 3.16.

3.8.2 Actions

Table 3.15. Management – key actions and priority levels

Action	Priority level
A.60. It is necessary to undertake detailed site-specific characterisation prior to the implementation of any restoration/rewetting programme (388, 519).	High
A.61. Peatland restoration efforts are required to mitigate the risk of peatland fires under a changing climate (778).	High
A.62. It is critical that the government provide a long-term financial framework to secure the continuity of the sustainable management of shared peatland resources (705).	High
A.63. There is a real need to expand the range of locally led integrated catchment/landscape management initiatives that can simultaneously provide multiple ecosystem services (575).	High
A.64. Any wind farm development on Irish peatlands should undergo rigorous examination and impact assessment (735).	High
A.65. Burning turf in private homes must be phased out as a community-led initiative, through the provision of grant-aided, accessible, sustainable energy sources dovetailed with carbon credits for rewetting from turf-producing bogs (618).	High
A.66. Bog remnants should be maintained as an essential part of rehabilitation management (277).	Medium
A.67. Restoration of the lagg area should be a key element of raised bog restoration efforts (393).	Medium

Action	Priority level
A.68. Standard forest fertilisation practices should be related more specifically to peat type and species requirements (724).	Medium
A.69. A well-informed and well-resourced global/ European peatland restoration strategy aligned with ecosystem accounting frameworks such as the SEEA EA would support better decision-making for optimal returns across an integrated range of flows relating to climate, water, biodiversity and sustainable development (275).	Medium
A.70. Ecological and hydrological monitoring are recommended to gauge both short- and long-term assessments of the response to restoration works. Monitoring also provides a means of demonstrating the actual impact of restoration measures and can help to allay fears that flooding will result on adjacent land (519).	Medium
A.71. Effective policies for the conservation and management of the uplands requires a cross-sectoral approach that can take account of environmental criteria and also land managers' socioeconomic objectives (666).	Medium
A.72. The trophic impacts of nitrogen deposition are poorly understood and have the potential to influence the conservation objectives of certain species. Research has begun to link nitrogen deposition with a loss of invertebrates and future work is required to link this with the availability of food for certain animal and bird species protected within the Natura 2000 network.	Medium
A.73. The potential area suitable for Sitka spruce on cutaway industrial peatland sites can be expanded when planted in combination with birch. Moreover, the potential utilisation of birch thinnings for biomass and the final Sitka spruce crop for timber may be a particularly suitable option for Bord na Móna, as it may potentially fulfil both bioenergy and timber production objectives (48).	Low
A.74. There is good growth potential for birch planted on cutaway peatlands and therefore this species should be integrated into planting programmes (720).	Low
A.75. The soil nutrient and moisture regime, as well as aeration, must be carefully considered in afforesting a cutaway peatland (736).	Low
A.76. There is a need for the very near surface of the peat profiles to be targeted in peatland ecohydrological studies, with a wider range of measurements needed to effectively characterise the dynamics within this critical pedosphere–atmosphere interface (848).	Low
A.77. The fine-scale characterisation of the surface moisture content is critical for understanding the spread of fires in peatlands (695, 697).	Low
A.78. Management plans should take into consideration the availability (in terms of both total area and connectivity) of preferred sheep habitats and specifically consider grazing pressure in and between those habitats (909).	Low
A.79. Seasonal grazing regimes should be devised that meet habitat conservation objectives at site level based on grazer behaviour and habitat condition (911).	Low
A.80. There is a pressing need for international agreement on a standardised set of environmental indicators to advance paludiculture innovation that addresses climate change and sustainability (657).	Low

SEEA EA, System of Environmental Economic Accounting – Ecosystem Accounting.

3.8.3 Research gaps

Table 3.16. Management – research gaps and priority levels

Research gap	Priority level
G.43. Innovative peatland restoration funding mechanisms are needed (705).	High
G.44. A radical new policy perspective is needed to preserve or restore many near-natural bogs (80).	High
G.45. Economic and social assessments of peatland restoration are required, building on existing economic impact assessment approaches (275).	High
G.46. Research is needed to develop accounts for ecosystem services that would assist in developing a broader risk register (related to potential reductions in or loss of flows, including services and benefits) and also provide opportunities to realise potential co-benefits of restoration related to climate, water, biodiversity and sustainable development, across the full peatland inventory (276).	Medium
G.47. There is a need for more research across a broader range of sites to assess the extent to which the impacts of wildfires may differ between habitat types and from those of experimental or controlled burning (436).	Medium
G.48. Further research is needed to elucidate ecosystem processes that control the retention and release of phosphorus in forested peatland catchments, and an extensive catchment-scale network of monitoring sites designed to capture the range of variation in phosphorus loss and to refine the identification of vulnerable site types is also required (518).	Medium
G.49. Future research opportunities might look at developing policy instruments and tools that take account of wider social and cultural values alongside market values (301).	Medium
G.50. Work is required to quantify the effect of nitrogen deposition on the role of peatlands as carbon sinks in Ireland, alongside plans to maximise their ability to function as carbon sinks. Such work could be achieved through linking functions of the National Ecosystem Monitoring Network (set up in 2018) with the Integrated Carbon Observing System carbon flux monitoring programme in Ireland.	Medium

Research gap	Priority level
G.51. Research is required to study the long-term nursing effect of birch and Sitka spruce and to evaluate the viability of silvicultural systems on cutaway peats (48).	Low
G.52. Grass seeding of the peatland immediately after timber harvesting can quickly immobilise significant amounts of phosphorus and warrants additional research (648).	Low
G.53. Further research is required on a wider range of sites to determine the conditions required to establish peat-forming habitats on cutover bogs (180).	Low
G.54. Work is required to determine how microbial communities functionally interact in the degradation of peatlands and how they respond to environmental changes, such as drainage and rewetting (533).	Low
G.55. A comparison of *in situ* peatland charcoal records with datasets of past climate, human population/density and peatland vegetation and moisture conditions is needed to better quantify the factors that control peatland fires (778).	Low
G.56. Future research on peatland fire behaviour should consider local variation in moisture content to gain a better understanding of the spread of smouldering fronts through peat layers (697).	Low
G.57. Research is needed to advance the current understanding of blanket bog hydrology (307).	Low
G.58 Given the lack of data available on zoosporic parasites and their potential impact on organic aquaculture practices, additional research needs to be conducted (658).	Low
G.59. A better understanding of the use of algae for bioremediation and improving water quality is needed in the integrated multi-trophic aquaculture field (655).	Low

3.9 Growing Media/Substrate

3.9.1 Synopsis of evidence

With the development of the professional horticulture sector in recent decades, peat has increasingly been used as a growing media in many countries where peat is a significant resource (Wilson *et al.*, 2023). Despite the environmental consequences of draining peatlands for peat extraction (i.e. elevated CO_2 emissions, loss of biodiversity, negative impacts on water quality), published research on alternatives in Ireland to peat as a growing substrate for crops/ornamentals remain scant. Key actions and research gaps related to the use of peat as a growing media/substrate are listed in Tables 3.17 and 3.18.

3.9.2 Actions

Table 3.17. Growing media/substrate – key actions and priority levels

Action	Priority level
A.81. Varying qualities of compost and digestate are currently being produced in Ireland, calling for a new quality standard. In addition, a review of the impurity standard and limit values in peat substrates should be undertaken in 2025 (313).	Low
A.82. The greatest risk to achieving the standards is the presence of contamination in the feedstock that is used in digestate and compost. A contamination working group should be established to develop a national plan (313).	Low

3.9.3 Research gap

Table 3.18. Growing media/substrate – research gap and priority level

Research gap	Priority level
G.60. Transparent, investigative studies on alternative growing media must be carried out.	High

3.10 Policy and Law

3.10.1 Synopsis of evidence

Peatlands are valuable ecosystems and are highly significant for global efforts to combat biodiversity loss and climate change and improve water quality, thus contributing to achieving most of the United Nations Sustainable Development Goals (705, 833). Other recent peatland-related developments include the adoption of the 2019 United Nations Environment Assembly resolution on the conservation and sustainable management of peatlands (705).

The environmental damage caused by peatland drainage is at the core of key international environmental issues. International biodiversity and climate change conventions (e.g. the Convention on Biological Diversity and UNFCCC) now recognise peatland protection, restoration and rewetting as a priority for action (705). At the EU level, peatlands have already been highlighted as playing a central role in achieving the temperature goals agreed in

the Paris Agreement, and the 2024 Restoration Law explicitly includes peatlands as a key ecosystem targeted for conservation and restoration efforts. At the national level, the Climate Action and Low Carbon Development Bill and Amendment (2020) has identified the establishment of legally binding GHG emissions targets (following EU targets) as a key priority for enabling the transition to a low-carbon economy (705).

Implementation has long been regarded as the "Achilles' heel" of the policymaking process, and Ireland's challenges in implementing environmental policy and biodiversity directives have been linked to a highly centralised system of public administration alongside a technically rational "science first" approach, barriers to participation and conflicts over land rights (117, 153, 663). Implementation responses are also strongly influenced by domestic politics, bureaucracy and economic interests (153). A top-down approach has also failed to facilitate acceptance of the requirements of EU directives at the local level (153, 662).

Research emphasises that SPM requires collaboration across all sectors, levels of government and research disciplines, and should include all stakeholder groups (214). Peatlands must be managed in an integrated, multi-stakeholder manner using a landscape approach with a combination of policy instruments (regulatory, incentive and educational) to ensure success (54, 117, 872).

Research has found that serious shortcomings persist in environmental enforcement across the EU, including Ireland, which ranks among the worst performers in terms of timely implementation of European Court of Justice judgments and failure to comply with environmental obligations (117). The absence of environmental lawyers within the Department of Climate, Energy and the Environment compared with other EU environmental ministries was noted as a barrier (117). Research also points to the need for reform in how environmental crimes are viewed, and how perpetrators are sentenced and prosecuted in Ireland (512).

Ireland's National Peatlands Strategy

Ireland's National Peatlands Strategy covers the period 2015–2025, which is coming to an end. It is therefore now time to review and plan for an innovative new strategy. A number of major projects and initiatives have begun or been continued as part of implementing the actions of the strategy. However, progress in the implementation of some actions has been slow (1021).

National peatland strategies have been developed in many European peatland countries, but mainstreaming with overall climate, biodiversity and land use policies is still lacking ambition and enforcement (872, 1003). A recent review of national peatland strategies in Europe found that almost all the strategies struggled with missing data, outdated data or poor data quality, for example on the condition of undesignated sites outside the Natura 2000 network (Special Areas of Conservation/ Special Protection Areas) and Natural Heritage Areas network in Ireland (1005). While the government has a clear role as a key investor in many peatland strategies, private or blended finance is often regarded as vital for meeting restoration ambitions (1003, 1004). Key actions and research gaps related to policy and law are listed in Tables 3.19 and 3.20.

3.10.2 Actions

Table 3.19. Policy and Law – key actions and priority levels

Action	Priority level
A.83. The National Peatlands Strategy should be updated, incorporating future scenarios and building on existing partnerships between state agencies, communities, landowners, policymakers and academics (1003, 1004). Key learnings from recent research on EU peatland strategies demonstrate the need for measures to ensure the effective coordination of peatland policies across governmental departments (1005). This includes setting up or reviewing cross-departmental and stakeholder working groups to monitor the implementation of a strategy. Further attention to capacity building, awareness raising and communication is also needed (705, 1005, 1021). A specific communications programme as part of strategy renewal and implementation would help in this regard.	High

Action	Priority level
A.84. To facilitate policy implementation and the enforcement of EU directives, there is a need for greater recognition of the purposes and objectives of EU environmental legislation; greater emphasis on long-term strategic approaches and tools, such as strategic environmental assessment; an emphasis on outcomes and results-based projects in enforcement action; involving stakeholders and managing conflict situations; overseeing and providing education/training for local and regional authorities; and supporting the role of civil society (117, 153).	High
A.85. Policy should support inclusive and collaborative governance and encourage bottom-up approaches to peatland management and conservation. Funding and other support should be provided to build local community capacity in monitoring and assessing peatlands through training, citizen science initiatives and knowledge exchange (705). Developing strong partnerships between state agencies and community groups and networks requires public sector organisations to have dedicated community liaison staff and expertise (301, 1006). Just transition funding should be distributed equitably to ensure that communities benefit from SPM initiatives and that the initiatives can be deployed to other peatland communities in other regions (301, 705, 1003).	High
A.86. Unless actively restored, the cessation of cutting alone is unlikely to enable biodiversity conservation targets to be achieved. Strategic financial planning approaches need to be developed to mobilise additional resources for conservation and restoration (578).	High
A.87. A closer alignment of regulatory, incentive and educational policy instruments is required, as regulation alone is inadequate to protect peatlands (54, 117). The majority of lands within Irish SACs are owned and managed by private landowners and farmers whose cooperation is crucial. Support is needed for collaborative forms of governance that incorporate local knowledge and enable stakeholders to take ownership of peatland conservation and rewetting (153, 301). It is crucial to create social acceptance and support for land consolidation and rewetting, as practical implementation often depends on the consent of all landowners in a hydrological unit (833).	High
A.88. To foster the sustainability of rewetted/restored peatland projects and achieve their climatic objectives on the necessary scale, enhanced communication strategies are needed to target communities, land managers and land users (1024).	High
A.89. Ecosystem markets are proliferating globally in response to increasing demand for climate change mitigation, and the provision of other public goods and peatlands is already at the heart of several regional ecosystem markets, national carbon markets and green finance. A methodology for rewetting drained temperate peatlands has been launched under the Verified Carbon Standard. The first carbon credits from peatland rewetting were sold in 2011 (by the German regional MoorFutures 2.0 scheme), followed in 2017 by the UK Peatland Code and in the Netherlands in 2020. While existing Irish scientific evidence is increasing, further data for certain land use and geographical regions are needed to develop such a code, which must also be adapted to Irish historical and current land use policy and law, as well as the multi-stakeholder environment, while addressing issues of additionality and ecosystem service trade-offs between multiple schemes (705, 737).	High
A.90. More sustainable models for agricultural policy are needed, including implementing results-based payments and payments for ecosystem services initiatives. European Innovation Partnership schemes should also be upscaled to support farmers in developing innovative approaches (paludiculture) that reduce their environmental footprint (705). Cross-boundary collaboration between peatland stakeholders could be encouraged by shifting the focus of agri-environmental schemes from contractual agreements with individuals to awarding collective payments that facilitate the management of ecosystem services across property boundaries and support self-governance of groups consisting of landowners and managers working alongside other peatland stakeholders (714). Support is needed to train skilled rewetting practitioners and create local employment related to rewetting and restoration (300, 1003).	High
A.91. State forestry and peat extraction companies must be transparent and show leadership in the restoration of commercial afforested peatlands and industrial extraction sites (872).	High
A.92. Area-appropriate interventions to curtail residential solid fuel combustion to deliver the health and environmental benefits of shifting from solid fuel use for residential heating should be developed (440). Education on the impacts of air quality on health should also be initiated (1022).	High
A.93. The greater coherence and targeting of implementing measures are needed. Environmental problems are often interconnected and a joined-up approach to addressing them is required (117). Implementation and enforcement of existing policy and legislation around the extraction of peat on privately owned peatlands is essential (1003). The legal status of all peat extraction activities needs to be urgently finalised together with the implementation of evidence-based mitigation measures (705). Compliance with existing regulations and the eradication of deficiencies or conflicts in this legislation must be improved to progress SPM in Ireland (705).	High
A.94. There is a need for progress in the development of a separate regulatory regime that will bring smaller-scale commercial and non-commercial peat extraction (lands < 30 ha) under a new local authority licensing system, incorporating EIA and appropriate assessment, as required, and enforcement powers (705). The regulatory framework applying to peat extraction should be communicated and disseminated to all local authorities.	High

Action	Priority level
A.95. A public GIS database should be developed to catalogue all rewetted or restored peatland projects and their associated datasets, and monitoring data (ecological, soil and water) collected through publicly funded environmental assessments of peatland-related projects or plans should be centralised. This database will then support the creation of a reliable valuation system for assessing land use management and alternative uses and aiding future peatland restoration and rewetting initiatives, scientific research and informed, science-based decision-making (726, 737).	High
A.96. A "culture" of policy evaluation should be developed. In common with other countries, Ireland has given insufficient attention and resources to the retrospective evaluation of climate change policies. The monitoring of climate policies across departments is significantly less well developed than the monitoring of emissions. A systems approach is needed to address both the mitigation of and adaptation to climate change (214).	Medium

EIA, environmental impact assessment; GIS, geographic information system; SAC, Special Area of Conservation.

3.10.3 Research gaps

Table 3.20. Policy and law – research gaps and priority levels

Research gap	Priority level
G.61. The capacity to implement the National Peatlands Strategy should be built by ensuring that there is a policy-relevant knowledge base and networks and mechanisms for science–policy interaction that link peatland research to local, regional and national policy needs, as strategy development is often hampered by a lack of data or poor data quality (1005). Support Irish peatlands research in expanding its funding platforms to European-level frameworks.	High
G.62. More research is needed on policy implementation processes and the practical, institutional and socio-cultural factors that influence environmental policy implementation, as these are critical pathways that determine success or failure (153). Integrating social science practitioners into knowledge exchange processes at the implementation level is also critical for facilitating and managing change in stakeholder behavioural patterns (112).	High
G.63. Enhancing knowledge about peatlands in Ireland through research and education is a high priority. There is a need for formal curricular modules on peatlands at all educational levels, especially in agriculture colleges (1003).	High
G.64. More research into the potential of paludiculture is required (1003).	High
G.65. A detailed map of the extent and condition of peatlands is required (1003).	High
G.66. The establishment of an open-source (publicly) available peatlands portal or a one-stop-shop for peatland-related data and resources for Ireland, including GIS data, is critical (1003).	High
G.67. Research on the availability, development and uptake of alternative growing media in Ireland (within both the domestic market and the horticultural industry) is required so that peat-free policies and incentives can be formulated and implemented (1004).	High
G.68. It is critical that the impacts of all activities involving the drainage of peatlands are correctly appraised and proven mitigation measures applied appropriately together with scientifically robust rehabilitation plans (705).	High
G.69. There is a pressing need to research, measure and drive sustainability via partnerships between academics and communities. Good examples of sustainability action at the community level exist in practitioner literature, but this literature is not peer reviewed or measured. Research funding for action research in communities should be prioritised because of the economy of scale and the potential sustainability gain (110).	High
G.70. Research is needed to gather contemporary data on residential fuel use in Ireland (440, 539). Further assessments are also needed of the impacts of climate-focused policies on air quality and the associated human health impacts (440).	High
G.71. Research is required to gain a better understanding of environmental crime prosecutions, assessing whether or not criminal sanctions in Ireland effectively control or deter environmental crime (512).	Medium

4 Sustainable Management of Peatlands: A Call to Action

Peatland research has expanded rapidly in the last two decades as peatlands are studied as dynamic parts of the physical and cultural landscape, undergoing continual changes through biogeochemical processes, as well as through human activity and climatic variability. Critically, knowledge should be utilised to foster societal acceptance of SPM, which involves more equitable and successful peatland conservation and utilisation outcomes. The PHI database presents a broad overview of where gaps in Irish peatland knowledge still exist. While research themes like biodiversity, management, the palaeo-environment, climate, water and soil already have well-defined agendas, urgent action is needed to secure long-term funding and coordination to ensure this critical work continues without interruption. In contrast, research on the cultural, societal, policy and legal dimensions of SPM is less well established, and funding and support are needed for research calls. Applied research directly involving farmers (rewetting agricultural or forest peat soils and new initiatives, e.g. paludiculture) is scarce, as is research on users of growing media. It should be noted that projects that aim to fill some of these gaps are under way. A repository of such projects has been produced as part of this project,[8] but it is important that this is maintained to harness the knowledge gathered and to communicate it to a wider audience.

Minimal overlap between studies confirms that funding allocations have avoided redundancy in research, aligning with the principles of transparent and cost-effective national research governance. However, this study highlights the issue of the poor visibility of key publications, especially from governmental institutions. The incomplete evidence base covered in recent Irish peatland literature reviews highlights an urgent need to establish systematic knowledge-sharing mechanisms between scientists and between scientists and stakeholders, especially policymakers.

The PHI database will raise awareness among researchers and together with the “living” glossary will help to overcome academic silos and facilitate the incorporation of insights from a range of disciplines. Further development and expansion of the database by various research groups around the country is recommended, building on the PHI project framework and evolving through successive updates via the replicable methodology. Incorporating new ideas and AI to rapidly update and share information is also recommended. Moreover, it is critical that older publications (pre-2000) be digitised, starting with reports from state organisations.

The PHI project collated evidence-based knowledge of Irish peatlands under 10 themes and incorporated critical observations into this major national resource (see PHI factsheets[9]). In total, 71 research gaps were identified, 50% of which were viewed as being of high priority. Ninety-six key actions were also provided across all themes, 60% of which were deemed to be of high priority. A thematic summary of these actions and research gaps is provided in Flood *et al*. (2025). Furthermore, four overarching strategic recommendations were identified to encourage research, civil society and policymakers to move towards better planning and SPM (Figure 4.1).

4.1 Accountability: Policy Implementation, Coherence and Collaborative Governance

Given the poor trends related to many peatland indicators, Ireland needs to improve the way in which it implements global and national policies related to this national resource. These policies raise awareness among not only policymakers, but also those responsible for regulation, planning and education. The case for the sustainable integrated management of peatlands is underpinned by existing legislation, compliance with which has a direct bearing on the

8 https://www.ucd.ie/peat-hub-ireland/researchonirishpeatlands/researchprojects/ (accessed 12 June 2025).

9 https://www.ucd.ie/peat-hub-ireland/researchonirishpeatlands/factsheets/ (accessed 12 June 2025).

Figure 4.1. Strategic recommendations for the sustainable management of Irish peatlands.

development and outcomes of SPM. Compliance with existing regulations and the eradication of deficiencies or conflicts in this legislation is critical, including the elimination of subsidies and other financial support for any economic activities that directly or indirectly degrade peatlands and their associated services. The conservation of remaining near-natural peatland resources and the prompt rewetting of degraded and degrading peatlands are critical from the perspectives of mitigating climate change (including preservation of the carbon store), protecting biodiversity and ensuring good water quality.

Several impediments to achieving SPM are evident in some legal frameworks and concern regulations related to water, forestry, agriculture and planning. Considerable evidence points to the unsustainability of afforested peatlands. Decisions on future land use must be site specific, account for the full suite of ecosystem services and show a clear regard for sensitive receptors, that is, the ecological status of downstream waterbodies, protected drinking water areas and protected habitats and species. Successful national peatland strategies, and therefore successful SPM, require the integration of policies across all governance levels (peatland mainstreaming like climate mainstreaming; Wichmann and Nordt, 2024). The current cross-departmental committee in charge of implementing Ireland's National Peatlands Strategy has a key role to play in communicating and sharing information between departments and promoting a "whole government" approach to SPM. Across the peatland stakeholder landscape in Ireland, more collaboration is needed, both horizontally and vertically, between research disciplines and projects, between sectors and from the national to the local level (Pschenyckyj *et al*., 2021). Meaningful engagement with landowners is important early in the collaborative process. More sustainable models for agricultural policy, such as the implementation of results-based payments and payments for ecosystem services, are needed for successful SPM.

4.2 Longevity: Long-term Monitoring and Funding of Sustainable Peatland Management Activities

The provision of sufficient recurrent funding is paramount to ensuring full implementation of regulations through the relevant national authorities. Funding should also cover long-term monitoring, which is not currently supported by funding platforms. It is critical that the Irish government provide a long-term management plan and associated financial frameworks to secure the continuity of the sustainable

management of shared peatland resources, including both designated and non-designated peatlands. The removal of unsustainable subsidies will generate revenue, which, along with market-based instruments and other pricing reforms, can help to incentivise SPM. The creation of subsidies and fiscal mechanisms that incentivise SPM activities (not only restoration of protected sites but also rewetting of degraded peat soils) should add to the limited public funding currently available and should be complemented by private finance. Carbon, biodiversity and water credit schemes could offer key incentives, enabling businesses, organisations and individuals to invest in land management and restoration. Furthermore, it is widely acknowledged that such schemes require support from the communities located around bogs and thus funding support should be enhanced for local communities. In addition to peatland community engagement schemes, incentives to promote citizen science initiatives could be an efficient means to help with long-term monitoring around the network of European sites. The advent of digital technologies could also enhance environmental and ecological sensing and provide robust methods to track and monitor peatland land use and land use changes and management practices over time. This is critical for extensively drained blanket bog areas, for example. However, several challenges must be overcome before the widespread deployment of these technologies for all peatland projects is possible, not least the provision of funding for capacity building (keeping trained researchers in the country) and especially nationwide ground truthing. Finally, one high-priority action includes the establishment of a public GIS database of rewetted/restored peatland projects and associated datasets, incorporating all ecological datasets collected from publicly funded environmental assessments of projects and plans involving peatlands. This could then support the valuation and forecasting of land use management approaches and alternatives, guiding future restoration projects and informed, science-based policy decision-making.

4.3 Equity: Knowledge Exchange, Communication and Capacity Building

In Ireland, questions of value will be key to deciding future land uses of peatlands, and therefore understanding people's values is crucial for securing societal acceptance and support for the restoration and conservation of peatlands. Attitudes to peatlands are deeply embedded historically, culturally and socially, and so education, collaboration and capacity building are required to foster changes in how peatlands are valued by society. This in turn will influence land use, decision-making and environmental stewardship for peatlands, as both direct (land use change, climate change and exploitation) and indirect (governance, institutions, economic and socio-cultural) drivers of change are underpinned by societal values and behaviours (IPBES, 2019). Such change is already visible in the emerging networks of relationships and cultural narratives around peatlands, signalling important shifts in community and societal values, from unsustainable extractive management to more sustainable management for both ecosystem services and the communities themselves. Such shifts need to be supported, scaled up and mainstreamed into wider society via education, communication, and knowledge-exchange and capacity-building initiatives. However, differences endure in the power, authority and access to resources that different stakeholders and groups have, often stemming from historical, social and political processes. Institutions must work to create "cultures of participation" and to promote a shift from top-down management to multi-level partnerships where the state enables civil society to act. To foster sustainable pathways, farmers, landowners and communities must be supported to act as agents of change and express their own visions of the future. Moreover, it is important that those in power are held to account for delivering on their promises and responsibilities. It is now imperative to nurture a paradigm shift towards regenerative policies, practices and land use for peatlands through impactful research, collaborative societal partnerships and strong policy implementation.

4.4 Holistic Knowledge: A New Paradigm for Future Research on Irish Peatlands

The results of this review suggest that, to ensure the sustainable management of Ireland's peatlands for current and future generations, Ireland must address numerous critical gaps, which will require interdisciplinary research. In order to ensure wider societal, environmental and policy impacts, three overarching recommendations are provided to

accelerate a new paradigm for peatland research in Ireland, as outlined below.

4.4.1 Empower stakeholders via participatory methodologies, engaged research and knowledge co-production

The findings of this research support calls for inclusion, transparency and reflection on power dynamics in research through collaborative partnerships, participatory methodologies and engaged research approaches (299, 705). Engaged research involves collaboration with a community (including local, business and farming communities) to investigate societal challenges and issues of concern, and encompasses a range of approaches and methods. As evidence from this research shows, it is vital to support and build societal partnerships, given the limited capacity and financial resources of many civil society groups and the need for ecological knowledge and information in the farming, business and wider communities. Transdisciplinary approaches to the co-production of knowledge bring actors from outside academia into the research process to integrate the best available knowledge, reconcile values and preferences, and create ownership of solutions. As part of the PHI project, new avenues of research were identified by surveying the research community, highlighting the emerging trends that may not yet be visible in the published literature.[10]

When commissioning research, the inclusion of the arts, humanities and social science disciplines, alongside economic and ecological disciplines, can help to provide a deeper understanding of the cultural and social dimensions of SPM. These disciplines include a spectrum of methodologies that support engagement with stakeholders and provide insights into barriers to the implementation of conservation policies and measures on the ground. They aim to move from "information and consultation" towards "collaboration and empowerment", via approaches such as action research, i.e. research that is initiated and driven by communities that are involved at all stages of research design, where feasible. Higher education institutions should also create better structures to facilitate impact, knowledge exchange and communication of research, going beyond the narrow focus on academic impact/publications as a measure of success. Finally, for effective knowledge exchange, consideration should be given to the legacy of projects, to ensure ongoing flows of information that may be necessary beyond initial research funding (Reed *et al*., 2014). This would require digitising past research not available online within all Irish institutions.

4.4.2 Integrate principles of open science and mechanisms for sharing data and knowledge

Open science policies and practices are transforming how research is designed, managed, shared and assessed, such that it is no longer sufficient to publish the results of publicly funded research without also making the data that support and validate the conclusions as open and accessible as possible (Digital Repository of Ireland, 2024). The principles outlined in Ireland's National Action Plan for Open Research should be incorporated into future research on Irish peatlands to ensure that environmental data are more accessible and that knowledge of peatland projects and their outputs is publicly available. The stakeholder survey identified the lack of access to state data and that of semi-state companies, such as Bord na Móna and Coillte (e.g. LIFE projects) and a lack of willingness to share data between institutions as issues that must be addressed. Publication of findings by the private sector and part-state-owned companies should be encouraged, to disseminate findings and facilitate knowledge exchange. Therefore, there is a need to develop a portal or repository for peatland project outputs and research and to ensure that these data are secure and accessible, so that peatland knowledge can be harnessed into the future. The establishment of the National Peatland Centre of Excellence by the University of Galway is a positive step in this regard, and platforms such as PeatSense also show promise for improving collaboration and data sharing. However, such initiatives require long-term funding and support to succeed and should focus not only on data but also on building a coordinated network for scientists and researchers to work with wider society and all peatland stakeholders. This will enable multidisciplinary, interdisciplinary

10 https://www.ucd.ie/peat-hub-ireland/researchonirishpeatlands/newsandevents/sustainablemanagementofirelandspeatlands/ (accessed 12 June 2025).

and transdisciplinary collaboration, as well as intergenerational learning between more established and early career researchers. Links with European and international peatland projects and initiatives are also important to harness already existing knowledge and best practice and create cross-cultural partnerships (e.g. the PeatDataHub (University of Leeds), the Global Peatland Database (Greifswald Mire Centre) and the Global Peatlands Assessment Database).

4.4.3 Consider the opportunities and challenges of using emerging technologies

The use of digital technologies to map peatlands, including remote-sensing (e.g. satellite imagery, radiometric), other digital mapping (historical maps) and AI (machine learning) technologies, has grown exponentially in the last two decades. Responses to the researcher survey identified significant opportunities for leveraging machine learning, AI and EO/remote-sensing technologies along with *in situ* measurements to monitor peatlands on a large scale in Ireland. Such technologies could be effectively employed for the robust monitoring and verification of peatland restoration and carbon credit schemes, with state regulation of carbon credits being seen as a necessary oversight mechanism. Employing such technologies would require ongoing training in a rapidly evolving field and platforms that incorporate integrated data streams (to efficiently share and utilise the data) into model development and that help to validate model predictions versus observations. Consideration should also be given to the infrastructure required to store and manage data. In this review, researchers cautioned against an overemphasis on "data-tech-as-solution" to environmental problems, given the environmental externalities produced by data generation. The use of technology was discussed in the scenarios workshop (see Appendix 3) also in terms of the governance and ownership of data related to peatland restoration, advocating for open, publicly accessible data. Ultimately, the use of digital technologies was seen as likely in all scenarios in the future, with alternative visions of the possibilities being discussed, from communities being trained to use monitoring equipment to only large corporations and a small, highly skilled workforce being employed to carry out the work.

5 Conclusions

The outputs of the PHI project provide a baseline of evidence for SPM in Ireland so that researchers, policymakers and all stakeholders can work together to take the urgent action that is needed to protect, manage and conserve these ecosystems. The project integrated current knowledge, identified areas of research that are lacking and proposed new directions for future inquiry. The glossary, database, 96 actions and 71 research gaps, and the accessible factsheets are “living” documents available to all stakeholders with responsibility for SPM. They are all intended to play a vital role in fostering the comprehensive perspective that is necessary for the sustainable management of peatland ecosystems. This will safeguard the ecosystem services and communal benefits that peatlands provide for current and future generations, helping to contribute to thriving ecosystems, economies and societies.

The anthropogenic impact on peatland ecosystems has led to the loss of much of this iconic Irish landscape. Reimagining peatland management for the future will involve taking account of a diversity of values and perspectives to manage trade-offs, create synergies and develop multifunctional landscapes. Our actions in these times matter and it is now imperative to nurture a paradigm shift towards regenerative policies, practices and land use for peatlands through collaboration and dialogue.

References

Aria, M. and Cuccurullo, C. (2017). Bibliometrix: an R-tool for comprehensive science mapping analysis. *Journal of Informetrics* 11: 959–975.

Berrang-Ford, L., Pearce, T. and Ford, J.D. (2015). Systematic review approaches for climate change adaptation research. *Regional Environmental Change* 15: 755–769.

Digital Repository of Ireland (2024). FAIR and open science: making research data findable, accessible, interoperable and reusable. Available online: https://dri.ie/fair-and-open-science/ (accessed 23 May 2025).

EPA (Environmental Protection Agency) (2024). *Ireland*: *National Inventory Report 2023 – Greenhouse Gas Emissions 1990–2020 Reported to the United Nations Framework Convention on Climate Change*. EPA, Johnstown Castle, Ireland.

FAO (Food and Agriculture Organization of the United Nations) (2017). Unlocking the potential of soil organic carbon – outcome of the Global Symposium on Soil Organic Carbon. In FAO (ed.), *Global Symposium on Soil Organic Carbon*. FAO, Rome, Italy, pp. 21–23.

Finch, M., Bhroin, N.N. and Krüger, S. (2024). Unlearning, relearning, staying with the trouble: scenarios and the future of education. *Prospects* 54: 475–482.

Flood, K., Wilson, D. and Renou-Wilson, F. (2025). Evidence synthesis and knowledge integration for sustainable peatland management. *Land* 14(7), https://doi.org/10.3390/land14071397.

Fluet-Chouinard, E., Stocker, B.D. and Zhang, B. (2023). Extensive global wetland loss over the past three centuries. *Nature* 614: 281–286.

Gusenbauer, M. and Haddaway, N.R. (2020). Which academic search systems are suitable for systematic reviews or meta-analyses? Evaluating retrieval qualities of Google Scholar, PubMed, and 26 other resources. *Research Synthesis Methods* 11: 181–217.

IPBES (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services) (2019). *Summary for Policymakers of the Global Assessment Report on Biodiversity and Ecosystem Services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. IPBES Secretariat, Bonn, Germany, p. 56.

IPCC (Intergovernmental Panel on Climate Change) (2023). *Climate Change 2023: Synthesis Report.* Contribution of Working Groups I, II and III to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. IPCC, Geneva, Switzerland.

Kumpulainen, M. and Seppänen, M. (2022). Combining Web of Science and Scopus datasets in citation-based literature study. *Scientometrics* 127: 5613–5631.

Langer, L., Erasmus, Y., Tannous, N. and Stewart, R. (2017). How stakeholder engagement has led us to reconsider definitions of rigour in systematic reviews. *Environmental Evidence* 6(1), 20.

National Parks and Wildlife Service (2015). *National Peatlands Strategy*. Department of Arts, Heritage and the Gaeltacht, Dublin, Ireland.

Pschenyckyj, C., Riondato, E., Wilson, D., Flood, K., O'Driscoll, C. and Renou-Wilson, F. (2021). *Optimising Water Quality Returns from Peatland Management while Delivering Co-benefits for Climate and Biodiversity: Synthesis Report*. The Water Forum/An Fóram Uisce, Nenagh, Ireland.

R Core Team (2023). *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria.

Reed, M.S., Stringer, L.C., Fazey, I., Evely, A.C. and Kruijsen, J.H. (2014). Five principles for the practice of knowledge exchange in environmental management. *Journal of environmental management* 146: 337–345.

Renou-Wilson, F., Bolger, T., Bullock, C., Convery, F., Curry, J., Ward, S., Wilson, D. and Müller, C. (2011). *BOGLAND: Sustainable Management of Peatlands in Ireland*. STRIVE Report No. 75, Environmental Protection Agency, Johnstown Castle, Ireland. Available online: https://www.epa.ie/publications/research/land-use-soils-and-transport/bogland-sustainable-management-of-peatlands-in-ireland-final-report.php (accessed 12 June 2025).

Rydin, H. and Jeglum, J. (2006). *The Biology of Peatlands*. Oxford University Press, New York, NY.

Tanneberger, F., Appulo, L., Ewert, S., Lakner, S., Ó Brolcháin, N., Peters, J. and Wichtmann, W. (2020). The power of nature-based solutions: how peatlands can help us to achieve key EU sustainability objectives. *Advanced Sustainable Systems* 5(1), 2000146, https://doi.org/10.1002/adsu.202000146.

Toronto, C.E. and Remington, R. (2020). *A Step-by-step Guide to Conducting an Integrative Review*. Springer, Cham, Switzerland.

UNEP (United Nations Environment Programme) (2022). *Global Peatland Assessment – The State of the World's Peatlands: Evidence for Action Toward the Conservation, Restoration and Sustainable Management of Peatlands. Summary for Policy Makers*. Global Peatland Initiative, Nairobi.

Wichmann, S. and Nordt, A. (2024). Unlocking the potential of peatlands and paludiculture to achieve Germany's climate targets: obstacles and major fields of action. *Frontiers in Climate* 6, https://doi.org/10.3389/fclim.2024.1380625.

Wilson, D., Hofer, B., Jarveoja, J., Jordan, S., Niinisto, S., Purre, A.-H., Rankin, T., Shurpali, N.J. and Sirin, A. (2023). Climate impact of peat extraction for horticultural use and fuel. In Strack, M. (ed), *Peatlands and Climate Change*. International Peatland Society, Jyvaskyla, Finland, pp. 266–307.

Appendix 1 Peat Hub Ireland Surveys

The survey results report is available to view on the PHI website.[11]

A1.1 Researcher Survey Questionnaire

1. Describe your broad area of research – you may provide details of your discipline in the "Other" comment box:

- Natural sciences
- Social sciences
- Engineering and technology
- Arts and humanities
- Agricultural science
- Other (please specify)

2. Please choose researcher level:

- Principal investigator
- Post-doctoral
- Postgraduate
- Technician/research manager/assistant
- Other (please specify)

3. Gender: how do you identify?

- Female
- Male
- Prefer not to say
- Prefer to self-describe

4. Please identify *up to five* important peer-reviewed facts, principles or theories that are known about Irish peatlands through research in your discipline.

5. What are the *main issues* facing peatlands in Ireland in your research discipline?

6. What are the *knowledge gaps* in your research discipline relating to Irish peatlands? These may relate to types of management, types of peatlands, geographic regions of Ireland, species, specific sectors or other categories as relevant to your discipline.

7. We are creating a "peatlands glossary" to encourage collaboration and shared understanding of key peatland concepts and ideas. Can you briefly *define three to five key terms or concepts for the glossary* related to your discipline, especially terms that might be misunderstood, defined differently or geographically distinct?

8. Can you suggest *three to five sources of peer-reviewed or grey literature* that are key to understanding your field of research on peatlands? This can be research outside Ireland but must be applicable to Irish peatlands. DOIs are sufficient.

9. Sustainability is a key concept in peatland management. It involves societal responsibility to optimise the social, cultural, environmental and economic contributions that peatlands make to the well-being of this and future generations. *What does "sustainable peatland management" mean in terms of research and practice in your particular discipline?*

10. Do you have any other comments relating to peatlands research in Ireland in terms of knowledge gaps, trends, risks or opportunities?

A1.2 Stakeholder Survey Questionnaire

1. Please describe the main sector you work in or your area of interest in peatlands. If more than one category applies to you, please tick the box that describes your *primary* occupation or interest.

2. Please describe your particular area of peatlands knowledge, expertise or interest.

3. Are you currently working on or participating in a peatland project in Ireland?

- EU LIFE programme (e.g. Wild Atlantic Nature, Peatlands and People)
- Horizon Europe (e.g. Waterlands)

11 https://www.ucd.ie/peat-hub-ireland/researchonirishpeatlands/ (accessed 12 June 2025).

- Interreg Europe (e.g. Care Peat)
- European Innovation Partnership (e.g. Projects List)
- EPA
- Volunteer or community-led project
- Industry
- Other (please specify)

4. What are the most crucial issues facing peatlands in your sector/area of interest?

5. In your sector/area of interest, what are the key knowledge gaps or areas where more research is needed for the sustainable management of peatlands in Ireland? Sustainable management is defined here as societal responsibility to optimise the social, cultural, environmental and economic contributions that peatlands make to the well-being of this and future generations.

6. We are creating a “peatlands glossary” to encourage collaboration and shared understanding of key peatland concepts and ideas. Can you suggest three key terms or concepts that you would like to see clearly explained in a glossary?

7. What are the main barriers to the use and/or application of peatland research in your sector/ area of interest? Please tick the three options you consider most significant.

- Insufficient communication of research and knowledge exchange.
- Complexity of translating peatland research findings into practical recommendations for stakeholders.
- Limited engagement of stakeholders in the research process (non-governmental organisations, local communities, landowners, farmers, industry representatives).
- Limited financial resources and insufficient long-term funding for peatland research and monitoring.
- Lack of collaboration and shared platforms between researchers, practitioners, policymakers and stakeholders, resulting in silos and an implementation gap.
- Greater influence of public perception, vested interests and lobby groups than research evidence in policymaking and decision-making for peatlands.
- Other (please specify).

8. Which of the following would enable the use/ uptake of peatland research in your sector/area of interest? Please rank in order of importance.

- More effective communication and dissemination of research: facilitate exchange of knowledge, ideas and research findings.
- Building shared understanding of research: use of plain-language summaries, policy briefs, infographics, media engagement.
- Enhance stakeholder engagement in peatlands research: involve stakeholders throughout the research process, co-design of projects, engaged research.
- Increased funding and resources: long-term funding to support research, monitoring and data collection.
- Mechanisms for collaboration and partnership: networks and platforms for collaboration between peatland researchers, policymakers, practitioners, landowners, communities and other stakeholders.
- Improve credibility and acceptance of peatlands research: use of participatory research approaches that include stakeholder deliberation and public dialogue on research findings.

9. Have you any other comments relating to research and its implementation by practitioners, policymakers and wider stakeholders?

10. Have you any final comments relating to the future of peatlands research in Ireland in terms of trends, risks or opportunities for sustainable peatland?

Appendix 2 Peat Hub Ireland Literature Review Methodology

Due to the volume of research over the time period and the range of sources used to compile the evidence, all databases were searched using the keyword search string "(irish OR ireland) AND (peatland OR bog OR fen OR mire OR bogland)". This search string fit the study scope and aims most appropriately. We tested different phrases and keyword strings using Boolean searching (AND, OR, NOT), adding various terms (biodiversity, restoration, just transition) to the core search string, e.g. (irish OR ireland) AND (peatland* OR bog OR fen OR mire OR bogland) AND (biodiversity). However, these additional terms yielded no additional articles in their results (Table A2.1).

This study combined two data sources initially (Web of Science and Scopus) to improve the quality and scope of the results. Web of Science generally covers natural sciences and engineering while Scopus includes the social sciences to a greater degree, and so combining these data sources leads to more comprehensive coverage in terms of disciplines (Kumpulainen and Seppänen, 2022). However, a number of challenges were experienced by the project team with regard to unifying and repairing data from different databases. The main issues were related to citation errors and inconsistent data formats between databases. These included issues with spelling and special characters, journals and authors presented in full versus abbreviated, missing or absent DOIs/URLs, and incomplete information relating to journal volumes and sources, all of which had to be manually corrected.

Peer-reviewed articles were identified using the title, abstract and keyword functions in the Scopus database, while the Web of Science search included the whole document in order to capture records that only mentioned the keywords in the body of the article. The databases were searched on 10 October 2023. We searched for book chapters, peer-reviewed journal articles and proceedings papers written in the English language. The search resulted in total of 790 articles in Web of Science and 439 articles in Scopus published between 2000 and 2023. These searches were combined using the bibliometrix packages (Aria and Cuccurullo, 2017) in R (R Core Team, 2023), thus

Table A2.1. Source of literature and keyword search strategy

Source	Keyword search
Web of Science	(irish OR ireland) AND (peatland OR bog OR fen OR mire OR bogland) (All Fields) and English (Languages) and IRELAND or ENGLAND or NORTH IRELAND or GERMANY or CANADA or SCOTLAND or NETHERLANDS or WALES or FRANCE (Countries/Regions)
Scopus	TITLE-ABS-KEY ((irish OR ireland) AND (peatland OR bog OR fen OR mire OR bogland)) AND PUBYEAR > 1999 AND PUBYEAR < 2024 AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (AFFILCOUNTRY , "Ireland" "United Kingdom" "Germany") "Netherlands" "Canada" "France"))
Google Scholar	(irish OR ireland) AND (peatland OR bog OR fen OR mire OR bogland)
Google Scholar	"peatland or bog" site: www.osi.ie "peatland or bog" site: www.gsi.ie "peatland or bog" site: www.epa.ie "peatland or bog" site: www.npws.ie "peatland" site: www.teagasc.ie
ProQuest Dissertations and Theses UK and Ireland	(irish OR ireland) AND (peatland OR bog OR fen OR mire OR bogland)

removing 575 duplicates and leaving 1496 unique records. Google Scholar was used as a supplementary data source to search for both peer-reviewed and grey literature using the same search string. This search provided an important source of grey literature (policy documents, technical reports and unpublished academic studies) to help counter publication bias, which can occur when journals do not publish studies that are not considered significant or authors do not submit papers that have negative results (Toronto and Remington, 2020). This search yielded reports, government documents and some civil society and non-governmental organisation documents. A limited number of studies from other geographical regions with relevance for the Irish context were also included.

Google Scholar was also used to search government and organisational websites using the keywords “peatland or bog”. Although Google Scholar is deemed insufficient as a principal search system due to issues with precision and reproducibility (Gusenbauer and Haddaway, 2020), its use to search these websites was warranted due to inadequate search functionality or inability to export results on the websites in question. A search on the ProQuest Dissertations and Theses UK & Ireland database also yielded 97 unpublished theses relating to Irish peatlands.

Appendix 3 Peat Hub Ireland Scenarios for 2050 Workshop

The PHI team held a workshop on 30 May 2024 in Tyrrellspass, County Westmeath, which had three aims: (i) to communicate the outcomes of the project, (ii) to collate feedback on the factsheets and other outputs, and (iii) to use scenarios to encourage creative thinking and sustainable action among a range of stakeholders for Irish peatlands. The team worked with Dr Matt Finch, a strategy and foresight practitioner who works with communities and institutions on scenario planning, strategy and policy.

The workshop began with a presentation from the PHI team (Dr Florence Renou-Wilson, Dr Kate Flood and Dr David Wilson) to communicate the outcomes of the project and set the context for the scenarios to come. Workshop participants then explored "possible peatland futures" scenarios for 2050 in two sessions. Session 1 began with an introduction to scenario planning and the presentation of three scenarios adapted from the University of Galway Horizon Integrative Mechanisms for Addressing Spatial Justice and Territorial Inequalities in Europe project. Scenario planning is recognised as a way to expand the time frame in which we think about issues such as peatland management and the resources needed to take peatlands research and stewardship into an uncertain future, opening up space to think about it as a longer-term endeavour. Attendees explored the scenarios in a gallery walk of poster presentations,[12] followed by small group discussions of implications for the future of sustainable peatlands management. Discussions were guided by the following three questions and the whole group, including online participants, came together to provide feedback:

- How would sustainable peatlands management be carried out in each scenario?
- Who would be involved in that management in each scenario?
- Which aspects of sustainable peatlands management would be easy in each scenario? Which aspects would be difficult?

Session 2 had a similar structure, with small group discussions followed by feedback. Participants were asked to reflect on what social, technological, cultural, policy, data and governance resources would be needed to take peatlands research, sustainable management and custodianship into an uncertain future. After lunch, participants were guided around Cloncrow Bog Natural Heritage Area with Eugene Dunbar from the local community group ETHOS and Elena Aitova who carried out her doctoral research at the site. Representatives from the Care Peat project and National Parks and Wildlife Service (partners on the Cloncrow project) also contributed to discussions on the restoration work, along with other attendees. We collated feedback on the day's activities, which is summarised below under the session headings and in the post-event feedback survey (Tables A3.1 and A3.2).

A3.1 Workshop Feedback Survey

The survey was sent out to the participants after the event, along with a link to a video of the presentations, and received 14 responses, with some participants commenting on more than one part of the workshop. The responses are summarised below.

1. What was your favourite part of the workshop?

- Cloncrow Bog walk (six responses).
- Discussing the future scenarios with a diverse range of people (five responses).
- Active involvement, networking and discussion, conversations with other stakeholders (four responses).
- The presentations (one response).

12 https://www.ucd.ie/peat-hub-ireland/researchonirishpeatlands/newsandevents/peathubirelandscenariosworkshop/ (accessed 12 June 2025).

Table A3.1. Session 1: on your gallery walk, consider changes to society, economy, environment and institutions. How would they affect sustainable peatlands management in each scenario?

People and planet	Peatlands for profit	Politics of peatlands
• Only one that's truly sustainable – economic, social, environment • Knowledge sharing • Takes longer but more durable – efforts go further • Recognise uniqueness of bogs – site-specific actions • Land use practices • Restrict land grab • Engagement • People involved and funding	• Can this actually be sustainable? • Efficient but not equitable • AI and profit driven with little people power • Low regulation of corporations • Increased infrastructure for automation • Compensate local communities? Training to use technology and robots • Communities in rural areas supported to monitor • Will bogs survive? Exist as we know them? • Carbon credits – land grab by private sector? • Fewer stakeholders, faster changes?	• Piecemeal – wide-scale restoration harder • Collaboration is harder between groups, easier within due to silos • Structures to integrate and communicate between bodies • Communications • Management – community driven, state • Engagement • Conflict

Note: In all three scenarios, high-tech surveying, automation and remote sensing are likely to be involved, as are technology corporations such as Google and Apple and a small pool of highly skilled workers.

Table A3.2. Session 2: what resources (e.g. social, technological, cultural, policy, data, governance) are needed now to successfully take peatlands research and custodianship into each future?

People and planet	Peatlands for profit	Politics of peatlands
• Funding for researchers and communities to engage • Legislation for non-deterioration • Structures and support for cooperatives/communities • Better conservation paradigms to know where to protect/recreate, e.g. conservation rating • Incentives and compensation for changing land use • More holistic evaluation methods and indicators (well-being vs economic) • Collaboration necessary to make this happen • Community fire plans – land management plans • Regulatory/legal requirements: Nature Restoration Law/Peatland Code • More knowledge and education around turbary rights – should there be some obligation attached to it? Need legal expertise and guidance. The commons • Highlighting archaeology • Degrowth	• Who owns the data and how are they governed. Open data accessible to public • State regulation of carbon credits for restoration • Open data? Resource – who owns it? Continuity – how to encourage people to use it; use it critically, use it to challenge things • Purchasing all the land • Consumer pressure? • Technology and data – who owns them, how are they used? How sustained? Hosting of data • Flexible and remote work	• Structures to integrate and communicate between bodies • Communications • Legislation for non-deterioration • Conflict resolution • Getting out of silos • Communication: vertical (government to local) and horizontal • Continuous education

> The walk in the bog was, of course, brilliant. But I think what I liked most about the workshop was getting to experience a framework for discourse between different stakeholders where everyone was approaching challenging ideas with an amount of vulnerability and openness. Things like the icebreaker question and being pushed outside of our cognitive comfort zones led to a kind of shared sense of uncertainty and unease that made it much easier for conversation and creativity to happen.

2. Was there anything that could have been improved about any part of the workshop?

   Participants agreed that more time would have been useful to really explore the scenarios and make the most of this approach (five responses). The addition of "alternative voices" to the workshop, including turf cutters and farmers, was also mentioned (three responses). The scenario planning was challenging for some participants who felt that it did not really work, with the discussions being "heavily grounded in the present, in the 'business as usual', in the 'I want to fit my idea of the future into the scenarios'". In general, the feedback was positive: "An excellent, well-planned workshop"; "I liked the whole day, it was very informative and inspiring, I took many useful notes! It was a fantastic 'Petri dish' for networking too".

3. How might you use and apply the PHI research in your work?

- "Promote a more consensual understanding of peatland research".
- "Useful as part of the National Land Use review and Land Evidence Forum".
- "All PHI material will enrich my knowledge on peatlands".
- "The glossary and database for research reports and direct general public to the factsheets".
- "Advocacy for peatland restoration (factsheets)".
- "I would use the glossary and factsheets as reference points for any research I do in this area".
- "Glossary for solid definitions when writing papers, database to look for papers for lit review".
- "Ensuring a common language".
- "Cite it".
- "The factsheets and glossary will be useful for peatland educators".
- "The glossary and database will be invaluable for my research – the factsheets for outreach".
- "Data and info very useful for enhancing skills and scope of peatland work".

4. Did you have any new or surprising insights during the scenarios part of the workshop? Any other reflections about the scenarios approach?

- "Surprised how negative people were to the 'Peatland for Profit' scenario".
- "Useful and innovative approach and one that may be considered as part of citizen engagement group of the Land Use Review. Royal society used a scenario approach as part of their 'multifunctional landscapes' work".
- "It was interesting to think about putting yourself in 2050 and where we might be".
- "For a broad audience it is a great method to invite debate, though with prescribed scenarios it is impossible to cover all eventualities, only the most likely scenarios or those within our vista can be considered".
- "Realising how the cultural heritage of peatlands could easily get left behind in favour of survival in any of the scenarios and so the need to establish/ justify its value for the future".
- "I thought this approach was really good and it made me think outside the 'practical solutions' box".
- "Seems to be a large focus on key sites of high conservation interest. Not clear how we can make leap to viewing all peatlands as potential for restoration, where will we need to go to achieve targets of nature restoration law for example".

5. Networking is an important part of peatland events to build collaboration opportunities and trust between different people, organisations and groups. On a scale of 1 to 5, how successful was the event at facilitating opportunities to connect with people and make new contacts?

6. Have you any thoughts on how future events/ initiatives can improve collaboration and help break down silos (disciplinary and sectoral) between different stakeholders involved in SPM?

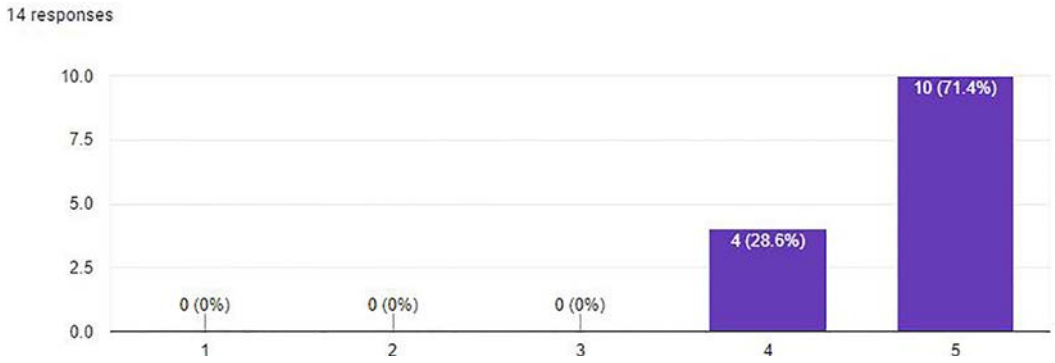

Figure A3.1. Participant responses to the workshop feedback survey question "On a scale of 1 to 5, how successful was the event at facilitating opportunities to connect with people and make new contacts?"

Diversity of voices/including all stakeholders (five responses): participants discussed the need to engage with "alternate voices", to have more representation of turf cutters, businesses and politicians/decision-makers, acknowledging the challenge of getting these groups to attend such events. A wider advertising approach to workshops was recommended to include a wider audience. In addition, sending peatland restoration delegates to farmers' events or similar "missing" stakeholder events so that they can be involved in the dialogue too.

> I think the setting is really important. Having the event where it was really felt like a neutral space that was also so connected to Cloncrow Bog. Ways to incorporate other stakeholders into research projects feels vital, particularly on the socio-cultural strand of ecosystems services. Community groups, local people, farmers, etc. (Basically, all the good work that the Community Wetlands Forum is doing!)

More interactive workshops and bog walks/ outdoor activities (five responses): participants mentioned bringing people together from different disciplines/community groups, and allowing for discussion on challenges, what is working well, what new learnings have been found, what gaps there are in peatland management, etc. Participants also acknowledged that an open approach by the presenters was refreshing and future events with a great networking component will help in forming consortia not with "the usual ones" and applying to projects together.

> When asked, everybody agrees more collaboration is needed, yet few seem to be truly willing to go for it. Collaboration can be defined as 'reciprocal altruism', repeated collaborative interactions would lead to trust. Conversely, if altruism is missing even on one side, there will be no reciprocity, no collaboration, no trust. We all need to be more altruistic, we all need to interact with each other more.

Benefits of local involvement and management techniques (three responses): participants enjoyed the bog walk and seeing the work carried out in a collaboration between research, agencies and the local community, who have provided vital education and engagement.

> Peatlands will require vast resources (human and other AI/mapping). It might be useful to use the Peat Hub as a centre point to engender local/citizen science initiatives – akin to pollinator programme for bogs?

An annual peatland showcase (one response): one participant emphasised the importance of keeping all involved in peatland management informed, with so many projects being undertaken on peatlands today within universities, state agencies, semi-state agencies, non-governmental organisations and community groups.

An event where we imagine and advocate for the future of a peatland discipline we are not familiar with e.g. a turf cutter/farmer in the shoes of a climate scientist, an ecologist and an archaeologist.

Active management and restoration (one response): one participant suggested getting people onto a site to block drains as a Meitheal. The Meitheal concept means that everyone has to work together to achieve a common goal, e.g. it could be a few hours as a part of a workshop.

Abbreviations

AI	Artificial intelligence
EO	Earth observation
EPA	Environmental Protection Agency
GHG	Greenhouse gas
GIS	Geographic information system
LIDAR	Light detection and ranging
PHI	Peat Hub Ireland
SPM	Sustainable peatland management
UNFCCC	United Nation Framework Convention on Climate Change

An Ghníomhaireacht Um Chaomhnú Comhshaoil

Tá an GCC freagrach as an gcomhshaol a chosaint agus a fheabhsú, mar shócmhainn luachmhar do mhuintir na hÉireann. Táimid tiomanta do dhaoine agus don chomhshaol a chosaint ar thionchar díobhálach na radaíochta agus an truaillithe.

Is féidir obair na Gníomhaireachta a roinnt ina trí phríomhréimse:

Rialáil: Rialáil agus córais chomhlíonta comhshaoil éifeachtacha a chur i bhfeidhm, chun dea-thorthaí comhshaoil a bhaint amach agus díriú orthu siúd nach mbíonn ag cloí leo.

Eolas: Sonraí, eolas agus measúnú ardchaighdeáin, spriocdhírithe agus tráthúil a chur ar fáil i leith an chomhshaoil chun bonn eolais a chur faoin gcinnteoireacht.

Abhcóideacht: Ag obair le daoine eile ar son timpeallachta glaine, táirgiúla agus dea-chosanta agus ar son cleachtas inbhuanaithe i dtaobh an chomhshaoil.

I measc ár gcuid freagrachtaí tá:

Ceadúnú

- Gníomhaíochtaí tionscail, dramhaíola agus stórála peitril ar scála mór;
- Sceitheadh fuíolluisce uirbigh;
- Úsáid shrianta agus scaoileadh rialaithe Orgánach Géinmhodhnaithe;
- Foinsí radaíochta ianúcháin;
- Astaíochtaí gás ceaptha teasa ó thionscal agus ón eitlíocht trí Scéim an AE um Thrádáil Astaíochtaí.

Forfheidhmiú Náisiúnta i leith Cúrsaí Comhshaoil

- Iniúchadh agus cigireacht ar shaoráidí a bhfuil ceadúnas acu ón GCC;
- Cur i bhfeidhm an dea-chleachtais a stiúradh i ngníomhaíochtaí agus i saoráidí rialáilte;
- Maoirseacht a dhéanamh ar fhreagrachtaí an údaráis áitiúil as cosaint an chomhshaoil;
- Caighdeán an uisce óil phoiblí a rialáil agus údaruithe um sceitheadh fuíolluisce uirbigh a fhorfheidhmiú
- Caighdeán an uisce óil phoiblí agus phríobháidigh a mheasúnú agus tuairisciú air;
- Comhordú a dhéanamh ar líonra d'eagraíochtaí seirbhíse poiblí chun tacú le gníomhú i gcoinne coireachta comhshaoil;
- An dlí a chur orthu siúd a bhriseann dlí an chomhshaoil agus a dhéanann dochar don chomhshaol.

Bainistíocht Dramhaíola agus Ceimiceáin sa Chomhshaol

- Rialacháin dramhaíola a chur i bhfeidhm agus a fhorfheidhmiú lena n-áirítear saincheisteanna forfheidhmithe náisiúnta;
- Staitisticí dramhaíola náisiúnta a ullmhú agus a fhoilsiú chomh maith leis an bPlean Náisiúnta um Bainistíocht Dramhaíola Guaisí;
- An Clár Náisiúnta um Chosc Dramhaíola a fhorbairt agus a chur i bhfeidhm;
- Reachtaíocht ar rialú ceimiceán sa timpeallacht a chur i bhfeidhm agus tuairisciú ar an reachtaíocht sin.

Bainistíocht Uisce

- Plé le struchtúir náisiúnta agus réigiúnacha rialachais agus oibriúcháin chun an Chreat-treoir Uisce a chur i bhfeidhm;
- Monatóireacht, measúnú agus tuairisciú a dhéanamh ar chaighdeán aibhneacha, lochanna, uiscí idirchreasa agus cósta, uiscí snámha agus screamhuisce chomh maith le tomhas ar leibhéil uisce agus sreabhadh abhann.

Eolaíocht Aeráide & Athrú Aeráide

- Fardail agus réamh-mheastacháin a fhoilsiú um astaíochtaí gás ceaptha teasa na hÉireann;
- Rúnaíocht a chur ar fáil don Chomhairle Chomhairleach ar Athrú Aeráide agus tacaíocht a thabhairt don Idirphlé Náisiúnta ar Ghníomhú ar son na hAeráide;
- Tacú le gníomhaíochtaí forbartha Náisiúnta, AE agus NA um Eolaíocht agus Beartas Aeráide.

Monatóireacht & Measúnú ar an gComhshaol

- Córais náisiúnta um monatóireacht an chomhshaoil a cheapadh agus a chur i bhfeidhm: teicneolaíocht, bainistíocht sonraí, anailís agus réamhaisnéisiú;
- Tuairiscí ar Staid Thimpeallacht na hÉireann agus ar Tháscairí a chur ar fáil;
- Monatóireacht a dhéanamh ar chaighdeán an aeir agus Treoir an AE i leith Aeir Ghlain don Eoraip a chur i bhfeidhm chomh maith leis an gCoinbhinsiún ar Aerthruailliú Fadraoin Trasteorann, agus an Treoir i leith na Teorann Náisiúnta Astaíochtaí;
- Maoirseacht a dhéanamh ar chur i bhfeidhm na Treorach i leith Torainn Timpeallachta;
- Measúnú a dhéanamh ar thionchar pleananna agus clár beartaithe ar chomhshaol na hÉireann.

Taighde agus Forbairt Comhshaoil

- Comhordú a dhéanamh ar ghníomhaíochtaí taighde comhshaoil agus iad a mhaoiniú chun brú a aithint, bonn eolais a chur faoin mbeartas agus réitigh a chur ar fáil;
- Comhoibriú le gníomhaíocht náisiúnta agus AE um thaighde comhshaoil.

Cosaint Raideolaíoch

- Monatóireacht a dhéanamh ar leibhéil radaíochta agus nochtadh an phobail do radaíocht ianúcháin agus do réimsí leictreamaighnéadacha a mheas;
- Cabhrú le pleananna náisiúnta a fhorbairt le haghaidh éigeandálaí ag eascairt as taismí núicléacha;
- Monatóireacht a dhéanamh ar fhorbairtí thar lear a bhaineann le saoráidí núicléacha agus leis an tsábháilteacht raideolaíochta;
- Sainseirbhísí um chosaint ar an radaíocht a sholáthar, nó maoirsiú a dhéanamh ar sholáthar na seirbhísí sin.

Treoir, Ardú Feasachta agus Faisnéis Inrochtana

- Tuairisciú, comhairle agus treoir neamhspleách, fianaise-bhunaithe a chur ar fáil don Rialtas, don tionscal agus don phobal ar ábhair maidir le cosaint comhshaoil agus raideolaíoch;
- An nasc idir sláinte agus folláine, an geilleagar agus timpeallacht ghlan a chur chun cinn;
- Feasacht comhshaoil a chur chun cinn lena n-áirítear tacú le hiompraíocht um éifeachtúlacht acmhainní agus aistriú aeráide;
- Tástáil radóin a chur chun cinn i dtithe agus in ionaid oibre agus feabhsúchán a mholadh áit is gá.

Comhpháirtíocht agus Líonrú

- Oibriú le gníomhaireachtaí idirnáisiúnta agus náisiúnta, údaráis réigiúnacha agus áitiúla, eagraíochtaí neamhrialtais, comhlachtaí ionadaíocha agus ranna rialtais chun cosaint chomhshaoil agus raideolaíoch a chur ar fáil, chomh maith le taighde, comhordú agus cinnteoireacht bunaithe ar an eolaíocht.

Bainistíocht agus struchtúr na Gníomhaireachta um Chaomhnú Comhshaoil

Tá an GCC á bainistiú ag Bord lánaimseartha, ar a bhfuil Ard-Stiúrthóir agus cúigear Stiúrthóir. Déantar an obair ar fud cúig cinn d'Oifigí:

1. An Oifig um Inbhunaitheacht i leith Cúrsaí Comhshaoil
2. An Oifig Forfheidhmithe i leith Cúrsaí Comhshaoil
3. An Oifig um Fhianaise agus Measúnú
4. An Oifig um Chosaint ar Radaíocht agus Monatóireacht Comhshaoil
5. An Oifig Cumarsáide agus Seirbhísí Corparáideacha

Tugann coistí comhairleacha cabhair don Ghníomhaireacht agus tagann siad le chéile go rialta le plé a dhéanamh ar ábhair imní agus le comhairle a chur ar an mBord.

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